THE REPUBLIC OF TURKEY
BAHCESEHIR UNIVERSITY

A FUZZY MULTI-ATTRIBUTE DECISION MAKING MODEL PROPOSAL TO SELECT CLINICAL CHIEF OF SURGERY

Master's Thesis

İpek Nur AKSU

ISTANBUL, 2012

THE REPUBLIC OF TURKEY

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Supervisor: Asst. Prof. Dr. Ahmet BEŞKESE

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This is to certify that we have read this thesis and that we find it fully adequate in scope, quality and content, as a thesis for the degree of Master of Science.

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June, 20, 2012 İpek Nur AKSU

ÖZET

CERRAHİ KLİNİK ŞEFİ SEÇİMİNDE BULANIK ÇOK NİTELİKİ KARAR VERME MODEL ÖNERİSİ

İpek Nur Aksu

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Günümüzde her firma, bireysel ve kurumsal verimliliği ve etkinliği arttırmayı amaçlayan çalışmalarda bulunmaktadır, şirketlerin sektörel anlamda başarılı olabilmeleri için geçerli ve uygulanabilir bir performans yönetim sisteminin kurulmasını ve işletilmesini sağlamaları gerekmektedir. Rekabet koşullarının giderek arttığı bu dönemde, şirketlerin personel performanslarının değerlendirilmesi geçmişe yönelik performans seviyesini gösterirken, geleceğe yönelik potansiyel performansı belirlemede ve performans arttırma çalışmalarında yeni bir bakış açısı sağlamaktadır.

Bu çalışmanın amacı sağlık personelinin özellikle cerrahların işe alım kriterlerini belirlemektir. Çalışma, ilgili iş için 3 adayı ve yıllardır sağlık sektöründe kariyer sahibi olan 2 uzman ile gerçekleştirilmiştir.

Bu çalışmada, kar amacı gözetmeyen kuruluşlarda personel performans değerlendirme sistemi, performans değerlendirme kriterlerinin belirlenmesi ve bu kriterlerin kurum açısından önem derecelerinin belirlenmesi için ağırlıklandırılması yer almaktadır. Çalışma iki bölümden oluşmaktadır, birinci bölüm İstanbul'da özel hastanelerde çalışan uzmanlardan alınan bazı bilgilerle işe alım kriterlerinin belirlenmesi ve sonrasında bütün bilgilerin bir araya getirilip işe alım kriterlerinin hiyerarşik yapısını olusturmaktır. Bulanık ortamda, kriterler Analitik Hiyerarşik Süreç ile sıralanmış ve önem dereceleri belirlenmiştir. İkinci bölüm ise pozisyon için uygun adayın TOPSIS methodu ile seçilmesidir.

Sonuç olarak, işe alım kriterleri, işe alım sürecini değerlendirme çeşitli methodlar kullanılarak belirlenmiştir. Bu veriler kullanılarak uygun adaya karar verilmiştir.

Anahtar Kelimeler: İşe alım süreci, Seçim, Bulanık AHP, Bulanık TOPSIS.

ABSTRACT

A FUZZY MULTI-ATTRIBUTE DECISION MAKING MODEL PROPOSAL TO SELECT CLINICAL CHIEF OF SURGERY

İpek Nur Aksu

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Today's companies, perform a work which aims to enhance individual and corporate efficiency and effectiveness. Companies need to provide establish and provide valid and applicable performance management system in order to become successful on sectoral. In a competitive environment, companies' staff performance evaluation as indicate retrospective performance level, identify prudential potential performance and provide new perspective to studies about enhance performance.

The purpose of this study is to specify the recruitment criteria of medical staff especially surgeons. Research is done on a group including 3 candidates for the related job and 2 experts that have a career in health sector for many years.

In this research, staff recruitment criteria, recruitment process evaluation then performance criteria and performance process evaluation of 3 workers and the ranking of importance for the corporation are involved for the non-profit organization. There are two parts in this study, first part includes identifying the criteria for selection, some information are get from the experts which working at hospitals in Istanbul then all in information are combined to build hierarchy of recruitment criteria. By using Analytical Hierarchy Process (AHP) in fuzzy environment criteria are ranked and the importance is identified. Second part includes Fuzzy TOPSIS method to select appropriate candidate for the position.

As a result, according to the methods recruitment criteria and process evaluation, for the surgeons are identified. By using these parts decided to appropriate candidate.

Keywords: Recruitment Process, Selection, Fuzzy AHP, Fuzzy TOPSIS.

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ABBREVIATIONS

AHP	:	Analytic Hierarchy Process
FAHP	:	Fuzzy Analytic Hierarchy Process
MADM	:	Multi Attribute Decision Making
MCDM	:	Multi Criteria Decision Making
TFN	:	Triangular Fuzzy Number
TOPSIS	:	Technique for Order Preference by Similarity to Ideal Solution
ELECTRE	:	Elimination and Choice Translating Reality English Elimination Et Choix Traduisant la Realité
CI	:	Consistency Index
CRI	:	Consistency Random Index
DMs	:	Decision Makers
WSM	:	Weighted Sum Model
WPM	:	Weighted Product Model
FPIS	:	Fuzzy Positive-Ideal Solution
FNIS	:	Fuzzy Negative-Ideal Solution
A	:	Alternative
C	:	Criteria
PROMETHEE	:	Preference Ranking Organization Method for Enrichment Evaluations
r	:	Correlation Coefficient
CR	:	Consistency Ratio
CI	:	Consistency Index
WSM	:	Weighted Sum Model
WPM	:	Weighted Product Model

SYMBOLS

WSM score of the best alternative	:	$A^{*}_{WSM-score}$
The decision criteria	:	n
The weight of importance of the $j-th$ criterion	:	w_j
The actual value of the $i-th$ alternative in terms of the $j-th$ criterion	:	a_{ij}
The eigenvalue	:	$\lambda_{\max}$
	:	
The positive outranking flow	:	$\Phi^{+}(a)$
The negative outranking flow	:	$\Phi^{-}(a)$
The net outranking flow	:	$\Phi(a)$
Preferred Index	:	$\Pi(\alpha,\beta)$

1. INTRODUCTION

Along with globalization, companies must continuously develop their competition skills and keep up with the alteration in order to survive and to be float. One of the most important and efficient ways to ensure competitive success, is to invest in human resources and use this resource.

Employees are the most valuable asset of a company in human resources management, which has doing set of activities carried out in order to manage effectively. The aim of human resource management is maximize the contributions of employee with business, to ensure integration of the business and increase satisfaction.

Human resources management; operation will be a new addition to the selection of employees for the performance evaluation of existing employees in the making, finding the differences between employees and managers and employees play an important role in drawing up of the relationship between the features that affect.

Fuzzy TOPSIS methods and Fuzzy AHP are examined in most businesses suppliers, machinery, plant location, selection of software and operating system problems, has been employed as in the literature.. In this study, clinical chief of the surgical department of a hospital with the help of these two methods for the solution to the problem of election candidates were searched.

This study is aim to clarify the method of Fuzzy AHP and Fuzzy TOPSIS with an application to identify selection process of clinical chief of surgery in health sector. This study consists of two parts.

The first section focused on fuzzy sets to decide criteria of selection and identify the importance of criteria to ranking selection criteria.

The second section includes the selection of appropriate candidate for the position of clinical chief of surgery from alternatives using Fuzzy TOPSIS method according to selection criteria and decision makers.

2. PROBLEM DEFINITION AND REVIEW

Health sector is expected to show a good performance. Workloads make their works difficult for healthcare workers,reduces the efficiency of employees, reduces their motivation and decreases performance. As a result, the quality of service is reduced**.**

Based on study of Liberatore and Nydick in 2008 about the analytic hierarchy process in medical and health care decision making ,in health sector, AHP method is used in some headings, such as Patient participation, Therapy/treatment, Organ transplantation, Project and technology evaluation and selection, Health care evaluation and policy Human resources are provided for decision-making in the field of personnel selection by AHP. The AHP has been applied in hospital human resource planning and in the selection of hospital laboratory personnel selection is analyzed by Kwak et al. (1997) using AHP .

Based on Weingarten et al. (1997) AHP approach for the selection of 5-year general surgery residents is discussed. In that study the AHP ratings model consists of three criteria: academic performance, personal fit, and surgical appropriateness. The weights of the criteria and the scores of the candidates were obtained from the resident selection committeeAnd also, Hemaida and Kalb (2001) applied the AHP for selecting first-year family practice residents at a Midwest medical center.

This study was designed to select candidate for the position of clinical chief of surgery at a private hospital in Istanbul. 3 qualified candidates are determined for this position and the election was decided among these candidates. After the first review three candidates A1, A2 and A3 remain for further evaluation. A committee of two decision-makers, D1 and D2 has been formed to conduct the interview and to select the most suitable candidate to the position.

Candidate selection for surgical sciences in health sector and relevant researches studied in different subjects by using same methods are introduced in this study.

AHP is a common method of multi-criteria decision-making which is developed by Thomas L. Saaty (1980). AHP paired comparison process may be inadequate in dealing with situations of uncertainty and instability therefore fuzzy AHP method has been developed to solve hierarchical problems. However, for real world environmental management problems that involve many stakeholders and conflicting viewpoints, the traditional AHP method is insufficient. Buckley (1985) applies the fuzzy theory to the AHP method to avoid neglecting extreme values.

There are many studies in literature about recruitment process. Borman(1980), Day and Silverman (1989), Barrick and Mount(1991) while discussing concept of recruitment process, they emphasize to pay attention personality factors to estimate performance of employee.

Recruitment process problem sometimes use for recruit a bank employee, sometimes use for recruit a top manager (CEO). Chen and Wan (1999), Kesner and Sebora (1994) and Changati and Sambharya (1987) indicate that manager's decisions deteramine to business strategy.

Many researchers studied about selection with AHP and fuzzy AHP in terms of different perspectives in literature. Kahraman, Cebeci and Ulukan (2003) for multi-criteria supplier selection, Zouggari and Benyoucef (2011) for multi-criteria group decision supplier selection, Mahmoodzadeh, Shahrabi, Pariazar, and Zaeri (2007) for project selection, Ballı and Korukoğlu (2009) for operating system selection, Güngör, Serhadlıoğlu, Kesen (2009) for personnel selection. Dursun and Karsak (2010) for a Fuzzy MCDM approach for personnel selection, Büyüközkan and Çiftçi (2012) for A combined fuzzy AHP and fuzzy TOPSIS based strategic analysis of electronic service quality in healthcare industry, Gibney and Shang (2007) for Decision making in academia: A case of the dean selection process, Kabak, Burmaoğlu and Kazançoğlu (2012) for A fuzzy hybrid MCDM approach for professional selection.

In literature there are many studies about personnel selection problems by using AHP and Fuzzy AHP in firms in all sectors. Today's personnel selection are getting more important for firms and also health sector especially hospitals although there is no adequate studies in literature about staff selection in health sector.

Studies in TOPSIS method by using fuzzy values have started with doctoral thesis by Negi in1989, Chen and Hwang with a published book in 1992. (Dündar et al, 2007: 292).

Triantaphyllou and Lin (1996) have developed Fuzzy TOPSIS method based on fuzzy arithmetic operations.In this study, fuzzy multiple criteria decision making methods as AHP, weighted sum method, weighted product and TOPSIS model also were placed on a comparison of these methods have dealt. TOPSIS method has considered expanding the fuzzy environment by Chen (2000). In this study, the rating of each alternative and each criterion weight, triangular fuzzy numbers expressed by the verbal variables were identified with the vertex to calculate the distance between two triangular fuzzy numbers proposed method.

Chu (2002), has suggested Fuzzy TOPSIS method for Location of the selection of the factory, the various alternatives in a variety of benchmarks on the basis of subjective criteria and the weights of the criteria stated in the help of linguistic variables.

Jahanshahloo et al. (2006), have dealt Fuzzy TOPSIS method in fuzzy decision-making with fuzzy data.

Tsaur et al. (2002), have benefied from fuzzy set theory to evaluate the quality of the airways service. AHP method was used to obtain the weights of criteria and TOPSIS method was used for grading criteria to determine factors to affects service quality.

Karsak (2002), has suggested MCDM based on fuzzy distance approach to evaluate alternatives of flexible manufacturing system.

Yong (2006), has suggested a new Fuzzy TOPSIS approach for Location choice of the factory. The proposed method includes less mixed process when compared with existing methods. Fuzzy numbers converted to the exact digits and decreased the complexity of the transaction. Because of the latest scores are in terms of absolute numbers,there is no necessity for ranking of fuzzy numbers.

Chu and Lin (2003), consider fuzzy TOPSIS method for robot selection. According to Topsis method, alternatives sort by degree of proximity coefficient, at the end of the study calculation is provided for the proposed method with numerical example.

Saghafian and Hejazi (2005), suggested Fuzzy TOPSIS method for fuzzy group decision making environment and the necessary calculations have dealt MATLAB 6.5 package program for the tools.

Chen et al. (2006), consider the fuzzy decision making approach to handle supplier selection problem in supply chain system. Mostly in determining the appropriate supplier quantitative and qualitative factors are taken into account, in this study the ratings and weights of these factors used in determining the linguistic variables.

Bottani and Rizzi (2006), presented approach is based on set theory and fuzzy TOPSIS method for determining the most appropriate third-party logistics (3PL) service providers.

Tadic et al.(2010) presented a study about ELV dismantling selection by using Fuzzy AHP and TOPSIS methods.

Wang and Elhag (2006), presented Fuzzy TOPSIS method based on alpha level set and nonlinear programming. Fuzzy TOPSIS method is also discussed in the relation between the fuzzy weighted average.

Supciller and Capraz (2011) consider application of supplier selection based on AHP and TOPSIS methods.

Zouggari and Benyoucef (2011) suggested Multi-Criteria Group Decision Supplier Selection Problem using Fuzzy Topsis based Approach.

3. DECISION THEORY

Due to various reasons, people will have to decide at any moment about various topics. Decision is the final judgment reached by thinking about any subject. Moreover decision making is choosing appropriate alternative with their goals among the various alternatives by decision maker. Decision theory examines decision process with analytical and systematic approach. Decision analysis or numerical methods, models, algorithms, and theories can help making decision.

3.1 DECISION MAKING PROCESS

People are confronted with the decision-making throughout their lives in almost every period. There are many definitions about decision, according to Öztürk, Decision-making, to choose the most suitable one of various activities according to hand and the conditions to reach a goal. Kuruüzüm and Atsan also define that, decision-making, is one of the alternative plans of action process of selecting towards the realization goals and objectives.

Actions of decision-making varies to examined the scope of the subject, whether simple or complex, and in order of severity. But in essence, the common features of these actions are the decision-making;

i. All decisions, requires a variety of alternatives or options to choose from.
ii. Every act of decision-making is to serve its purpose and decisions are usually intended for a particular purpose.
iii. Decision-making action requires the time process. Because the decision-making process is a process that took place at various times.
iv. Decisions are based on future-oriented and future estimations.
v. Decision-maker, consider the possibility of not realized or has to bear the risks of the targeted goals due to the uncertainty of the future.

While decision making is the selection process that chooses appropriate alternatives in case of confrontation for own purpose in these alternatives, decision making process includes these transactions, respectively. Tekin has studied about the decision making process and suggests that stages of decision making process are as follows;

i. Awareness of the problem
ii. Identification and characterization of the problem
iii. Determination of alternatives
iv. Evaluation of alternatives
v. Determine the best alternative
vi. Evaluation of the decision

Stages of decision-making process are not standardized. Problems encountered in the structure of the decision, according to the size of the environment and decided to change some of these stages.

3.2 DECISION MAKING TYPES

While some events are kind of uncontrollable events, some events have partial randomness. Decision making models to be used vary depending on attributes of variables and the output of options and consequences forms. Decision-making can be classified under three main subjects as respect of the number of criteria, respect of current information and respect of decision maker. Hence the decision-making models can be classified as follows;

i. Single-Criteria Decision-Making
ii. Multi-Criteria Decision-Making
iii. Decision Making Under Certainty
iv. Decision Making Under Uncertainty
v. Individual Decision-Making
vi. Group Decision Making

3.2.1 Single-Criteria Decision-Making

Evaluation is adhering to a single criterion in decision-making process.

3.2.2 Multi-Criteria Decision-Making

Multiple criteria decision problems often involve conflicting. Multiple criteria decision making is the process under more than one alternative that among often conflict by decision maker's election. In MCDM, the steps of selection can be classified as follows;

Primarily determined by the relevant criteria and alternatives

Degrees of importance to the criteria determined

Each alternative is evaluated and the alternatives are ranked according to all criteria. (Ballı 2005 p.12).

In the literature there are different methods used for solving MCDM. Methods commonly used in applications can be listed as follows;

i. Weighted Sum Model (WSM)
ii. Weighted Product Model (WPM)
iii. Analytic Hierarchy Process (AHP)
iv. ELECTRE
v. PROMETHEE
vi. TOPSIS

3.2.2.1 Weighted Sum Model (WSM)

Weighted sum model is one of the most widely used methods of decision-making. If there *m* alternatives and *n* criteria, best alternative satisfies that the following expression; (Fishburn, 1967; Triantaphyllou, 2000)

$$A^{*}_{WSM-Score} = \max \sum_{j=1}^{n} a_{ij} w_j , \; for \quad i = 1,2,3,\ldots, m \tag{3.1}$$

In this equation $A^{*}_{WSM-score}$ is the WSM score of the best alternative, n is the decision criteria a_{ij} is the actual value of the $i-th$ alternative in terms of the $j-th$ criterion and w_j is the weight of importance of the $j-th$ criterion.

3.2.2.2 Weighted Product Model (WPM)

Weighted product model is comparable with weighted sum model. There is a difference that in place of addition in the model there is multiplication. Each alternative is compared with the others by multiplying a number of ratios, one for each criterion. Each ratio is increased to the power equivalent to the relative weight of the related criterion. Usually, in order to compare two alternatives A_K and A_L, the following product (Bridgman [1922] and Miller and Starr [1969]) have to be calculated**:**

$$R(A_K / A_L) = \prod_{j=1}^{n} (a_{Kj} / a_{Lj})^{w_j} \tag{3.2}$$

Where n is the number of criteria, a_{ij} is the actual value of the $i-th$ alternative in terms of the $j-th$ criterion and w_j is the weight of importance of the $j-th$ criterion and w_j is the weight of importance of the $j-th$ criterion.

If $R(A_K / A_L)$ is greater than or equal to one, that it shows that alternative A_K is more requested than A_L.

3.2.2.3 Analytic Hierarchy Process (AHP)

AHP is a common method of multi-criteria decision making which is developed by Thomas L. Saaty (1980). There are many studies about AHP in the literature; the reason for this is that easily understandable method by decision-makers. Vaidya and Kumar studied about Analytic Hierarchy Process and determined the steps of the process.

Steps of AHP are as follows;

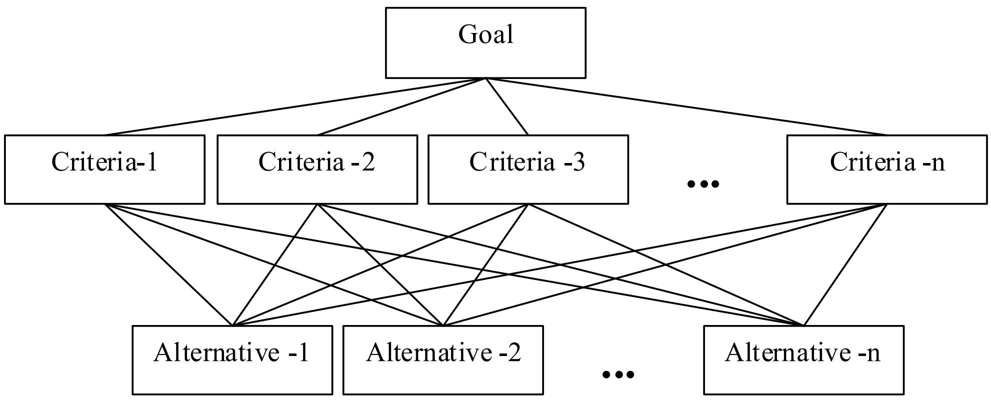
Establish the hierarchical construction. There are different levels for goal, criteria, sub-criteria and alternatives, then compare alternatives by pair-wise comparisons matrix on the basis of each criterion.

Then compare each criterion in the corresponding level and set them on the numerical scale. There will be n (n-1) / 2 comparisons, where n is the number of elements with the consideration that diagonal elements are equal '1' and the other elements will simply be reciprocals of the earlier comparisons.

Make the calculations to find the maximum Eigen value, consistency index CI, consistency ratio CR and normalized values for each criteria and alternative.

If the maximum Eigen value, CI and CR are satisfactory then decision is taken based on the normalized values; else the procedure is repeated till these values lie in a desired range.

Figure 3.1: AHP Structure



The simplest method for creating the structure of a decision problem is the hierarchical structure of three-digit. The main goal is located at the top of this hierarchical structure. Consists of a lower-level criterion that affects the quality of the decision. If these criteria have properties that affect the main goal, other steps may be included in the hierarchy. Alternatives are located at the bottom of the hierarchy.

In general meaning decision making is; to choose optimum from alternative group in respect of at least one goal or factor. Therefore elements of decision making problems; decision maker, factors, results, environment and priority of decision maker.
A decision problem should conceivable to choose best alternative from other alternatives which effect decision problem's goal.
In AHP the first step is determine factors and its inferior factors and constitution hierarchical structure according to decision maker's goal. (Dagdeviren M., 2007)

In AHP, firstly define the goal and try to determine factors which effect selection according to goal, in this stage should use questionnaire study or idea of professionals about this subject to determine all factors which effect selection. Thereafter determine potential alternatives according to defining factors (Saaty, T.L., 1980).

As mentioned in many studies, AHP steps are included in study of Al-Harbi(2001).

According to Saaty, developed the following steps for applying the AHP:

1. Define the problem and determine its goal.

2. Structure the hierarchy from the top (the objectives from a decision-maker's viewpoint) through the intermediate levels (criteria on which sub-sequent levels depend) to the lowest level which usually contains the list of alternatives.

3. Construct a set of pair-wise comparison matrices (size n x n) for each of the lower levels with one matrix for each element in the level immediately above by using the relative scale measurement shown in Table 3.1. The pair-wise comparisons are
done in terms of which element dominates the other. It allows to convert the qualitative judgments into numerical values, also with intangible attributes.

Table 3.1 : Pair-wise comparison scale for AHP preferences

Numerical rating	Verbal judgements of preferences
9	Extremely preferred
8	Very strongly to extremely
7	Very strongly preferred
6	Strongly to very strongly
5	Strongly preferred
4	Moderately to strongly
3	Moderately preferred
2	Equally to moderately
1	Equally preferred

4. There are n (n -1) / judgments required to develop the set of matrices in step 3. Reciprocals are automatically assigned in each pair-wise comparison.

5. Hierarchical synthesis is now used to weight the eigenvectors by the weights of the criteria and the sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy.

6. Having made all the pair-wise comparisons, the consistency is determined by using

the eigenvalue, λmax, to calculate the consistency index, CI as follows:

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio CR of CI with the appropriate value in Table 3.2.

Table 3.2: Average random consistency (RI)

Size of matrix	1	2	3	4	5	6	7	8	9	10
Random consistency	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

AHP allows inconsistency, but provides a measure of the inconsistency in each set of judgments. The consistency of the judgmental matrix can be determined by a measure called the consistency ratio (CR), defined as

$$CR = \frac{CI}{RI} \quad \textbf{(3.3)}$$

The CR is acceptable, if it does not exceed 0.10. If it is more, the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.

7. Steps 3-6 are performed for all levels in the hierarchy.

3.2.2.4 Electre

ELECTRE (ELimination Et Choix Traduisant la REalité) for the first time the method proposed by Roy then has been developed. In 1965 the new multiple criteria outranking method was presented for the first time at a conference in Italy and then the original ideas of ELECTRE methods were first published in 1966.

ELECTRE I (Roy, 1968) was the first decision-aid method using the concept of outranking relation. Tzeng and Shiau have included the model and steps of ELECTRE in the research. ELECTRE I is a discrete model. The algorithm is to search for 'kernel' which is a non- inferior solution. The condition of the kernel is based on the assumption of intransitive ordering of alternatives and following formula: alternative i is preferred to alternative j (i > j) if and only if

$c(i, j) \geq p$ and

$d(i, j) \leq q$

p and q are determined by the decision makers. c (i, j) and d (i, j) are defined as follows;

$$c(i, j) = \frac{\sum_{k \in i_k > j_k} W_k + 1/2 \sum_{k \in i_k = j_k} W_k}{\sum_k W_k} \quad \textbf{(3.4)}$$

$$d(i, j) = \underset{k \in i_k < j_k}{Max} \frac{i_k(f/1) - j_k(\bar{f}/1)}{K(1)} \quad \textbf{(3.5)}$$

c (i, j): concord index **(3.6)**

d (i, j): discord index **(3.7)**

W_k : Kth criterion weight **(3.8)**

$i_k > j_k$: i>j at Kth criterion **(3.9)**

$i_k = j_k$: alternative I and j have no difference (i=j) at Kth criterion **(3.10)**

$i_k < j_k$: i < j alternative I is inferior to alternative j at Kth criterion **(3.11)**

$i_k(f/1) - j_k(\bar{f}/1)$: the discomfort caused by going from level $(\bar{f}/1)$ to level $(f/1)$ of criterion K **(3.12)**

$K(1)$: total range of scale. **(3.13)**

The idea of modulating the credibility of the outranking insertion was introduced in ELECTRE II (Roy and Bertier, 1973) where two models of preferences are taken into account: the first one being relatively poor but strongly justified and the second one richer but less defensible. ELECTRE IV is a method in which no kj is introduced. This does not mean that each criterion has exactly the same 'weight'. ELECTRE IV is appropriate for cases in which we are not willing or able to introduce information on the specific role (i.e. importance) devoted to each criterion in the aggregation procedure. A sequence of nested outranking relations is introduced:

$$S_1 \subset S_2 \subset \cdots \subset S_r , \qquad \textbf{(3.14)}$$

Each S_i is defined by referring to concordance and discordance concepts (for an exhaustive definition of these five binary relations, see Roy and Bouyssou, 1989).

ELECTRE method is designed to solve problems that require selection. ELECTRE method is based on to establish outranking relations between preferred and not preferred alternatives. To establish outranking relations, concordance and discordance indexes are created.

3.2.2.5 Promethee

PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations) method is one of the multi-criteria decision making method developed by Brans et al (1986). Compared with other methods, concepts and applications more easily in terms of a ranking method. PROMETHEE includes the PROMETHEE I for partial ranking of the alternatives and the PROMETHEE II for complete ranking of the alternatives. Over the years, several versions of the PROMETHEE methods such as the PROMETHEE III for ranking based on interval, the PROMETHEE IV for complete or partial ranking of the alternatives when the set of viable solutions is continuous, the PROMETHEE V for problems with segmentation constraints were developed**.**

For each criterion, the preference function translates the difference between the evaluations obtained by two alternatives into a preference degree ranging from zero to one. In order to facilitate the selection of a specific preference function, Vincke and Brans (1985) proposed six basic types: (1) usual criterion, (2) U-shape criterion, (3) V-shape criterion, (4) level criterion, (5) V-shape with indifference criterion and (6)

Gaussian criterion. These six types are particularly easy to define. For each criterion, the value of anindifference threshold, q; the value of a strict preference threshold,
p; and the value of an intermediate value between p and q, s, has to be fixed (Brans and Mareschal, 1992). In each case, these parameters have a clear significance for the decision-maker. Stepwise procedure for PROMETHEE II as follows.

Step 1. Determination of derivations based on pair-wise comparisons

$$d_j (a,b)= g_j (a) - g_j (b) \quad \textbf{(3.15)}$$

Where $d_j (a,b)$ denotes the difference between the evaluations of *a* and *b* on each criterion.

Step 2. Application of the preference function

$$P_j (a,b) = F_j[d_j (a,b)] \quad j=1,...,k \quad \textbf{(3.16)}$$

Where $P_j (a,b)$denotes the preference of alternative a with regard to alternative b on each criterion, as a function of $d_j (a,b)$.

Step 3. Calculation of an overall or global preference index

$$\forall a,b \in A, \quad \pi(a,b) = \sum_{j=1}^{k} P_j(a,b)w_j \quad \textbf{(3.17)}$$

Where $\pi (a,b)$ of *a* over *b (from 0 to 1)* is defined as the weighted sum *p(a,b)* of for each criterion, and w_j is the weight associated with *j*th criterion.

Step 4. Calculation the outranking flows / The PROMETHEE I partial ranking

$$\Phi^+ = \frac{1}{n-1}\sum_{x \in A} \pi(a,x) \quad \textit{and} \quad \Phi^- = \frac{1}{n-1}\sum_{x \in A} \pi(a,x) \quad \textbf{(3.18)}$$

Where $\Phi^+(a)$ and $\Phi^-(a)$ denote the positive outranking flow and negative outranking flow for each alternative, respectively.

Step 5. Calculation of net outranking flow / The PROMETHEE II complete ranking

$$\Phi(a) = \Phi^+(a) - \Phi^-(a) \quad \textbf{(3.19)}$$

Where $\Phi(a)$ denotes the net outranking flow for each alternative.

These steps presents stepwise procedure for implementing PROMETHEE II. The procedure is started to determine deviations based on pair-wise comparisons. It is followed by using a relevant preference function for each criterion in Step 2, calculating global preference index in Step 3, and calculating positive and negative outranking flows for each alternative and partial ranking in Step 4. The procedure is come to an end with the calculation of net outranking flow for each alternative and complete ranking.

PROMETHEE method, the steps can be summarized as follows;

i. For each criterion, the alternatives are compared in pairs. Preferred level is expressed by a number in the range of [0.1].

ii. By taking the weighted average of the preferences which is calculated at first step for each criterion, multi-criteria preference index is created for each alternative.

The preferred index $\prod(\alpha, \beta)$ in the range of [0.1], taking into consideration of all criteria, refers to the status of preferred α alternative to the β alternative. Weight factors are determined by the decision maker.

Ranking between alternatives is done by considering the following values:

$\prod(\alpha, \beta)$ is the sum of indices represents the preffered status of an α alternative over all alternatives. φ^+ is called outflow and α indicates how superior alternative than other alternatives.

$\prod(\alpha, i)$ is the sum of indices indicates that the levels of all the alternatives to be preferred as compared to α. φ^- is called inflow and α indicates how superior alternative than other alternatives.

PROMETHEE method comprises the steps of**:**

i. General criteria selection

ii. Determine the relevance of superiority

iii. Evaluated choices and determine the rankings between alternatives

In PROMETHEE method multi-criteria decision problem is defined as follows:

$$Max\{f1(a),...,fk(a)I \quad a \in K\} \qquad \textbf{(3.20)}$$

Where K is the finite set of alternatives and f_i, $i= 1,..., k$ shows the criteria of k will be maximized.

criterion for f to be of real value; Assuming that should be maximized of $f: K\rightarrow R;$ for each alternative to a □ K, f (a) shows the result of evaluation of this alternative. The results obtained by comparing two alternatives a,b□ K should be the expressed comparing in terms of preferring.

Preferred Function P as follows:

$$P = K \times K \rightarrow \boldsymbol{(0,1)} \qquad \textbf{(3.21)}$$

Preference function, indicates the level of preferring alternative a to alternative b;

P (a,b) = 0 indicates that there is no difference between a and b.

P (a,b) ≈ 0 indicates that a is weakly preferred according to b.

P (a,b) ≈ 1 indicates that a is strongly preferred according to b.

P (a,b) = 1 indicates that a is absolute preferable according to b.

Preferred Function is a function of the difference between these two evaluation functions;

P (a, b) = P (f (a) – f (b))

For each node in a sequence for superiority the outflow as follows:

$$\varphi^{+}(a) = \sum_{b \epsilon k} \Pi(a, b) \quad (3.22)$$

Outflow equals to sum of the values of the arrows that the arrows from the node *a*.

The symmetrical inflow as follows:

$$\varphi^{-}(a) = \sum_{b \epsilon k} \Pi(b, a) \quad (3.23)$$

Inflow measures the quality of superiority ranking for node a.

The net flow is calculated as follows;

$$\varphi(a) = \varphi^{+}(a) - \varphi^{-}(a) \quad \textbf{(3.24)}$$

3.2.2.6 Topsis

TOPSIS (technique for order performance by similarity to ideal solution) developed by Hwang and Yoon in 1981.

TOPSIS (technique for order performance by similarity to ideal solution) is a useful technique in dealing with multi attribute or multi-criteria decision making (MADM/MCDM) problems in the real world. The main advantage of this method is its simplicity and ability to yield an indisputable preference order.

The main concept of this method is that the most preferred alternative should have the shortest distance from the positive ideal solution (PIS) and the longest distance from the negative ideal solution (NIS). PIS is the one that maximizes the benefit criteria and minimizes the cost criteria, while the NIS maximizes the cost criteria and minimizes the benefit criteria. In traditional TOPSIS, the weights of the criteria and the ratings of alternatives are known precisely and are treated as crisp numerical data. However, under many conditions crisp data are inadequate to model real-life decision problems; in addition, perfect knowledge is not easily acquired. Unquantifiable, incomplete and non-obtainable information make precise judgment impossible. Therefore, fuzzy TOPSIS has been proposed where criteria weights and alternative ratings are given by linguistic variables that are expressed by fuzzy numbers.

According to Chakraborty Table 3.3 illustrates the comparative performance of widely used MADM methods with respect to their stability, mathematical calculations involved, computational time and simplicity.

Table 3.3: Comparative Performance of widely used MADM methods

MADM Method	Stability	Mathematical Calculations Involved	Required computational time	Simplicity
TOPSIS	Medium	Moderate	Moderate	Moderately critical
AHP	Poor	Maximum	Very High	Very critical
ELECTRE	Medium	Moderate	High	Moderately critical
PROMETHEE	Medium	Moderate	High	Moderately

critical

In addition to making group environments more manageable, many operations in each step of TOPSIS are scrutinized so that a broad view of TOPSIS can be established. The operations within the TOPSIS process include: decision matrix normalization, distance measures, and aggregation operators.

For MADM, a decision matrix is usually required prior to the beginning of the process. The decision matrix contains competitive alternatives row-wise, with their attributes' ratings or scores column-wise. Normalization is an operation to make these scores conform to or reduced to a norm or standard. To compare the alternatives on each attribute, the normalized process is usually made column-wise, and the normalized value will be a positive value between 0 and 1.

Balli and Korukoglu performed a study about TOPSIS method that TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is one of the useful Multi Attribute Decision Making techniques that is very simple and easy to implement, so that it is used when the user prefers a simpler weighting approach. On the other hand, the AHP approach provides a decision hierarchy and requires pairwise comparison among criteria. Based on Lee et al.(2001) the user needs a more detailed knowledge about the criteria in the decision hierarchy to make informed decisions in using the AHP. TOPSIS method was firstly proposed by Hwang and Yoon (1981). Based on Beniztez et al. (2007) in this technique, the best alternative would be the one that is nearest to the positive ideal solution and farthest from the negative ideal solution. The positive ideal solution is a solution that maximizes the benefit criteria and minimizes the cost criteria, whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria according to Wang and Elhag (2006) and Wang and Lee (2007). Based on Ertugrul and Karakasoglu (2007) in other words, the positive ideal solution is composed of all best values attainable of criteria, whereas the negative ideal solution consists of all worst values attainable of criteria. In that study, TOPSIS method is used for determining the final ranking of the operating systems.

The method is calculated as follows;

Step 1. Decision matrix is normalized via Eq.

$$r_{ij} = \frac{w_{ij}}{\sqrt{\sum_{j=1}^{J} w_{ij}^2}} \qquad j = 1,2,3,...,J \qquad i = 1,2,3,...,n \tag{3.25}$$

Step 2. Weighted normalized decision matrix is formed:

$$w_{ij} = w_{ij} * r_{ij}, \qquad j = 1,2,3,...,J \qquad i = 1,2,3,...,n \tag{3.26}$$

Step 3. Positive ideal solution (PIS) and negative ideal solution (NIS) are determined:

$$\begin{aligned} A^* &= \{v_1^*, v_2^*, ..., v_n^*,\} \quad \text{Maximum values} \\ A^- &= \{v_1^-, v_2^-, ..., v_n^-,\} \quad \text{Minimum values} \end{aligned} \tag{3.27}$$

Step 4. The distance of each alternative from PIS and NIS are calculated:

$$\begin{aligned} d_i^* &= \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^*\right)^2}, j = 1,2,...,J \\ d_i^- &= \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2}, i = 1,2,...,J \end{aligned} \tag{3.28}$$

Step 5. The closeness coefficient of each alternative is calculated:

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, \mathrm{i} = 1,2,..., \mathrm{J} \tag{3.29}$$

Step 6. By comparing $\mathrm{CC_i}$ values,the ranking of alternatives are determined**.**

3.2.3 Decision Making Under Certainty

In decision making under certainty, the conditions under which the options known to be realized. There is complete information to a selection of problems in this condition. Decision makers choose the best alternative that provides the highest benefit while knowing the possible consequences in decision making under certainty. (Zimmermann, 1991: 241 ; Ecer).

3.2.4 Decision Making Under Uncertainty

Decision making under uncertainty, the most difficult and the most common decision-making situation. In decision making under uncertainty.There are less or incomplete information related to the problem.

3.2.5 Individual Decision Making

Decision-making can be divided into two group as individual and group decision-making in terms of decision maker. In individual group decision making, decision is taken by one person by selecting one alternative of all decision alternatives.

3.2.6 Group Decision Making

Many people participate in decision-making process, and different personal preferences take the form of a single preferred. (Harrison, 1999: 14; imrek, 2003: 132-133; Daft, 1991)

There are a number of advantages of group decision making;

i. Produced a large number of alternative decision

ii. Decision makers' multilateral trend can be reduced concerning some decision alternatives.

iii. Facilitates the adoption of decisions.

iv. Decision alternatives can be evaluated in more detail.

v. Decision alternatives may be limited within the framework of shown responses.

vi. Participation environment is formed. Interested persons are invited to participate in decisions.

vii. Conclusions can be reached that organizational benefit not individual.

viii. Offers a broad perspective of the problem identification and analysis.

ix. Uncertainty can be reduced about the results of the alternatives.

x. Participation allows satisfaction to the group members.

xi. There are a number of disadvantages of group decision making;

xii. The group may react to the decision.

xiii. To decide may take a long time.

xiv. To achieve consensus may be difficult**.**

xv. The grouping may be when deciding on the group members.

4. FUZZY LOGIC

4,1 FUZZY SET THEORY

Exact description of many real-life situations is very difficult to do because of the high degree of uncertainty. The concept of fuzzy logic was first given by Lotfi A. Zadeh to literature in 1965. Fuzzy logic has become more important in Japan, after 1970 in the eastern world. The Japanese used this information structure and operation of the technological devices. In the Western world in those days still making use of binary logic called the logic of Aristotle. Aristotelian logic, approaches the events as yes-no, black white, 0-1 and so on such as bilateral basis. This is not the idea of the exact location of the two values are not (Sen, 2001: 10).

According to study of Application of fuzzy sets in soil science by McBratney et al.(1997) in a formal definition of a fuzzy set, we presuppose that X = {x} is a finite set (or space) of points, which could be elements, objects or properties; a fuzzy subset, A of X, is defined by a function, μ_A, in the ordered pairs:

$A = \{X, \mu_A (x)\}$ for each $x \in X$

In plain language, a fuzzy subset is defined by the membership function defining the membership grades of fuzzy objects in the ordered pairs consisting of the objects and their membership grades. The relation $\mu_A (x)$ is therefore termed as a membership

function (MF) defining the grade of membership x (the object) in A and $x \in X$

indicates that x is an object of, or is contained in X. For all A, $\mu_A (x)$ takes on the values between and including 0 and 1. In practice, $X = \{x_1, x_2, \dots, x_n\}$ and Equation is written as:

$A = x_1, \mu_A (x_1) + x_2, \mu_A (x_2) + \dots + x_n, \mu_A (x_n),$ **(4.1)**

the + is used as defined in the set theoretic sense. If $\mu_A (x) = 0$, then $x, \mu_A (x)$ is omitted.

The membership degree of the fuzzy set can be described with triangular, trapezoidal, Gaussian, sigmodial functions or different functions can be formed with (Baslıgil, H. 2005).

Figure 4.1: Examples of triangular fuzzy numbers

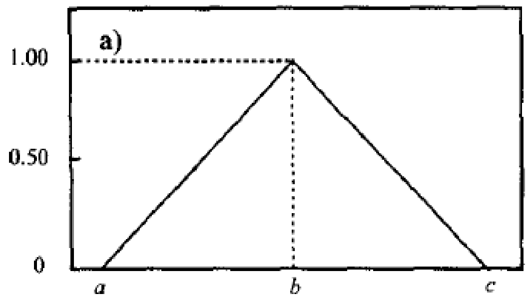


Figure 4.2: Examples of trapezoidal fuzzy numbers

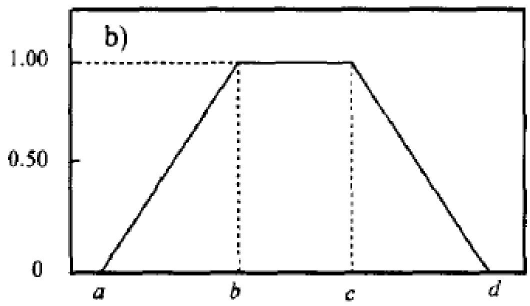
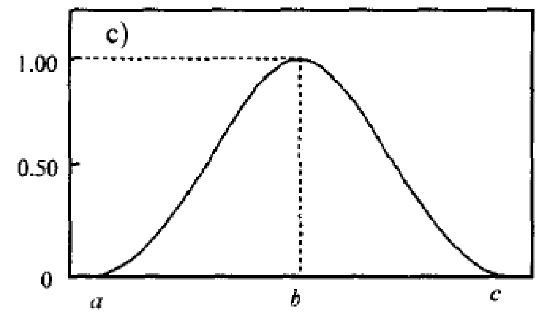


Figure 4.3: Examples of Gaussian fuzzy numbers



4.2 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 (Deng, H., 1999) It is possible to use different fuzzy numbers according to the situation. Generally in practice triangular and trapezoidal fuzzy numbers are used (Baykal, N., & Beyan, T., 2004).

4.2.1 Triangular Fuzzy Numbers

The simplest fuzzy number is the so-called triangular fuzzy number (Bardossy and Duckstein, 1995) with its characteristic Membership Fuction written as;

$$\mu_A(x) = \begin{cases} 0 & x \leq a \\ \dfrac{x-a}{b-a} & a < x \leq b \\ \dfrac{c-x}{c-b} & b < x \leq c \\ 0 & c < x \end{cases}$$

Fig. 4.l. illustrates the MF of triangular fuzzy number.

4.2.2 Trapezoidal Fuzzy Numbers

On this issue according to study of Ertugrul, I.& Gunes, M. (2007) ,in applications it is often convenient to work with trapezoidal fuzzy numbers because of their computational simplicity, and they are useful in promoting representation and information processing in a fuzzy environment.

Trapezoidal fuzzy numbers can be expressed as (n_1, n_2, n_3, n_4). A trapezoidal fuzzy number ñ is shown in Fig. 4.4.

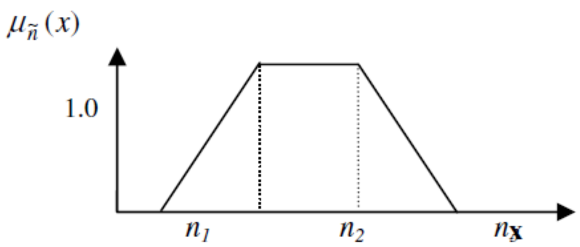


Figure 4.4: A Trapezoidal fuzzy number, ñ

Trapezoidal fuzzy numbers are a special class of fuzzy numbers, defined by four real numbers, expressed as (n_1, n_2, n_3, n_4). Their membership functions are described as

$$\mu_{\tilde{n}}(x) = \begin{cases} 0, & x < n_1 \\ \dfrac{x - n_1}{n_2 - n_1}, & n_1 \le x \le n_2 \\ 1, & n_2 \le x \le n_3 \\ \dfrac{x - n_4}{n_3 - n_4}, & n_3 \le x \le n_4 \\ 0, & x > n_4 \end{cases} \quad \textbf{(4.2)}$$

There are various operations on trapezoidal fuzzy numbers. But here, three important operations used in this study are illustrated. If we define, two positive trapezoidal fuzzy numbers A = (m_1, m_2, m_3, m_4) and B = (n_1, n_2, n_3, n_4) then

$$\begin{aligned} A \oplus B &= (m_1 + n_1, m_2 + n_2, m_3 + n_3, m_4 + n_4 \\ A \otimes B &= (m_1 \cdot n_1, m_2 n_2, m_3 n_3, m_4 \cdot n_4) \\ A \otimes k &= (m_1 k, m_2 k, m_3 k, m_4 k) \\ A \varphi B &= (m_1 / n_4, m_2 / n_3, m_3 / n_2, m_4 / n_1) \end{aligned} \quad \textbf{(4.3)}$$

(k is a positive real number)

According to (Li, D.F. 2006) The distance between two trapezoidal fuzzy numbers can be calculated by using Euclidean distance as:

$$d_v(\tilde{m}, \tilde{n}) = \sqrt{\frac{(m_1 - n_1)^2 + 2(m_2 - n_2)^2 + 2(m_3 - n_3)^2 + (m_4 - n_4)}{6}} \quad \textbf{(4.4)}$$

5. METHODOLOGY

5.1 APPLICATION OF FAHP AND FUZZY TOPSIS METHODS TO SELECT OF CLINICAL CHIEF OF SURGERY

Kelemenis et al (2011) mentioned about Fuzzy TOPSIS as many scholars have deal with the human resource selection problem from the decision science point of view. Tools and techniques from operational research and artificial intelligence fields have been used to cope with this specific decision problem. Fuzzy sets and numbers, expert systems, artificial neural networks and multicriteria decision analysis techniques lie among them. Based on a critical perspective of the some academic studies as shown in Table 5.1, are the main comments that constitute the cornerstone on which the proposed approach is based.

Table 5.1: Some academic studies about personnel selection problem

Proposed by	Fuzziness	Techniques	Empirical application	Illustrative example	Group decision making	Main criteria
Liang and Wang (1992)	Yes	Fuzzy numbers	No	Personnel placement	Yes	General aptitude, leadership, self-confidence, professional knowledge
Carlsson et al. (1997)	No	OWA Operators	Doctoral student selection	No	Yes	Research interests (fit in research groups, on the frontier of research, contributions), academic background (university, grade average, time for acquiring degree)
Storey Hooper et al. (1998)	No	Expert Systems	Field grade officer selection for advanced training	No	No	Hierarchical grade, military education level, civilian education level, official photograph, height and weight, assignment history, officer efficiency report evaluations
McIntyre et al. (1999)	No	Analytic Hierarchy Process	Selection of division director in a University department	No	No	Administration, Teaching, Research, Service, Industry
Chen (2000)	Yes	Fuzzy TOPSIS	No	System analysis engineer selection in a software company	Yes	Emotional steadiness, oral communication skill, personality, past experience, self-confidence
Karsak (2000)	Yes	Fuzzy Multiple Objective Programming	No	Personnel Selection for an expatriate position	No	Personality assessment, leadership excellence, excellence in oral communication skills, past experience, computer skills, fluency in foreign language, aptitude test score, annual salary request
Butkiewicz (2002)	Yes	Fuzzy numbers	No	Staff selection in a tourism agency	No	Education, working knowledge, geographical knowledge, apparition, computer skills, know-how of office equipment, serenity, responsibility, patience, competence, ability of good discussion
Cho and Ngai (2003)	No	Discriminant analysis, decision trees, artificial neural networks	Insurance sales agents selection	No	No	Sex, date of birth, nationality, academic level, number of dependants, job position, work experience, management experience, total amount of insurance sold, eligibility to sell particular products, commencement date, termination date, previous job nature, previous annual income
Yeh (2003)	No	Total sum (TS) method, simple additive weighting (SAW) method, weighted product (WP) method, TOPSIS	Scholarship student selection	No	No	Community services, sports/hobbies, work experience, energy, communication skills, attitude to business, maturity, leadership
Drigas et al. (2004)	Yes	Expert systems, Neuro-Fuzzy techniques	Unemployed matching	No	No	Age, education, additional education (training), previous employment (experience), foreign language (English), computer knowledge
Huang et al. (2004)	Yes	Fuzzy Neural Networks, Fuzzy Analytic Hierarchy Process, simple additive weighting (SAW) method	Middle manager selection	No	Yes	Capability trait, motivational trait, personality trait, conceptual skill, interpersonal skill, technical skill
Chen and Cheng (2005)	Yes	Fuzzy numbers	No	IS project manager recruitment	Yes	Analysis and design, Programming, Interpersonal skills, business knowledge, IS environment knowledge, IS applications knowledge
Jereb et al. (2005)	No	Expert Systems, decision rules	No	Personnel selection	No	Education, relational skills, working skills, performance, leadership, working approach, other (self-confidence, emotional stability, self control)
Saghafian and Hejazi (2005)	Yes	Fuzzy TOPSIS	No	University professor hiring	Yes	Publications and researches, teaching skills, practical experiences in industries and corporations, past experiences in teaching, teaching discipline
Seol and Sarkis (2005)	No	Analytic Hierarchy Process	No	Internal auditor selection	No	Technical skills, analytic/design skills, appreciative skills, personal skills, interpersonal skills, organizational skills
Shih et al. (2005)	No	Nominal group technique, Analytic Hierarchy Process, TOPSIS, Borda's function	On-line manager recruitment	No	Yes	knowledge tests (including language test, professional test, and safety rule test), skill tests (including professional skills and computer skills), and interviews (including panel interview and one-to-one interviews)
Baykasoglu et al. (2007)	Yes	Fuzzy multiple objective mathematical programming, simulated annealing	No	Project team members selection	No	Communication skills, technical expertise, problem solving ability, decision making skills, available time period, salary request

Proposed by	Fuzziness	Techniques	Empirical application	Illustrative example	Group decision making	Main criteria
Golec and Kahya (2007)	Yes	Fuzzy numbers, fuzzy rules	No	Employee evaluation and selection	No	Communication skills, personal traits and self-motivation, interpersonal skills and ability to sell self and ideas, decision making ability, technical knowledge base skills, career development aspiration, management skills
Mehrabad and Brojeny (2007)	No	Expert Systems	intelligent selection in an R&D organization	No	No	Educational level, work experience management experience
Shih et al. (2007)	No	Group TOPSIS	No	On-line manager recruitment in a local chemical company	Yes	Knowledge tests (language test, professional test, safety rule test), skill tests (professional skills, computer skills), interviews
Chien and Chen (2008)	No	Decision trees, decision rules	Engineers and managers selection in a semiconductor company	No	No	Age, gender, marital status, educational background, work experience, school tiers, recruitment channel
Dağdeviren (2008)	Yes	Analytic Network Process (ANP), TOPSIS	Electronics engineer selection in a manufacturing company	No	No	Ability to work in different business units, past experience, team player, fluency in a foreign language, strategic thinking, oral communication skills, computer skills
Mahdavi et al. (2008)	Yes	Fuzzy TOPSIS	No	System analyst selection in a software company	Yes	Emotional steadiness, oral communication skill, personality, past experience, self-confidence
Güngör et al. (2009)	Yes	Fuzzy Analytic Hierarchy Process	No	Personnel selection	No	General work factors (work experience, foreign language, bachelor degree, master degree, analytical thinking, basic comp. skill), complimentary work factors (decision making, working in teams, effective time using, determination of goal, long life learning, willingness), individual factors (core ability, culture, age, appearance, oral, written comm.)
Saremi et al. (2009)	Yes	Fuzzy TOPSIS	TQM consultant selection	No	Yes	Knowledge of business (strategies, process, markets), relevant experience (TQM project, similar firms), technical skills (people, system, specific abilities), management skills (organization, economic stability, acceptable insurance, certificates), implementation cost

Kelemenis et all (2011)

5.1.1 Selection Problem of Clinical Chief of Surgery

A hospital uses recruitment criteria to evaluate surgeon's convenience to the hospital structure. Selection criteria are developed to measure important aspects of the surgeons in hospitals: Knowledge, Skills and Abilities are the main criteria, Occupational Knowledge, Foreign Language Knowledge, Graduated School and Academic Publishing are the sub-criteria of Knowledge, Basic Skills, Complex Problem Solving Skills, System Skills, Experience, Number of Case, Success rate of Cases, Stabilisation and Reference are the sub-criteria of the Skills, Psychomotor Abilities, Cognitive Abilities and Managerial Competence are the sub-criteria of the Abilities.

5.1.2 Selection Criteria of Clinical Chief of Surgery

Main Criteria are determined as Knowledge, Skills and Abilities. Each criteria includes sub-criteria.

Knowledge:

i. Occupational Knowledge: Knowledge of the information and techniques needed to diagnose and treat human injuries, diseases, and deformities and includes symptoms, treatment alternatives, drug properties and interactions, preventive health-care measures.
ii. Foreign Language Knowledge: Knowledge of the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar.
iii. Graduated School: Most of these occupations require graduate school. For example, they may require a master's degree, and some require a Ph.D., M.D.
iv. Academic Publishing: Academical papers and studies about the occupation.

Skills:

i. Basic Skills: Developed capacities that facilitate learning or the more rapid acquisition of knowledge. To have basis required by surgery.
ii. Complex Problem Solving Skills: Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.
iii. System Skills: Developed capacities used to understand, monitor, and improve socio-technical systems.
iv. Experience: Extensive skill, knowledge, and experience are needed for these occupations. Many require more than five years of experience. For example, surgeons must complete four years of college and an additional five to seven years of specialized medical training to be able to do their job.
v. Number of Case: To have many cases during his professional life.
vi. Success rate of Cases: The presence or absence of successful cases.
vii. Stabilisation: Long-term work in a hospital.
viii. Reference: Views of supervisors.

Abilities:

Psychomotor Abilities: Abilities that influence the capacity to manipulate and control objects.

i. Manual Dexterity: The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects.
ii. Finger Dexterity: The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects.

Cognitive Abilities: Abilities that influence the acquisition and application of knowledge in problem solving

i. Problem Sensitivity: The ability to tell when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing there is a problem.
ii. Deductive Reasoning: The ability to apply general rules to specific problems to produce answers that make sense.
iii. Inductive Reasoning: The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).
iv. Oral Comprehension: The ability to listen to and understand information and ideas presented through spoken words and sentences.
v. Oral Expression: The ability to communicate information and ideas in speaking so others will understand.
vi. Written Comprehension: The ability to read and understand information and ideas presented in writing.
vii. Selective Attention: The ability to concentrate on a task over a period of time without being distracted.

Managerial Competence: Management principles involved in strategic planning, resource allocation, human resources modeling, leadership technique, production methods, and coordination of people and resources.

5.1.3 Solution of Clinical Chief of Surgery Selection Problem by Using Fuzzy AHP

Kahraman and Cebi was studied about selection by using Fuzzy AHP according to this study; the importance of the weights are defined by decision makers directly, they obtained by pair-wise comparisons. If the assessments of the weights are in pairwise comparisons, the importance of the weights determined by AHP.

The aggregated decision matrix is constructed to satisfy each decision maker in the group if there is a group decision. Therefore, to obtain the aggregation of the importance weight of each criterion and the rating of each alternative (Chen,2000) as follows;

$$\widetilde{S}_{ij} = \frac{1}{K}\widetilde{S}_{ij}^{1} + \widetilde{S}_{ij}^{2} + \ldots + \widetilde{S}_{ij}^{t} + \ldots + \widetilde{S}_{ij}^{K}, \qquad \widetilde{S}_{ij}^{t} = (a_{ij}, b_{ij}, c_{ij}),$$

$$\widetilde{w}_{j} = \frac{1}{K}\widetilde{w}_{j}^{1} + \widetilde{w}_{j}^{2} + \ldots + \widetilde{w}_{j}^{t} + \ldots \widetilde{w}_{j}^{K}, \qquad \widetilde{w}_{j}^{t} = (w_{jt}, w_{jm}, w_{ju}), \tag{5.1}$$

where K is the number of decision makers; $\widetilde{S}_{ij}$ is the ratings of alternatives; $\widetilde{w}_j$ is the importance of the criterion, and I and j represent alternative *i* and criterion *j*, respectively. Then, a fuzzy decision matrix is constructed.

In this study, Buckley's FAHP is used to find the fuzzy weights since it is easy to implement. The procedure can be summarized as follows (Chen & Hwang, 1992):

$$\tilde{C} = \begin{vmatrix} 1 & \tilde{c}_{12} & \ldots & \tilde{c}_{1n} \\ \tilde{c}_{21} & 1 & \ldots & \tilde{c}_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{c}_{m1} & \tilde{c}_{m2} & \cdots & 1 \end{vmatrix} \tag{5.2}$$

Where $\tilde{C}$ pair-wise comparison matrix and

$$\tilde{c}_{ij} = \begin{cases} i > j, (1,1,3), (1,3,5), (3,5,7), (5,7,9,), (7,9,9), \\ i = j, 1, \\ i < j, (1,1,3)^{-1}, (1,3,5)^{-1}, (3,5,7)^{-1}, (5,7,9)^{-1}, (7,9,9)^{-1} \end{cases} \tag{5.3}$$

The linguistic scale is given in Table 5, for triangular fuzzy numbers.

Then, the fuzzy weight matrix is calculated by Buckley's Method as follows:

$$\tilde{r}_i = (\tilde{c}_{i1} \otimes \tilde{c}_{i2} \otimes \cdots \otimes \tilde{c}_{in})^{1/n},$$

$$\tilde{w}_i = (\tilde{r}_i \otimes (\tilde{r}_1 + \tilde{r}_2 + \cdots \tilde{r}_n)^{-1}, \quad \textbf{(5.4)}$$

where $\tilde{c}_{in}$ is the fuzzy comparison value of criterion i to criterion n, $\tilde{r}_i$ is the geometric mean of fuzzy comparison value of criterion i to each criterion. After the importance of weight matrix is obtained, defuzzification process which converts a fuzzy number into a crisp value is utilized. At first, fuzzy numbers will be defuzzified into crisp values and then normalization procedure will be applied. For the defuzzification process, centroid method, which provides a crisp value based on the center of the gravity, is selected since it is the most commonly used method (Opricovic & Tzeng, 2004). Following equation presents both defuzzification and normalization procedure in one formula.

$$w_r = \frac{\tilde{w}_r}{\sum_{j=1}^{n} \tilde{w}_j} = \frac{w_{rl} + w_{rm} + w_{ru}}{\sum_{j=1}^{n} \tilde{w}_j}, \quad \textbf{(5.5)}$$

where the importance of r^{th} criterion, w_r, is a non-fuzzy number and n is the number of the criteria.

Acccording to the method, application of the problem can be summarized as follows;

Step 1: Decision makers decide the importance level of criteria by using pair-wise comparison matrix with linguistic scale as shown in Table 5.2. Kahraman, C. , Cebi ,S.,2009 use this scale from Hsieh et al. ,2004, modified form as follows;

Table 5.2: Linguistic Scale for Weight Matrix

Linguistic scales	Scale of fuzzy number	
(1,1,1)	Just equal	(Je)
(1,1,3)	Equally important	(Eq)
(1,3,5)	Weakly important	(Wk)
(3,5,7)	Essentially important	(Es)
(5,7,9)	Very strong important	(Vs)
(7,9,9)	Absolutely important	(Ab)

The hierarchy of the problem is shown below.

i. As it seen in Figure 5.1, The hierarchical structure of this decision problem's criteria and candidates are shown. Triangular fuzzy numbers which are given in Figure 5.2 is used to transform linguistic terms in to fuzzy set as seen in Figure 5.4.

Figure 5.1: The Hierarchical Structure of Candidate Selection

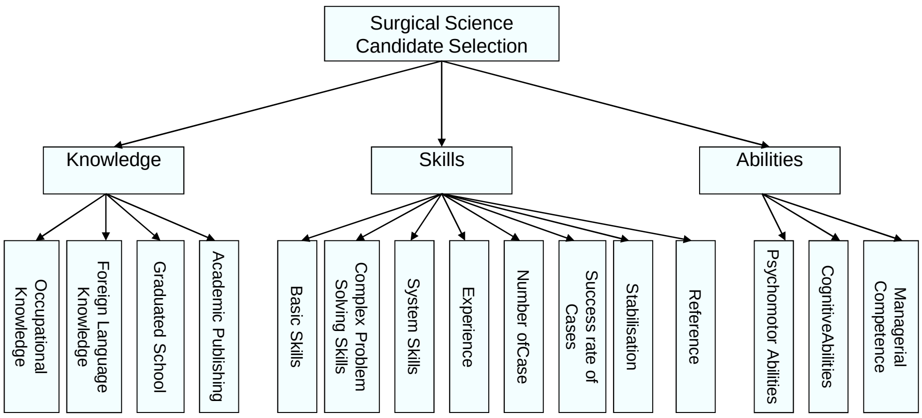
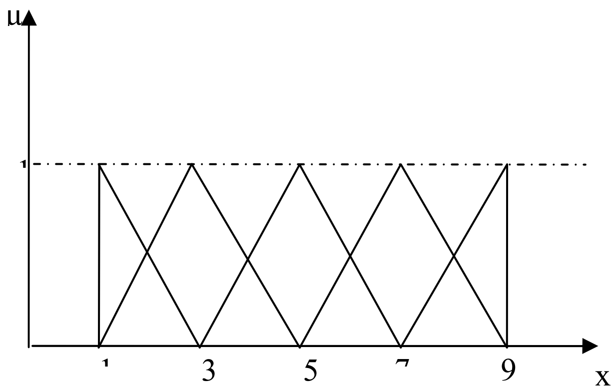


Figure 5.2: Membership function for importance weight of criteria



ii. Aggregated fuzzy matrix for mail goal can be obtained as follows:

Table 5.3: Fuzzy Aggregated Decision Matrix

	Knowledge			Skills			Abilities		
Knowledge	1.00	1.00	1.00	0.12	0.17	0.26	0.17	0.26	0.57
Skills	3.87	5.92	7.94	1.00	1.00	1.00	1.00	1.00	3.00
Abilities	1.73	3.87	5.92	0.33	1.00	1.00	1.00	1.00	1.00

Step 2: Then, the fuzzy weight matrix is calculated by Buckley's Method as follows and stated in Table 5.5.

Table 5.4: The geometric mean of fuzzy comparison values

$\tilde{r}_i$			
0.27	0.35	0.53	$\tilde{r}_1$
1.57	1.81	2.88	$\tilde{r}_2$
0.83	1.57	1.81	$\tilde{r}_3$

Step 3: After the importance of weight matrix is obtained, defuzzification process which converts a fuzzy number into a crisp value is utilized. At first, fuzzy numbers will be defuzzified into crisp values and then normalization procedure will be applied. For the defuzzification process, centroid method, which provides a crisp value based on the center of the gravity, is selected since it is the most commonly used method (Opricovic & Tzeng, 2004). Following equation presents both defuzzification and normalization procedure in one formula as stated in Table 5.6.

Table 5.5: Fuzzy weight matrix

$\tilde{w}_i$			
0.05	0.09	0.20	$\tilde{w}_1$
0.30	0.54	1.08	$\tilde{w}_2$
0.16	0.42	0.68	$\tilde{w}_3$

Table 5.6: Fuzzy weights after defuzzification and normalization

$\tilde{w}_r$	
0.10	**Knowledge**
0.54	**Skills**
0.36	**Abilities**

The fuzzy weight vector of the criteria obtained by Buckley formulations is presented in Table 5.5. After that defuzzification procedure is done and Table 5.6 is obtained. In Figure 5.3.,the hierarchical structure of importance of the criteria is given after the application of procedure for all criteria.

Figure 5.3: The Hierarchical Structure of importance criteria

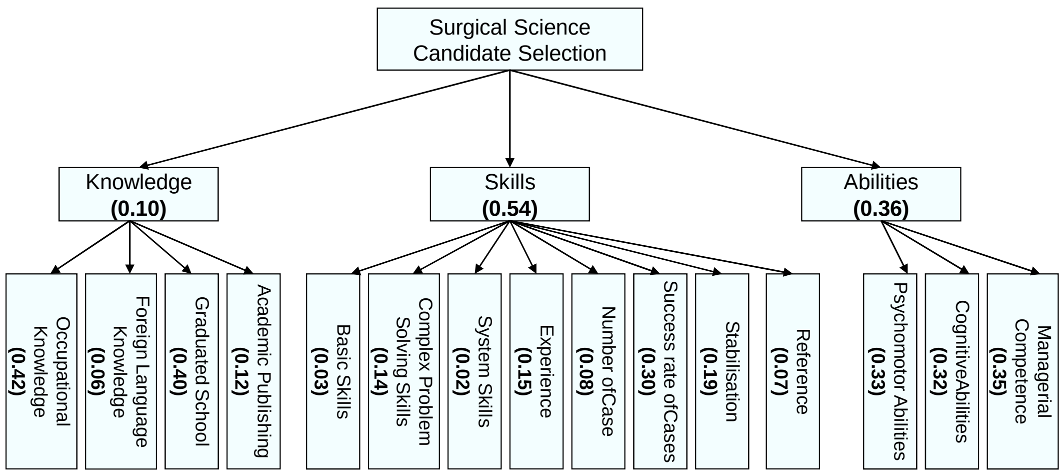
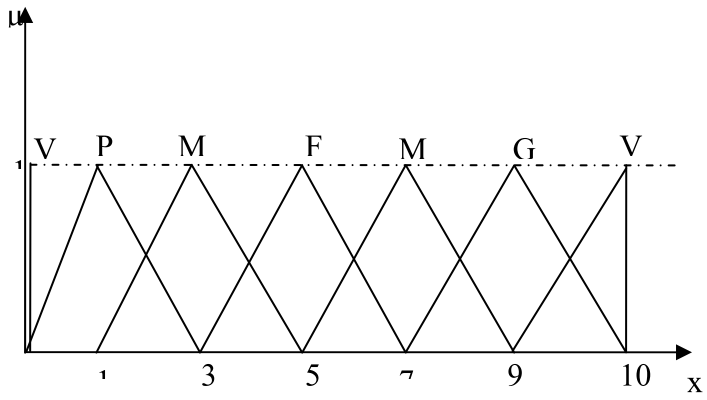


Figure 5.4: **Membership functions of linguistic terms.**



5.1.4 Application with a FUZZY TOPSIS Method to the Problem

Human judgments, often vague and may not be possible to express the numerical values.More realistic approach, linguistic values instead of numeric values may be used.In other words, the decision criteria for current problem severity levels linguistic variables can be expressed (Chen, 2000).

Which is one of FMCDM Fuzzy TOPSIS, the values of both qualitative and quantitative criteria deals with the decision criteria Fuzzy TOPSIS, has a flexible structure (Chen Et al., 2005).

Fuzzy TOPSIS method and the method by which to help group decision in fuzzy environments. For the solution; the decision-makers, decision criteria, and alternatives are needed Decision-makers express their thoughts related with decision criteria and alternatives verbally. Fuzzy TOPSIS method based on the decision criteria used in evaluating alternatives for decision-makers could have a different weight lies. Fuzzy TOPSIS method with the help decision-makers about the reviews of decision criteria and alternatives, changing into a triangular or trapezoidal fuzzy numbers closeness coefficient is calculated for each alternative. Alternatives are ranked using the calculated closeness coefficients. The method of valuation of alternatives to eliminate the problems posed by the subjectivity of the group decision-making and allows for more accurate decision-making.

Assume that a decision group has K persons, then the importance of the criteria and the rating of alterna- tives with respect to each criterion can be calculated as

$$\tilde{x}_{ij} = \frac{1}{K}\left[\tilde{x}_{ij}^{1}(+)\tilde{x}_{ij}^{2}(+)...(+)\tilde{x}_{ij}^{K}\right]$$

$$\tilde{w}_{j} = \frac{1}{K}\left[\tilde{w}_{j}^{1}(+)\tilde{w}_{j}^{2}(+)...(+)\tilde{w}_{j}^{K}\right] \quad \textbf{(5.6)}$$

Where $\tilde{x}_{ij}^{K}$ and $\tilde{w}_{j}^{K}$ are the rating and the importance weight of the Kth decision maker. As stated above, a fuzzy multicriteria groupdecision-making problem which can be concisely expressed in matrix format as

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & ... & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & ... & \tilde{x}_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix} \quad \textbf{(5.7)}$$

where $\tilde{x}_{ij}, \forall_{i,j}$ and $\tilde{w}_{j}$, $j = 1,2,...,n$ are linguistic variables. These linguistic variables can be described by triangular fuzzy numbers $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and $\tilde{w}_{j} = (w_{j1}, w_{j2}, w_{j3})$.

To avoid the complicated normalization formula used in classical TOPSIS, the linear scale transformation is used here to transform the various criteria scales into a comparable scale. Therefore, we can obtain the normalized fuzzy decision matrix denoted by $\tilde{R}$ **.**

$$\tilde{R} = \left[\tilde{r}_{ij}\right]_{m \times n}, \quad \textbf{(5.8)}$$

where B and C are the set of benefit criteria and cost criteria, respectively, and

$$\mathbf{\tilde{r}_{ij}} = \left(\frac{a_{ij}}{c_{j}^{*}}, \frac{b_{ij}}{c_{j}^{*}}, \frac{c_{ij}}{c_{j}^{*}}\right), j \in B; \quad \textbf{(5.9)}$$

$$\mathbf{\tilde{r}_{ij}} = \left(\frac{a_{j}^{-}}{c_{ij}}, \frac{a_{j}^{-}}{b_{ij}}, \frac{a_{j}^{-}}{a_{ij}}\right), j \in C; \quad \textbf{(5.10)}$$

$$c_j^* = \max_i c_{ij} \quad if \quad j \in B\ ; \quad \textbf{(5.11)}$$

$$a_j^- = \min_i a_{ij} \quad if \quad j \in C\ . \quad \textbf{(5.12)}$$

The normalization method mentioned above is to preservethe property that the ranges of normalized triangular fuzzy numbers belong to [0; 1].

Considering the different importance of each criterion, we can construct the weighted normalized fuzzy decision matrix as

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{m\times n}, \quad i = 1,2,...,n, \quad \textbf{(5.13)}$$

where $\tilde{v}_{ij} = \tilde{r}_{ij}(.)\tilde{w}_j$. **(5.14)**

According to the weighted normalized fuzzy decision matrix, we know that the elements $\tilde{v}_{ij}, \forall_{i,j}$ are normalized positive triangular fuzzy numbers and their ranges belong to the closed interval [0; 1]. Then, we can define the fuzzy positive-ideal solution (FPIS, A^*)and fuzzy negative-ideal solution (FNIS, A^-) as

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, ...\tilde{v}_n^*),$$
$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, ...\tilde{v}_n^-), \quad \textbf{(5.15)}$$

Where $\tilde{v}_j^* = (1,1,1)$ and $\tilde{v}_j^- = (0,0,0)$, j=1,2,...,n . The distance of each alternative from A^* and A^- can be currently calculated as

$$d_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^*), \quad i = 1,2,...,m,$$
$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-), \quad i = 1,2,...,m, \quad \textbf{(5.16)}$$

where $d(\cdot,\cdot)$ is the distance measurement between two fuzzy numbers. A closeness coefficient is defined to determine the ranking order of all alternatives once the d_i^* and d_i^- of each alternative $A_i (i = 1,2,...,m)$ has been calculated. The closeness coefficient of each alternative is calculated as

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, \qquad i = 1,2,...,m. \tag{5.17}$$

Obviously, an alternative A_i is closer to the FPIS (A^*)and farther from FNIS(A^-) as CC_i approaches to 1. Therefore, according to the closeness coefficient, we can determine the ranking order of all alternatives and select the best one from among a set of feasible alternatives.

In sum, an algorithm of the multi-person multicriteria decision making with fuzzy set approach is given in the following.

Step 1: Form a committee of decision-makers, then identify the evaluation criteria.

Step 2: Choose the appropriate linguistic variables for the importance weight of the criteria and the linguistic ratings for alternatives with respect to criteria.

Step 3: Aggregate the weight of criteria to get the aggregated fuzzy weight $\tilde{w}_j$ of criterion C_j, and pool the decision makers' opinions to get the aggregated fuzzy rating $\tilde{x}_{ij}$ of alternative A_i under criterion C_j.

Step 4: Construct the fuzzy decision matrix and the normalized fuzzy decision matrix.

Step 5: Construct the weighted normalized fuzzy decision matrix.

Step 6: Determine FPIS and FNIS.

Step 7: Calculate the distance of each alternative from FPIS and FNIS, respectively.

Step 8: Calculate the closeness coefficient of each alternative.

Step 9: According to the closeness coefficient, the ranking order of all alternatives can be determined.

The grades of 3 alternatives have been issued according to 15 criteria as shown in Table 5.8. By using Table 5.7. Then, the fuzzy decision matrix is formed on the basis of triangular fuzzy numbers related to criteria and alternatives. Finally, the fuzzy weights of alternatives are determined. Table 5.9 shows the result of the mentioned functions. The normalized fuzzy decision matrix is formed as shown in Table 5.10. Finally, the weighted normalized fuzzy decision matrix is formed on the basis of Table 5.10 and the related results are presented in Table 5.11.

Table 5.7: Illustrate linguistic variables to grade alternatives

Very poor	(VP)	(0,0,1)
Poor	(P)	(0,1,3)
Medium poor	(MP)	(1,3,5)
Fair	(F)	(3,5,7)
Medium good	(MG)	(5,7,9)
Good	(G)	(7,9,10)
Very good	(VG)	(9,10,10)

Table 5.8: The ratings of the three candidates by decision makers under all criteria

Criteria	Candidates	Decision Makers	
		D_1	D_2
C_{11}	A_1	(5,7,9)	(3,5,7)
	A_2	(9,10,10)	(9,10,10)
	A_3	(7,9,10)	(5,7,9)
C_{12}	A_1	(3,5,7)	(7,9,10)
	A_2	(7,9,10)	(9,10,10)
	A_3	(3,5,7)	(3,5,7)
C_{13}	A_1	(3,5,7)	(5,7,9)
	A_2	(9,10,10)	(7,9,10)
	A_3	(7,9,10)	(7,9,10)
C_{14}	A_1	(7,9,10)	(7,9,10)
	A_2	(9,10,10)	(9,10,10)
	A_3	(3,5,7)	(1,3,5)
C_{21}	A_1	(3,5,7)	(3,5,7)
	A_2	(7,9,10)	(7,9,10)
	A_3	(9,10,10)	(7,9,10)
C_{22}	A_1	(5,7,9)	(9,10,10)
	A_2	(7,9,10)	(5,7,9)
	A_3	(7,9,10)	(7,9,10)
C_{23}	A_1	(7,9,10)	(7,9,10)

	A_2	(5,7,9)	(7,9,10)
	A_3	(5,7,9)	(3,5,7)
C_{24}	A_1	(3,5,7)	(5,7,9)
	A_2	(9,10,10)	(9,10,10)
	A_3	(7,9,10)	(7,9,10)
C_{25}	A_1	(3,5,7)	(3,5,7)
	A_2	(7,9,10)	(7,9,10)
	A_3	(5,7,9)	(5,7,9)
C_{26}	A_1	(7,9,10)	(7,9,10)
	A_2	(7,9,10)	(7,9,10)
	A_3	(5,7,9)	(5,7,9)
C_{27}	A_1	(3,5,7)	(9,10,10)
	A_2	(9,10,10)	(7,9,10)
	A_3	(3,5,7)	(5,7,9)
C_{28}	A_1	(7,9,10)	(7,9,10)
	A_2	(7,9,10)	(7,9,10)
	A_3	(7,9,10)	(7,9,10)
C_{31}	A_1	(7,9,10)	(7,9,10)
	A_2	(7,9,10)	(7,9,10)
	A_3	(9,10,10)	(9,10,10)
C_{32}	A_1	(7,9,10)	(5,7,9)
	A_2	(7,9,10)	(7,9,10)
	A_3	(7,9,10)	(7,9,10)
C_{33}	A_1	(7,9,10)	(5,7,9)
	A_2	(9,10,10)	(9,10,10)
	A_3	(7,9,10)	(7,9,10)

Table 5.9: The fuzzy decision matrix and fuzzy weights of three alternatives

	C_{11}			**C_{12}**			**C_{13}**			**C_{14}**			**C_{21}**		
A_1	*(4.00*	*6.00*	*8.00)*	*(5.00*	*7.00*	*8.50)*	*(4.00*	*6.00*	*8.00)*	*(7.00*	*9.00*	*10.00)*	*(3.00*	*5.00*	*7.00)*
A_2	*(9.00*	*10.00*	*10.00)*	*(8.00*	*9.50*	*10.00)*	*(8.00*	*9.50*	*10.00)*	*(9.00*	*10.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*
A_3	*(6.00*	*8.00*	*9.50)*	*(3.00*	*5.00*	*7.00)*	*(7.00*	*9.00*	*10.00)*	*(2.00*	*4.00*	*6.00)*	*(8.00*	*9.50*	*10.00)*

	C_{22}			**C_{23}**			**C_{24}**			**C_{25}**			**C_{26}**		
A_1	*(7.00*	*8.50*	*9.50)*	*(7.00*	*9.00*	*10.00)*	*(4.00*	*6.00*	*8.00)*	*(3.00*	*5.00*	*7.00)*	*(7.00*	*9.00*	*10.00)*
A_2	*(6.00*	*8.00*	*9.50)*	*(6.00*	*8.00*	*9.50)*	*(9.00*	*10.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*
A_3	*(7.00*	*9.00*	*10.00)*	*(4.00*	*6.00*	*8.00)*	*(7.00*	*9.00*	*10.00)*	*(5.00*	*7.00*	*9.00)*	*(5.00*	*7.00*	*9.00)*

	C_{27}			C_{28}			C_{31}			C_{32}			C_{33}		
A_1	*(6.00*	*7.50*	*8.50)*	*(7.00*	*9.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(6.00*	*8.00*	*9.50)*	*(6.00*	*8.00*	*9.50)*
A_2	*(8.00*	*9.50*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(9.00*	*10.00*	*10.00)*
A_3	*(4.00*	*6.00*	*8.00)*	*(7.00*	*9.00*	*10.00)*	*(9.00*	*10.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*

Table 5.10: The Fuzzy Normalized Decision Matrix

	C_{11}			C_{12}			C_{13}			C_{14}			C_{21}		
A_1	*(0.40*	*0.60*	*0.80)*	*(0.50*	*0.70*	*0.85)*	*(0.40*	*0.60*	*0.80)*	*(0.70*	*0.90*	*1.00)*	*(0.30*	*0.50*	*0.70)*
A_2	*(0.90*	*1.00*	*1.00)*	*(0.80*	*0.95*	*1.00)*	*(0.80*	*0.95*	*1.00)*	*(0.90*	*1.00*	*1.00)*	*(0.70*	*0.90*	*1.00)*
A_3	*(0.60*	*0.80*	*0.95)*	*(0.30*	*0.50*	*0.70)*	*(0.70*	*0.90*	*1.00)*	*(0.20*	*0.40*	*0.60)*	*(0.80*	*0.95*	*1.00)*

	C_{22}			C_{23}			C_{24}			C_{25}			C_{26}		
A_1	*(0.70*	*0.85*	*0.95)*	*(0.70*	*0.90*	*1.00)*	*(0.40*	*0.60*	*0.80)*	*(0.30*	*0.50*	*0.70)*	*(0.70*	*0.90*	*1.00)*
A_2	*(0.60*	*0.80*	*0.95)*	*(0.60*	*0.80*	*0.95)*	*(0.90*	*1.00*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.70*	*0.90*	*1.00)*
A_3	*(0.70*	*0.90*	*1.00)*	*(0.40*	*0.60*	*0.80)*	*(0.70*	*0.90*	*1.00)*	*(0.50*	*0.70*	*0.90)*	*(0.50*	*0.70*	*0.90)*

	C_{27}			C_{28}			C_{31}			C_{32}			C_{33}		
A_1	*(0.60*	*0.75*	*0.85)*	*(0.70*	*0.90*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.60*	*0.80*	*0.95)*	*(0.60*	*0.80*	*0.95)*
A_2	*(0.80*	*0.95*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.90*	*1.00*	*1.00)*
A_3	*(0.40*	*0.60*	*0.80)*	*(0.70*	*0.90*	*1.00)*	*(0.90*	*1.00*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.70*	*0.90*	*1.00)*

Table 5.11: The Fuzzy Weighted Normalized Matrix

	C_{11}			C_{12}			C_{13}			C_{14}			C_{21}		
A_1	*(0,00*	*0,02*	*0,12)*	*(0,00*	*0,00*	*0,02)*	*(0,00*	*0,02*	*0,12)*	*(0,00*	*0,01*	*0,05)*	*(0,00*	*0,01*	*0,07)*
A_2	*(0,01*	*0,04*	*0,15)*	*(0,00*	*0,00*	*0,02)*	*(0,01*	*0,03*	*0,15)*	*(0,00*	*0,01*	*0,05)*	*(0,00*	*0,01*	*0,10)*
A_3	*(0,01*	*0,03*	*0,15)*	*(0,00*	*0,00*	*0,02)*	*(0,01*	*0,03*	*0,15)*	*(0,00*	*0,00*	*0,03)*	*(0,00*	*0,02*	*0,10)*

	C_{22}			C_{23}			C_{24}			C_{25}			C_{26}		
A_1	*(0,01*	*0,06*	*0,40)*	*(0,00*	*0,01*	*0,07)*	*(0,01*	*0,05*	*0,38)*	*(0,00*	*0,02*	*0,16)*	*(0,03*	*0,17*	*0,84)*
A_2	*(0,01*	*0,06*	*0,40)*	*(0,00*	*0,01*	*0,07)*	*(0,01*	*0,08*	*0,47)*	*(0,01*	*0,04*	*0,23)*	*(0,03*	*0,17*	*0,84)*
A_3	*(0,01*	*0,06*	*0,42)*	*(0,00*	*0,01*	*0,06)*	*(0,01*	*0,07*	*0,47)*	*(0,00*	*0,03*	*0,21)*	*(0,02*	*0,13*	*0,75)*

	C_{27}			C_{28}			C_{31}			C_{32}			C_{33}		
A_1	*(0,01*	*0,08*	*0,48)*	*(0,00*	*0,03*	*0,23)*	*(0,02*	*0,12*	*0,52)*	*(0,01*	*0,09*	*0,52)*	*(0,02*	*0,13*	*0,49)*
A_2	*(0,02*	*0,10*	*0,57)*	*(0,00*	*0,03*	*0,23)*	*(0,02*	*0,12*	*0,52)*	*(0,01*	*0,10*	*0,54)*	*(0,02*	*0,17*	*0,52)*
A_3	*(0,01*	*0,06*	*0,45)*	*(0,00*	*0,03*	*0,23)*	*(0,02*	*0,14*	*0,52)*	*(0,01*	*0,10*	*0,54)*	*(0,02*	*0,15*	*0,52)*

After the weighted normalized fuzzy decision matrix is formed, the fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS) are determined by:

A^* = [(0.15, 0.15, 0.15), (0.02, 0.02, 0.02), (0.15, 0.15, 0.15), (0.05, 0.05, 0.05), (0.10, 0.10, 0.10), (0.40, 0.40, 0.40), (0.07, 0.07, 0.07), (0.47, 0.47, 0.47), (0.23, 0.23, 0.23), (0.84, 0.84, 0.84), (0.57, 0.57, 0.57), (0.23, 0.23, 0.23), (0.52, 0.52, 0.52),(0.54 ,0.54, 0.54), (0.52, 0.52, 0.52)]

A^- = [(0.00, 0.00, 0.00), (0.00, 0.00, 0.00), (0.00, 0.00, 0.00),(0.00, 0.00, 0.00), (0.0, 0.00, 0.00), (0.01, 0.01, 0.01), (0.00, 0.00, 0.00), (0.01, 0.01, 0.01), (0.00, 0.00, 0.00), (0.02, 0.02, 0.02), (0.01, 0.01, 0.01), (0.00, 0.00, 0.00), (0.02, 0.02, 0.02), (0.01, 0.01, 0.01), (0.02, 0.02, 0.02)]

Then, the distance of each alternative from the FPIS and FNIS with respect to each criterion is calculated by using the vertex method by:

$$d(A_1, A^*) = \sqrt{\frac{1}{3}\left[(0.15-0.00)^2 + (0.15-0.02)^2 + (0.15-0.12)^2\right]} = 0.11$$

$$d\left(A_1, A^-\right) = \sqrt{\frac{1}{3}\left[(0.00-0.00)^2 + (0.00-0.02)^2 + (0.00-0.12)^2\right]} = 0.07$$

Here only the calculation of the distance of the first alternative to the FPIS and FNIS for the first criterion is shown, as the calculations are similar in all steps. The results of all alternatives' distances from the FPIS and FNIS are shown in Tables 5.12 and 5.13.

Table 5.12: Distance from FPIS

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{31}	C_{32}	C_{33}
A_1	*0,11*	*0,01*	*0,11*	*0,04*	*0,08*	*0,30*	*0,05*	*0,37*	*0,18*	*0,61*	*0,43*	*0,17*	*0,37*	*0,40*	*0,37*
A_2	*0,10*	*0,01*	*0,11*	*0,04*	*0,07*	*0,30*	*0,05*	*0,35*	*0,17*	*0,61*	*0,42*	*0,17*	*0,37*	*0,39*	*0,35*
A_3	*0,11*	*0,02*	*0,11*	*0,04*	*0,07*	*0,30*	*0,05*	*0,35*	*0,17*	*0,63*	*0,44*	*0,17*	*0,36*	*0,39*	*0,36*

Table 5.13: Distance from FNIS

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{31}	C_{32}	C_{33}
A_1	*0,07*	*0,01*	*0,07*	*0,03*	*0,04*	*0,23*	*0,04*	*0,21*	*0,10*	*0,48*	*0,27*	*0,13*	*0,29*	*0,30*	*0,28*
A_2	*0,05*	*0,01*	*0,09*	*0,03*	*0,06*	*0,23*	*0,04*	*0,27*	*0,14*	*0,48*	*0,32*	*0,13*	*0,29*	*0,31*	*0,30*
A_3	*0,09*	*0,01*	*0,09*	*0,02*	*0,06*	*0,24*	*0,03*	*0,27*	*0,12*	*0,43*	*0,26*	*0,13*	*0,30*	*0,31*	*0,30*

Then closeness coefficients of alternatives are calculated. According to the closeness coefficient of alternatives, the ranking order of alternatives is determined.. Value of this parameters and final ranking order of alternatives are presented in Table 14.

Table 5.14: **Computation of di*, di- and CCi and the rating order of alternatives**

	A_1	A_2	A_3	Ranking Order
d_i^*	*3.61*	*3.52*	*3.59*	$A_2 > A_3 > A_1$
d_i^-	*2.56*	*2.77*	*2.66*	
CC_i	0,42	0,44	0,43	

Alternatives sorted in descending order by looking at the values of the relative distance of the alternatives. Accordingly, the sort determined as **A2 > A3 > A1** in alternatives of Clinical chief of surgery. In other words, an alternative A2 should choose in clinical director of surgical alternatives with the highest value of the relative distance.

6. CONCLUSION

Decision-making is often seen as a difficult process in particular group decision-making, need to made choice among many alternatives based on decision criteria, decision-making getting more difficult. Such decision is appropriate to use the theory of fuzzy decision making in many environments. Thus, the uncertainty in the evaluation of the data using the fuzzy approach can be effectively represented, and a decision can be reached more effectively.

In this study, selection problem in the health sector for the surgeon the FAHP method was proposed. First, the decision criteria defined as knowledge, skills and abilities by decision makers in command of the subject in business. And sub-criteria defined as Occupational Knowledge, Foreign Language Knowledge, Graduated School, Academic Publishing for knowledge, Basic Skills, Complex Problem Solving Skills, System Skills, Experience, Number of Case, Success Rate of Cases, Stabilisation, Reference for skills, Psychomotor Abilities, Cognitive Abilities, Managerial Competence for abilities. Criteria and alternatives were evaluated by pairwise comparisons in the method of FAHP. These evaluations were made with the help of questionnaires. Two decision makers in the enterprise answered questionnaire then fuzzy decision matrices were created with these values then determined priority values of selection criteria.

In the application of the study, selection criteria are determined with Fuzzy AHP method then according to priority degree of criteria, appropriate candidate is chosen among three candidates to the position of clinical chief of surgery by using Fuzzy TOPSIS method.

In this context, two decision makers assessed selection criteria by using questionnaire for each candidate then criteria are ordered according to their importance level. After evolution of criteria by using Fuzzy AHP, decision makers assessed each candidates according to priority of criteria to select appropriate candidate by using Fuzzy TOPSIS.

The closeness coefficients of candidates were evaluated by using Fuzzy TOPSIS method algorithm. The candidate with the highest coefficient of closeness, according to evaluation that the best surgeon for the position. After determining the fuzzy positive and negative ideal solution, the distances from these points of each alternative are calculated and closeness coefficient of each alternative are obtained separately. By looking at the values of closeness coefficient, ranking of alternatives was determined as $A_2 > A_3 > A_1$.

The results obtained in accordance with candidate A_2 is proposed to recruit for the position of chief of the hospital's surgical clinic.

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APPENDICES

APPENDIX A1 : Questionnaire

Questionnaire

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

QUESTIONS FOR FIRST DECISION MAKER

With respect to the overall goal ‘‘Selection of Appropriate Candidates for Surgical Sciences’’,

Q1.How important is Knowledge (C1) when it is compared with Skill (C2)?

Q2.How important is Knowledge (C1) when it is compared with Ability (C3)?

Q3.How important is Skill (C2) when it is compared with Ability (C3)?

With respect to the main attribute ‘‘Knowledge (C1)’’,

Q1.How important is Occupational Knowledge (C11) when it is compared with Foreign Language Knowledge (C12)?

Q2.How important is Occupational Knowledge (C11) when it is compared with Graduated School (C13)?

Q3.How important is Occupational Knowledge (C11) when it is compared with Academic Publishing (C14)?

Q4.How important is Foreign Language Knowledge (C12) when it is compared with Graduated School (C13)?

Q5.How important is Foreign Language Knowledge (C12) when it is compared with Academic Publishing (C14)?

Q6.How important is Graduated School (C13) when it is compared with Academic Publishing (C14)?

With respect to the main attribute ‘‘Skill (C2)’’,

Q1. How important is Basic Skills (C21) when it is compared with Complex Problem Solving Skills (C22)?

Q2. How important is Basic Skills (C21) when it is compared with System Skills (C23)?

Q3. How important is Basic Skills (C21) when it is compared with Experience (C24)?

Q4. How important is Basic Skills (C21) when it is compared with Number of Case (C25)?

Q5. How important is Basic Skills (C21) when it is compared with Success rate of Cases (C26)?

Q6. How important is Basic Skills (C21) when it is compared with Stabilisation (C27)?

Q7. How important is Basic Skills (C21) when it is compared with Reference (C28)?

Q8. How important is Complex Problem Solving Skills (C22) when it is compared with System Skills (C23)?

Q9. How important is Complex Problem Solving Skills (C22) when it is compared with Experience (C24)?

Q10. How important is Complex Problem Solving Skills (C22) when it is compared with Number of Case (C25)?

Q11. How important is Complex Problem Solving Skills (C22) when it is compared with Success rate of Cases (C26)?

Q12. How important is Complex Problem Solving Skills (C22) when it is compared with Stabilisation (C27)?

Q13. How important is Complex Problem Solving Skills (C22) when it is compared with Reference (C28)?

Q14. How important is System Skills (C23) when it is compared with Experience (C24)?

Q15. How important is System Skills (C23) when it is compared with Number of Case (C25)?

Q16. How important is System Skills (C23) when it is compared with Success rate of Cases (C26)?

Q17. How important is System Skills (C23) when it is compared with Stabilisation (C27)?

Q18. How important is System Skills (C23) when it is compared with Reference (C28)?

Q19. How important is Experience (C24) when it is compared with Number of Case (C25)?

Q20. How important is Experience (C24) when it is compared with Success rate of Cases (C26)?

Q21. How important is Experience (C24) when it is compared with Stabilisation (C27)?

Q22. How important is Experience (C24) when it is compared with Reference (C28)?

Q23. How important is Number of Case (C25) when it is compared with Success rate of Cases (C26)?

Q24. How important is Number of Case (C25) when it is compared with Stabilisation (C27)?

Q25. How important is Number of Case (C25) when it is compared with Reference (C28)?

Q26. How important is Success rate of Cases (C26) when it is compared with Stabilisation (C27)?

Q27. How important is Success rate of Cases (C26) when it is compared with Reference (C28)?

Q28. How important is Success to Stabilisation (C27) when it is compared with Reference (C28)?

With respect to the main attribute ‘‘Ability (C3)’’,

Q1. How important is Psychomotor Abilities (C31) when it is compared with Cognitive Abilities (C32)?

Q2.How important is Psychomotor Abilities (C31) when it is compared with Managerial Competence (C33)?

Q3.How important is Cognitive Abilities (C32) when it is compared with Managerial Competence (C33)?

With respect to the sub-attribute ‘‘(Cxy)’’, respectively,

Q1.How important is A1 when it is compared with A2 and A3?

Q2.How important is A2 when it is compared with A1 and A3?

Q3.How important is A3 when it is compared with A1 and A2?

QUESTIONS FOR SECOND DECISION MAKER

With respect to the overall goal ‘‘Selection of Appropriate Candidates for Surgical Sciences’’,

Q1.How important is Knowledge (C1) when it is compared with Skill (C2)?

Q2.How important is Knowledge (C1) when it is compared with Ability(C3)?

Q3.How important is Skill (C2) when it is compared with Ability (C3)?

With respect to the main attribute ‘‘Knowledge (C1)’’,

Q1.How important is Occupational Knowledge (C11) when it is compared with Foreign Language Knowledge (C12)?

Q2.How important is Occupational Knowledge (C11) when it is compared with Graduated School (C13)?

Q3.How important is Occupational Knowledge (C11) when it is compared with Academic Publishing (C14)?

Q4.How important is Foreign Language Knowledge (C12) when it is compared with Graduated School (C13)?

Q5.How important is Foreign Language Knowledge (C12) when it is compared with Academic Publishing (C14)?

Q6. How important is Graduated School (C13) when it is compared with Academic Publishing (C14)?

With respect to the main attribute ‘‘Skill (C2)’’,

Q1. How important is Basic Skills (C21) when it is compared with Complex Problem Solving Skills (C22)?

Q2. How important is Basic Skills (C21) when it is compared with System Skills (C23)?

Q3. How important is Basic Skills (C21) when it is compared with Experience (C24)?

Q4. How important is Basic Skills (C21) when it is compared with Number of Case (C25)?

Q5. How important is Basic Skills (C21) when it is compared with Success rate of Cases (C26)?

Q6. How important is Basic Skills (C21) when it is compared with Stabilisation (C27)?

Q7. How important is Basic Skills (C21) when it is compared with Reference (C28)?

Q8. How important is Complex Problem Solving Skills (C22) when it is compared with System Skills (C23)?

Q9. How important is Complex Problem Solving Skills (C22) when it is compared with Experience (C24)?

Q10. How important is Complex Problem Solving Skills (C22) when it is compared with Number of Case (C25)?

Q11. How important is Complex Problem Solving Skills (C22) when it is compared with Success rate of Cases (C26)?

Q12. How important is Complex Problem Solving Skills (C22) when it is compared with Stabilisation (C27)?

Q13. How important is Complex Problem Solving Skills (C22) when it is compared with Reference (C28)?

Q14. How important is System Skills (C23) when it is compared with Experience (C24)?

Q15. How important is System Skills (C23) when it is compared with Number of Case (C25)?

Q16. How important is System Skills (C23) when it is compared with Success rate of Cases (C26)?

Q17. How important is System Skills (C23) when it is compared with Stabilisation (C27)?

Q18. How important is System Skills (C23) when it is compared with Reference (C28)?

Q19. How important is Experience (C24) when it is compared with Number of Case (C25)?

Q20. How important is Experience (C24) when it is compared with Success rate of Cases (C26)?

Q21. How important is Experience (C24) when it is compared with Stabilisation (C27)?

Q22. How important is Experience (C24) when it is compared with Reference (C28)?

Q23. How important is Number of Case (C25) when it is compared with Success rate of Cases (C26)?

Q24. How important is Number of Case (C25) when it is compared with Stabilisation (C27)?

Q25. How important is Number of Case (C25) when it is compared with Reference (C28)?

Q26. How important is Success rate of Cases (C26) when it is compared with Stabilisation (C27)?

Q27. How important is Success rate of Cases (C26) when it is compared with Reference (C28)?

Q28. How important is Success to Stabilisation (C27) when it is compared with Reference (C28)?

With respect to the main attribute ‘‘Ability (C3)’’, Q1.How important is Psychomotor Abilities (C31) when it is compared with Cognitive Abilities (C32)?

Q2.How important is Psychomotor Abilities (C31) when it is compared with Managerial Competence (C33)?

Q3.How important is Cognitive Abilities (C32) when it is compared with Managerial Competence (C33)?

With respect to the sub-attribute ‘‘(Cxy)’’, respectively,

Q4.How important is A1 when it is compared with A2 and A3?

Q5.How important is A2 when it is compared with A1 and A3?

Q6.How important is A3 when it is compared with A1 and A2?

APPENDIX A2 : Pairwise Comparisons For Decision Criteria

Pairwise Comparison for selecting criteria in surgeon selection problem by first decision maker

Criteria	Absolutely Important	Very Strongly Important	Essentially Important	Weakly Important	Equally Important	Just Equal	Equally Important	Weakly Important	Essentially Important	Very Strongly Important	Absolutely Important	Criteria
Knowledge										X		Skills
Knowledge									X			Abilities
Skills					X							Abilities

Pairwise Comparison for selecting criteria in surgeon selection problem by second decision maker

Criteria	Absolutely Important	Very Strongly Important	Essentially Important	Weakly Important	Equally Important	Just Equal	Equally Important	Weakly Important	Essentially Important	Very Strongly Important	Absolutely Important	Criteria
Knowledge									X			Skills
Knowledge								X				Abilities
Skills					X							Abilities

Pairwise Comparison for criterias in surgeon selection problem by first decision maker

Knowledge			Importance (or preference) of one sub-attribute over another									
Criteria	Absolutely Important	Very Strongly Important	Essentially Important	Weakly Important	Equally Important	Just Equal	Equally Important	Weakly Important	Essentially Important	Very Strongly Important	Absolutely Important	Criteria
Occupational Knowledge	X											Foreign Language Knowledge
Occupational Knowledge									X			Graduated School
Occupational Knowledge			X									Academic Publishing
Foreign Language										X		Graduated School
Foreign Language									X			Academic Publishing
Graduated School		X										Academic Publishing

Pairwise Comparison for criterias in surgeon selection problem by second decision maker

Knowledge			Importance (or preference) of one sub-attribute over another									
Criteria	Absolutely Important	Very Strongly Important	Essentially Important	Weakly Important	Equally Important	Just Equal	Equally Important	Weakly Important	Essentially Important	Very Strongly Important	Absolutely Important	Criteria
Occupational Knowledge			X									Foreign Language Knowledge
Occupational Knowledge			X									Graduated School
Occupational Knowledge			X									Academic Publishing
Foreign Language									X			Graduated School
Foreign Language								X				Academic Publishing
Graduated School				X								Academic Publishing

Pairwise Comparison for criterias in surgeon selection problem by first decision maker

Skills			Importance (or preference) of one sub-attribute over another									
Criteria	Absolutely Important	Very Strongly Important	Essentially Important	Weakly Important	Equally Important	Just Equal	Equally Important	Weakly Important	Essentially Important	Very Strongly	Absolutely Important	Criteria
Basic Skills				X								Complex Problem Solving Skills
Basic Skills			X									System Skills
Basic Skills									X			Experience
Basic Skills					X							Number of Case
Basic Skills										X		Success rate of Cases
Basic Skills									X			Stabilisation
Basic Skills								X				Reference
Complex Problem Solving Skills		X										System Skills
Complex Problem Solving Skills									X			Experience
Complex Problem Solving Skills			X									Number of Case
Complex Problem Solving Skills										X		Success rate of Cases
Complex Problem Solving Skills									X			Stabilisation
Complex Problem Solving Skills					X							Reference
System Skills										X		Experience
System Skills								X				Number of Case
System Skills											X	Success rate of Cases
System Skills									X			Stabilisation
System Skills										X		Reference

Experience					X							Number of Case
Experience										X		Success rate of Cases
Experience									X			Stabilisation
Experience			X									Reference
Number of Case									X			Success rate of Cases
Number of Case								X				Stabilisation
Number of Case									X			Reference
Success rate of Cases										X		Stabilisation
Success rate of Cases				X								Reference
Stabilisation			X									Reference

Pairwise Comparison for criterias in surgeon selection problem by second decision maker

Skills			Importance (or preference) of one sub-attribute over another									
Criteria	Absolutely Important	Very Strongly Important	Essentially Important	Weakly Important	Equally Important	Just Equal	Equally Important	Weakly Important	Essentially Important	Very Strongly Important	Absolutely Important	Criteria
Basic Skills									X			Complex Problem Solving Skills
Basic Skills								X				System Skills
Basic Skills										X		Experience
Basic Skills										X		Number of Case
Basic Skills										X		Success rate of Cases
Basic Skills										X		Stabilisation
Basic Skills								X				Reference
Complex Problem Solving Skills			X									System Skills
Complex Problem Solving Skills				X								Experience
Complex Problem Solving Skills				X								Number of Case
Complex Problem Solving Skills					X							Success rate of Cases
Complex Problem Solving Skills				X								Stabilisation
Complex Problem Solving Skills				X								Reference
System Skills								X				Experience
System Skills									X			Number of Case

System Skills									X			Success rate of Cases
System Skills									X			Stabilisation
System Skills								X				Reference
Experience					X							Number of Case
Experience								X				Success rate of Cases
Experience				X								Stabilisation
Experience				X								Reference
Number of Case										X		Success rate of Cases
Number of Case			X									Stabilisation
Number of Case			X									Reference
Success rate of Cases			X									Stabilisation
Success rate of Cases			X									Reference
Stabilisation				X								Reference

Pairwise Comparison for criterias in surgeon selection problem by first decision maker

Abilities			Importance (or preference) of one sub-attribute over another									
Criteria	Absolutely Important	Very Strongly Important	Essentially Important	Weakly Important	Equally Important	Just Equal	Equally Important	Weakly Important	Essentially Important	Very Strongly Important	Absolutely Important	Criteria
Psychomotor Abilities								X				Cognitive Abilities
Psychomotor Abilities									X			Managerial Competence
Cognitive Abilities								X				Managerial Competence

Pairwise Comparison for criterias in surgeon selection problem by second decision maker

Abilities			Importance (or preference) of one sub-attribute over another									
Criteria	Absolutely Important	Very Strongly Important	Essentially Important	Weakly Important	Equally Important	Just Equal	Equally Important	Weakly Important	Essentially Important	Very Strongly Important	Absolutely Important	Criteria
Psychomotor Abilities				X								Cognitive Abilities
Psychomotor Abilities			X									Managerial Competence
Cognitive Abilities					X							Managerial Competence

APPENDIX A3: Pairwise Comparisons for Decision Criteria With Fuzzy Number

Pairwise Comparison of Main Goal for criteria in surgeon selection problem by first decision maker with Fuzzy Numbers

Goal	Knowledge	Skills	Abilities
Knowledge	(1,1,1)	$(5,7,9)^{-1}$	$(3,5,7)^{-1}$
Skills	(5,7,9)	(1,1,1)	(1,1,3)
Abilities	(3,5,7)	$(1,1,3)^{-1}$	(1,1,1)

Pairwise Comparison of Main Goal for criteria in surgeon selection problem by second decision maker with Fuzzy Numbers

Goal	Knowledge	Skills	Abilities
Knowledge	(1,1,1)	$(3,5,7)^{-1}$	$(1,3,5)^{-1}$
Skills	(3,5,7)	(1,1,1)	(1,1,3)
Abilities	(1,3,5)	$(1,1,3)^{-1}$	(1,1,1)

Fuzzy Aggregated Decision Matrix

	Knowledge			Skills			Abilities		
Knowledge	1.00	1.00	1.00	0.12	0.17	0.26	0.17	0.26	0.57
Skills	3.87	5.92	7.94	1.00	1.00	1.00	1.00	1.00	3.00
Abilities	1.73	3.87	5.92	0.33	1.00	1.00	1.00	1.00	1.00

Pairwise Comparison criteria of Knowledge for sub-criteria in surgeon selection problem by first decision maker with Fuzzy Numbers

Knowledge	Occupational Knowledge	Foreign Language Knowledge	Graduated School	Academic Publishing
Occupational Knowledge	(1,1,1)	(7,9,9)	$(3,5,7)^{-1}$	(3,5,7)
Foreign Language Knowledge	$(7,9,9)^{-1}$	(1,1,1)	$(5,7,9)^{-1}$	$(3,5,7)^{-1}$
Graduated School	(3,5,7)	(5,7,9)	(1,1,1)	(5,7,9)
Academic Publishing	$(3,5,7)^{-1}$	(3,5,7)	$(5,7,9)^{-1}$	(1,1,1)

Pairwise Comparison criteria of Knowledge for sub-criteria in surgeon selection problem by second decision maker with Fuzzy Numbers

Knowledge	Occupational Knowledge	Foreign Language Knowledge	Graduated School	Academic Publishing
Occupational Knowledge	(1,1,1)	(3,5,7)	(3,5,7)	(3,5,7)
Foreign Language Knowledge	$(3,5,7)^{-1}$	(1,1,1)	$(3,5,7)^{-1}$	$(1,3,5)^{-1}$
Graduated School	$(3,5,7)^{-1}$	(3,5,7)	(1,1,1)	(1,3,5)
Academic Publishing	$(3,5,7)^{-1}$	(1,3,5)	$(1,3,5)^{-1}$	(1,1,1)

Fuzzy Aggregated Decision Matrix

	Occupational Knowledge			Foreign Language Knowledge			Graduated School			Academic Publishing		
Occupational Knowledge	1.00	1.00	1.00	4.58	6.71	7.94	0.65	1.00	1.52	3.00	5.00	7.00
Foreign Language Knowledge	0.12	0.15	0.21	1.00	1.00	1.00	0.12	0.17	0.26	0.17	0.26	0.57
Graduated School	0.65	1.00	1.52	3.87	5.92	7.94	1.00	1.00	1.00	2.24	4.58	6.71
Academic Publishing	0.14	0.20	0.33	1.73	3.87	5.92	0.15	0.21	0.45	1.00	1.00	1.00

Pairwise Comparison criteria of Skills for sub-criteria in surgeon selection problem by first decision maker with Fuzzy Numbers

Skills	Basic Skills	Comple x Problem Solving Skills	Syste m Skills	Experienc e	Number of Case	Success rate of Cases	Stabilisatio n	Reference
Basic Skills	(1,1,1)	(1,3,5)	(3,5,7)	$(3,5,7)^{-1}$	(1,1,3)	$(5,7,9)^{-1}$	$(3,5,7)^{-1}$	$(1,3,5)^{-1}$
Complex Problem Solving Skills	$(1,3,5)^{-1}$	(1,1,1)	(5,7,9)	$(3,5,7)^{-1}$	(3,5,7)	$(5,7,9)^{-1}$	$(3,5,7)^{-1}$	(1,1,3)
System Skills	$(3,5,7)^{-1}$	$(5,7,9)^{-1}$	(1,1,1)	$(5,7,9)^{-1}$	$(1,3,5)^{-1}$	$(7,9,9)^{-1}$	$(3,5,7)^{-1}$	$(5,7,9)^{-1}$
Experien ce	(3,5,7)	(3,5,7)	(5,7,9)	(1,1,1)	(1,1,3)	$(5,7,9)^{-1}$	$(3,5,7)^{-1}$	(3,5,7)
Number of Case	$(1,1,3)^{-1}$	$(3,5,7)^{-1}$	(1,3,5)	$(1,1,3)^{-1}$	(1,1,1)	$(3,5,7)^{-1}$	$(1,3,5)^{-1}$	$(3,5,7)^{-1}$
Success rate of Cases	(5,7,9)	(5,7,9)	(7,9,9,)	(5,7,9)	(3,5,7)	(1,1,1)	$(5,7,9)^{-1}$	(1,3,5)
Stabilisat ion	(3,5,7)	(3,5,7)	(3,5,7)	(3,5,7)	(1,3,5)	(5,7,9)	(1,1,1)	(3,5,7)
Referenc e	(1,3,5)	$(1,1,3)^{-1}$	(5,7,9)	$(3,5,7)^{-1}$	(3,5,7)	$(1,3,5)^{-1}$	$(3,5,7)^{-1}$	(1,1,1)

Pairwise Comparison criteria of Skills for sub-criteria in surgeon selection problem by second decision maker with Fuzzy Numbers

Skills	Basic Skills	Complex Problem Solving Skills	System Skills	Experience	Number of Case	Success rate of Cases	Stabilisation	Reference
Basic Skills	(1,1,1)	$(3,5,7)^{-1}$	$(1,3,5)^{-1}$	$(5,7,9)^{-1}$	$(5,7,9)^{-1}$	$(5,7,9)^{-1}$	$(5,7,9)^{-1}$	$(1,3,5)^{-1}$
Complex Problem Solving Skills	(3,5,7)	(1,1,1)	(3,5,7)	(1,3,5)	(1,3,5)	(1,1,3)	(1,3,5)	(1,3,5)
System Skills	(1,3,5)	$(3,5,7)^{-1}$	(1,1,1)	$(1,3,5)^{-1}$	$(3,5,7)^{-1}$	$(3,5,7)^{-1}$	$(3,5,7)^{-1}$	$(1,3,5)^{-1}$
Experience	(5,7,9)	$(1,3,5)^{-1}$	(1,3,5)	(1,1,1)	(1,1,3)	$(1,3,5)^{-1}$	(1,3,5)	(1,3,5)
Number of Case	(5,7,9)	$(1,3,5)^{-1}$	(3,5,7)	$(1,1,3)^{-1}$	(1,1,1)	$(5,7,9)^{-1}$	(3,5,7)	(3,5,7)
Success rate of Cases	(5,7,9)	$(1,1,3)^{-1}$	(3,5,7)	(1,3,5)	(5,7,9)	(1,1,1)	(3,5,7)	(3,5,7)
Stabilisation	(5,7,9)	$(1,3,5)^{-1}$	(3,5,7)	$(1,3,5)^{-1}$	$(3,5,7)^{-1}$	$(3,5,7)^{-1}$	(1,1,1)	(1,3,5)
Reference	(1,3,5)	$(1,3,5)^{-1}$	(1,3,5)	$(1,3,5)^{-1}$	$(3,5,7)^{-1}$	$(3,5,7)^{-1}$	$(1,3,5)^{-1}$	(1,1,1)

Fuzzy Aggregated Decision Matrix

	Basic Skills			Complex Problem Solving Skills			System Skills			Experience			Number of Case			Success rate of Cases			Stabilisation			Reference		
Basic Skills	1.00	1.00	1.00	0.37	0.77	1.28	0.77	1.28	2.65	0.12	0.17	0.26	0.33	0.37	0.77	0.11	0.14	0.20	0.12	0.17	0.26	0.20	0.33	1.00
Complex Problem Solving Skills	0.77	1.28	2.65	1.00	1.00	1.00	3.87	5.92	7.94	0.37	0.77	1.28	1.73	3.87	5.92	0.33	0.37	0.77	0.37	0.77	1.28	1.00	1.73	3.87
System Skills	0.37	0.77	1.28	0.12	0.17	0.26	1.00	1.00	1.00	0.15	0.21	0.45	0.17	0.26	0.57	0.12	0.17	0.26	0.14	0.20	0.33	0.15	0.21	0.45
Experience	3.87	5.92	7.94	0.77	1.28	2.65	2.24	4.58	6.71	1.00	1.00	1.00	1.00	1.00	3.00	0.15	0.21	0.45	0.37	0.77	1.28	1.73	3.87	5.92
Number of Case	1.28	2.65	3.00	0.17	0.26	0.57	1.73	3.87	5.92	0.33	1.00	1.00	1.00	1.00	1.00	0.12	0.17	0.26	0.77	1.28	2.65	0.65	1.00	1.52
Success rate of Cases	5.00	7.00	9.00	1.28	2.65	3.00	4.58	6.71	7.94	2.24	4.58	6.71	3.87	5.92	7.94	1.00	1.00	1.00	0.57	0.84	1.18	1.73	3.87	5.92
Stabilisation	3.87	5.92	7.94	0.77	1.28	2.65	3.00	5.00	7.00	0.77	1.28	2.65	0.37	0.77	1.28	0.84	1.18	1.72	1.00	1.00	1.00	1.73	3.87	5.92
Reference	1.00	3.00	5.00	0.26	0.57	1.00	2.24	4.58	6.71	0.17	0.26	0.57	0.65	1.00	1.52	0.17	0.26	0.57	0.17	0.26	0.57	1.00	1.00	1.00

Pairwise Comparison criteria of Abilities for sub-criteria in surgeon selection problem by first decision maker with Fuzzy Numbers

Abilities	Psychomotor Abilities	Cognitive Abilities	Managerial Competence
Psychomotor Abilities	(1,1,1)	$(1,3,5)^{-1}$	$(3,5,7)^{-1}$
Cognitive Abilities	(1,3,5)	(1,1,1)	$(1,3,5)^{-1}$
Managerial Competence	(3,5,7)	(1,3,5)	(1,1,1)

Pairwise Comparison criteria of Abilities for sub-criteria in surgeon selection problem by second decision maker with Fuzzy Numbers

Abilities	Psychomotor Abilities	Cognitive Abilities	Managerial Competence
Psychomotor Abilities	(1,1,1)	(1,3,5)	(3,5,7)
Cognitive Abilities	$(1,3,5)^{-1}$	(1,1,1)	(1,1,3)
Managerial Competence	$(3,5,7)^{-1}$	$(1,1,3)^{-1}$	(1,1,1)

Fuzzy Aggregated Decision Matrix

	Psychomotor Abilities			Cognitive Abilities			Managerial Competence		
Psychomotor Abilities	1.00	1.00	1.00	0.45	0.99	2.24	0.65	1.00	1.52
Cognitive Abilities	0.45	0.99	2.24	1.00	1.00	1.00	0.45	0.57	1.73
Managerial Competence	0.65	1.00	1.52	0.57	1.73	2.24	1.00	1.00	1.00

Fuzzy Weight Matrix

Occupational Knowledge	0,23	0,43	0,77
Foreign Language Knowledge	0,03	0,05	0,11
Graduated School	0,21	0,41	0,76
Academic Publishing	0,06	0,11	0,25
Basic Skills	0,01	0,03	0,10
Complex Problem Solving Skills	0,05	0,13	0,39
System Skills	0,01	0,02	0,07
Experience	0,05	0,14	0,44
Number of Case	0,03	0,08	0,22
Success rate of Cases	0,13	0,34	0,78
Stabilisation	0,07	0,19	0,52
Reference	0,02	0,07	0,21
Psychomotor Abilities	0,14	0,33	0,76
Cognitive Abilities	0,13	0,27	0,80
Managerial Competence	0,16	0,40	0,76

APPENDIX A4: Curriculum Vitae Of Candidates

Cv of 1st Candidate

General Surgery - Organ Transplant Specialist

The Task Received Medical Units	:	General Surgery, Organ Transplantation
Place and Date of Birth	:	Çanakkale, Turkey / 1974
Foreign Languages	:	English

Experience

2005 – Halen	Specialist General Surgery and Organ Transplantation, Organ Transplant Center	İstanbul/Turkey
2004 – 2005	General Surgeon – reserve officer	Diyarbakır/Turkey
2004 – 2004	General Surgeon	İstanbul/Turkey

Education

1998 - 2003	General Surgery Residency Training	İstanbul/Turkey
1992 - 1998	Education of Medical Doctor	İstanbul/Turkey

Professional Training Attended, Courses and Conferences

- Vascular Repair Techniques, Practical Training Course, 2004
- 5th and 7th Colon and Rectal Diseases, Postgraduate Education Course, 2000 / 2004
- 2nd Trauma and Emergency Surgery Postgraduate Education Course, 2001
- 11. Postgraduate of Breast Diseases training course, 2006
- participation national and international congresses and symposium

Professional Awards and Levels

Proof of proficiency of Turkish Surgery (BOARD) (2005 / 1080)

Professional Memberships

- Society of Turkish Surgery
- Organ Transplant Association of Turkey
- Society of Emergency Surgery and Traumatology

Scientific Publications

- Publication of 20 national and international journals, presented with 18 oral presentations at various conferencesand 12 poster presentation. Two sections of written in the books of Laparoscopic Surgery.

Cv of 2nd Candidate

Head of the Department of Plastic Surgery

The Task Received Medical Units : Aesthetic Plastic and Reconstructive Surgery

Place and Date of Birth : İstanbul, Turkey / 1959

Foreign Languages : English

Experience

2011 – Still	Head of the Department of Plastic Surgery	İstanbul/Turkey
2002 – 2011	Aesthetic Plastic and Reconstructive Surgeon – reserve officer	Diyarbakır/Turkey
1992 – 2002	Instructor-Aesthetic Plastic and Reconstructive Surgeon	İstanbul/Turkey
1983 - 1985	Compulsory duties	Ordu/Turkey

Education

1997 - Still	Associate Professor	İstanbul/Turkey
1985 - 1990	Plastic and Reconstructive Surgery Residency Training	İstanbul/Turkey
1977 - 1983	Education of Medical Doctor	Ankara/Turkey

Professional Training Attended, Courses and Conferences

- 1990 – 1991 University of Alabama at Birmingham, Fellow Clinical and Research
- Has given over 100 international conferences as an invited speaker at the congress.

Professional Memberships

v. Head of the Turkish Society of Aesthetic Plastic Surgery.
vi. ISAPS (International Society of Aesthetic Plastic Surgery) Education Council Chair - Education Committee Chairman and Board Member
vii. Plastic Reconstructive Surgery Journal (American Plastic Association of surgeons – ASPS – Official Journal) Editorial Board Member

Cv of 3rd Candidate

Brain and Neurological Surgery Specialist

The Task Received Medical Units	:	Brain Surgery
Place and Date of Birth	:	Erzurum, Turkey / 1966
Foreign Languages	:	English

Experience

2010 – Still	Brain and Neurological Surgery Specialist	Antalya/Turkey
2008 – 2010	Brain and Neurological Surgery Specialist	Istanbul/Turkey
2005 – 2008	Brain and Neurological Surgery Specialist	İstanbul/Turkey
2004 - 2005	Brain and Neurological Surgery Specialist	Istanbul/Turkey
2001-2004	Lecturer, Department of Neurological Surgery	Ankara/Turkey
1999-2001	Brain and Neurological Surgery Specialist	Istanbul/Turkey

Education

1994 - 1999	Neurosurgery Residency Training	İstanbul/Turkey
1983 - 1989	Education of Medical Doctor	İzmir/Turkey

Professional Training Attended, Courses and Conferences

- Turkey Board of Neurosurgery
- Pediatric Neurosurgery
- Microsurgery Laboratory Study

Professional Memberships

viii. Turkish Society of Neurosurgery
ix. The Turkish Medical Association

Scientific Publications

iii. Writing the Book Section, Spinal Infections
iv. 6 pieces of published papers in international refereed journals, international conference speech, 8 national publications, 35 papers in national conferences.

APPENDIX A5: Assesment of Decision Makers for Candidates

Evaluation of alternatives with respect to Occupational Knowledge

Occupational Knowledge	D1	D2
A1	MG	F
A2	VG	VG
A3	G	MG

Evaluation of alternatives with respect to Foreign Language Knowlegde

Foreign Language Knowledge	D1	D2
A1	F	G
A2	G	VG
A3	F	F

Evaluation of alternatives with respect to Graduated School

Graduated School	D1	D2
A1	F	MG
A2	VG	G
A3	G	G

Evaluation of alternatives with respect to Academic Publishing

Academic Publishing	D1	D2
A1	G	G
A2	VG	VG
A3	F	MP

Evaluation of alternatives with respect to Basic Skills

Basic Skills	D1	D2
A1	F	F
A2	G	G
A3	VG	G

Evaluation of alternatives with respect to Complex Problem Solving Skills

Complex Problem Solving Skills	D1	D2
A1	MG	VG
A2	G	MG
A3	G	G

Evaluation of alternatives with respect to System Skills

System Skills	D1	D2
A1	G	G
A2	MG	G
A3	MG	F

Evaluation of alternatives with respect to Experience

Experience	D1	D2
A1	F	MG
A2	VG	VG
A3	G	G

Evaluation of alternatives with respect to Number of Case

Number of Case	D1	D2
A1	F	F
A2	G	G
A3	MG	MG

Evaluation of alternatives with respect to Success rate of Cases

Success rate of Cases	D1	D2
A1	G	G
A2	G	G
A3	MG	MG

Evaluation of alternatives with respect to Stabilisation

Stabilisation	D1	D2
A1	F	VG
A2	VG	G
A3	F	MG

Evaluation of alternatives with respect to Reference

Reference	D1	D2
A1	G	G
A2	G	G
A3	G	G

Evaluation of alternatives with respect to Psychomotor Abilities

Psychomotor Abilities	D1	D2
A1	G	G
A2	G	G
A3	VG	VG

Evaluation of alternatives with respect to Cognitive Abilities

Cognitive Abilities	D1	D2
A1	G	MG
A2	G	G
A3	G	G

Evaluation of alternatives with respect to Managerial Competence

Managerial Competence	D1	D2
A1	G	MG
A2	VG	VG
A3	G	G

APPENDIX A6: Assesment of Decision Makers for Candidates with Fuzzy Numbers

Ratings of alternatives with respect to Occupational Knowledge with Fuzzy Numbers

Occupational Knowledge	D1	D2
A1	(5,7,9)	(3,5,7)
A2	(9,10,10)	(9,10,10)
A3	(7,9,10)	(5,7,9)

Ratings of alternatives with respect to Foreign Language Knowlegde with Fuzzy Numbers

Foreign Language Knowledge	D1	D2
A1	(3,5,7)	(7,9,10)
A2	(7,9,10)	(9,10,10)
A3	(3,5,7)	(3,5,7)

Ratings of alternatives with respect to Graduated School with Fuzzy Numbers

Graduated School	D1	D2
A1	(3,5,7)	(5,7,9)
A2	(9,10,10)	(7,9,10)
A3	(7,9,10)	(7,9,10)

Ratings of alternatives with respect to Academic Publishing with Fuzzy Numbers

Academic Publishing	D1	D2
A1	(7,9,10)	(7,9,10)
A2	(9,10,10)	(9,10,10)
A3	(3,5,7)	(1,3,5)

Ratings of alternatives with respect to Basic Skills with Fuzzy Numbers

Basic Skills	D1	D2
A1	(3,5,7)	(3,5,7)
A2	(7,9,10)	(7,9,10)
A3	(9,10,10)	(7,9,10)

Ratings of alternatives with respect to Complex Problem Solving Skills with Fuzzy Numbers

Complex Problem Solving Skills	D1	D2
A1	(5,7,9)	(9,10,10)
A2	(7,9,10)	(5,7,9)
A3	(7,9,10)	(7,9,10)

Ratings of alternatives with respect to System Skills with Fuzzy Numbers

System Skills	D1	D2
A1	(7,9,10)	(7,9,10)
A2	(5,7,9)	(7,9,10)
A3	(5,7,9)	(3,5,7)

Ratings of alternatives with respect to Experience with Fuzzy Numbers

Experience	D1	D2
A1	(3,5,7)	(5,7,9)
A2	(9,10,10)	(9,10,10)
A3	(7,9,10)	(7,9,10)

Ratings of alternatives with respect to Number of Case with Fuzzy Numbers

Number of Case	D1	D2
A1	(3,5,7)	(3,5,7)
A2	(7,9,10)	(7,9,10)
A3	(5,7,9)	(5,7,9)

Ratings of alternatives with respect to Success rate of Cases with Fuzzy Numbers

Success rate of Cases	D1	D2
A1	(7,9,10)	(7,9,10)
A2	(7,9,10)	(7,9,10)
A3	(5,7,9)	(5,7,9)

Ratings of alternatives with respect to Stabilisation with Fuzzy Numbers

Stabilisation	D1	D2
A1	(3,5,7)	(9,10,10)
A2	(9,10,10)	(7,9,10)
A3	(3,5,7)	(5,7,9)

Ratings of alternatives with respect to Reference with Fuzzy Numbers

Reference	D1	D2
A1	(7,9,10)	(7,9,10)
A2	(7,9,10)	(7,9,10)
A3	(7,9,10)	(7,9,10)

Ratings of alternatives with respect to Psychomotor Abilities with Fuzzy Numbers

Psychomotor Abilities	D1	D2
A1	(7,9,10)	(7,9,10)
A2	(7,9,10)	(7,9,10)
A3	(9,10,10)	(9,10,10)

Ratings of alternatives with respect to Cognitive Abilities with Fuzzy Numbers

Cognitive Abilities	D1	D2
A1	(7,9,10)	(5,7,9)
A2	(7,9,10)	(7,9,10)
A3	(7,9,10)	(7,9,10)

Ratings of alternatives with respect to Managerial Competence with Fuzzy Numbers

Managerial Competence	D1	D2
A1	(7,9,10)	(5,7,9)
A2	(9,10,10)	(9,10,10)
A3	(7,9,10)	(7,9,10)

APPENDIX A7: Ratings of Candidates by Decision Makers

The ratings of the three candidates by decision makers under all criteria

Criteria	Candidates	Decision Makers	
		D_1	D_2
C_{11}	A_1	MG	F
	A_2	VG	VG
	A_3	G	MG
C_{12}	A_1	F	G
	A_2	G	VG
	A_3	F	F
C_{13}	A_1	F	MG
	A_2	VG	G
	A_3	G	G
C_{14}	A_1	G	G
	A_2	VG	VG
	A_3	F	MP
C_{21}	A_1	F	F
	A_2	G	G
	A_3	VG	G
C_{22}	A_1	MG	VG
	A_2	G	MG
	A_3	G	G
C_{23}	A_1	G	G
	A_2	MG	G
	A_3	MG	F
C_{24}	A_1	F	MG
	A_2	VG	VG
	A_3	G	G
C_{25}	A_1	F	F
	A_2	G	G
	A_3	MG	MG
C_{26}	A_1	G	G
	A_2	G	G
	A_3	MG	MG
C_{27}	A_1	F	VG
	A_2	VG	G
	A_3	F	MG
C_{28}	A_1	G	G
	A_2	G	G

	A_3	G	G
C_{31}	A_1	G	G
	A_2	G	G
	A_3	VG	VG
C_{32}	A_1	G	MG
	A_2	G	G
	A_3	G	G
C_{33}	A_1	G	MG
	A_2	VG	VG
	A_3	G	G

The ratings of the three candidates by decision makers under all criteria

Criteria	Candidates	Decision Makers	
		D_1	D_2
C_{11}	A_1	(5,7,9)	(3,5,7)
	A_2	(9,10,10)	(9,10,10)
	A_3	(7,9,10)	(5,7,9)
C_{12}	A_1	(3,5,7)	(7,9,10)
	A_2	(7,9,10)	(9,10,10)
	A_3	(3,5,7)	(3,5,7)
C_{13}	A_1	(3,5,7)	(5,7,9)
	A_2	(9,10,10)	(7,9,10)
	A_3	(7,9,10)	(7,9,10)
C_{14}	A_1	(7,9,10)	(7,9,10)
	A_2	(9,10,10)	(9,10,10)
	A_3	(3,5,7)	(1,3,5)
C_{21}	A_1	(3,5,7)	(3,5,7)
	A_2	(7,9,10)	(7,9,10)
	A_3	(9,10,10)	(7,9,10)
C_{22}	A_1	(5,7,9)	(9,10,10)
	A_2	(7,9,10)	(5,7,9)
	A_3	(7,9,10)	(7,9,10)
C_{23}	A_1	(7,9,10)	(7,9,10)
	A_2	(5,7,9)	(7,9,10)
	A_3	(5,7,9)	(3,5,7)
C_{24}	A_1	(3,5,7)	(5,7,9)
	A_2	(9,10,10)	(9,10,10)
	A_3	(7,9,10)	(7,9,10)
C_{25}	A_1	(3,5,7)	(3,5,7)
	A_2	(7,9,10)	(7,9,10)

	A_3	(5,7,9)	(5,7,9)
C_{26}	A_1	(7,9,10)	(7,9,10)
	A_2	(7,9,10)	(7,9,10)
	A_3	(5,7,9)	(5,7,9)
C_{27}	A_1	(3,5,7)	(9,10,10)
	A_2	(9,10,10)	(7,9,10)
	A_3	(3,5,7)	(5,7,9)
C_{28}	A_1	(7,9,10)	(7,9,10)
	A_2	(7,9,10)	(7,9,10)
	A_3	(7,9,10)	(7,9,10)
C_{31}	A_1	(7,9,10)	(7,9,10)
	A_2	(7,9,10)	(7,9,10)
	A_3	(9,10,10)	(9,10,10)
C_{32}	A_1	(7,9,10)	(5,7,9)
	A_2	(7,9,10)	(7,9,10)
	A_3	(7,9,10)	(7,9,10)
C_{33}	A_1	(7,9,10)	(5,7,9)
	A_2	(9,10,10)	(9,10,10)
	A_3	(7,9,10)	(7,9,10)

APPENDIX A8: Fuzzy Decision Matrix of Alternatives with TOPSIS

The fuzzy decision matrix and fuzzy weights of three alternatives

	C_{11}			C_{12}			C_{13}			C_{14}			C_{21}		
A_1	*(4.00*	*6.00*	*8.00)*	*(5.00*	*7.00*	*8.50)*	*(4.00*	*6.00*	*8.00)*	*(7.00*	*9.00*	*10.00)*	*(3.00*	*5.00*	*7.00)*
A_2	*(9.00*	*10.00*	*10.00)*	*(8.00*	*9.50*	*10.00)*	*(8.00*	*9.50*	*10.00)*	*(9.00*	*10.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*
A_3	*(6.00*	*8.00*	*9.50)*	*(3.00*	*5.00*	*7.00)*	*(7.00*	*9.00*	*10.00)*	*(2.00*	*4.00*	*6.00)*	*(8.00*	*9.50*	*10.00)*

	C_{22}			C_{23}			C_{24}			C_{25}			C_{26}		
A_1	*(7.00*	*8.50*	*9.50)*	*(7.00*	*9.00*	*10.00)*	*(4.00*	*6.00*	*8.00)*	*(3.00*	*5.00*	*7.00)*	*(7.00*	*9.00*	*10.00)*
A_2	*(6.00*	*8.00*	*9.50)*	*(6.00*	*8.00*	*9.50)*	*(9.00*	*10.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*
A_3	*(7.00*	*9.00*	*10.00)*	*(4.00*	*6.00*	*8.00)*	*(7.00*	*9.00*	*10.00)*	*(5.00*	*7.00*	*9.00)*	*(5.00*	*7.00*	*9.00)*

	C_{27}			C_{28}			C_{31}			C_{32}			C_{33}		
A_1	*(6.00*	*7.50*	*8.50)*	*(7.00*	*9.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(6.00*	*8.00*	*9.50)*	*(6.00*	*8.00*	*9.50)*
A_2	*(8.00*	*9.50*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(9.00*	*10.00*	*10.00)*
A_3	*(4.00*	*6.00*	*8.00)*	*(7.00*	*9.00*	*10.00)*	*(9.00*	*10.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*	*(7.00*	*9.00*	*10.00)*

The Fuzzy Normalized Decision Matrix

	C_{11}			C_{12}			C_{13}			C_{14}			C_{21}		
A_1	*(0.40*	*0.60*	*0.80)*	*(0.50*	*0.70*	*0.85)*	*(0.40*	*0.60*	*0.80)*	*(0.70*	*0.90*	*1.00)*	*(0.30*	*0.50*	*0.70)*
A_2	*(0.90*	*1.00*	*1.00)*	*(0.80*	*0.95*	*1.00)*	*(0.80*	*0.95*	*1.00)*	*(0.90*	*1.00*	*1.00)*	*(0.70*	*0.90*	*1.00)*
A_3	*(0.60*	*0.80*	*0.95)*	*(0.30*	*0.50*	*0.70)*	*(0.70*	*0.90*	*1.00)*	*(0.20*	*0.40*	*0.60)*	*(0.80*	*0.95*	*1.00)*

	C_{22}			C_{23}			C_{24}			C_{25}			C_{26}		
A_1	*(0.70*	*0.85*	*0.95)*	*(0.70*	*0.90*	*1.00)*	*(0.40*	*0.60*	*0,80)*	*(0.30*	*0.50*	*0.70)*	*(0.70*	*0.90*	*1.00)*
A_2	*(0.60*	*0.80*	*0.95)*	*(0.60*	*0.80*	*0.95)*	*(0.90*	*1.00*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.70*	*0.90*	*1.00)*
A_3	*(0.70*	*0.90*	*1.00)*	*(0.40*	*0.60*	*0.80)*	*(0.70*	*0.90*	*1.00)*	*(0.50*	*0.70*	*0.90)*	*(0.50*	*0.70*	*0.90)*

	C_{27}			C_{28}			C_{31}			C_{32}			C_{33}		
A_1	*(0.60*	*0.75*	*0.85)*	*(0.70*	*0.90*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.60*	*0.80*	*0.95)*	*(0.60*	*0.80*	*0.95)*
A_2	*(0.80*	*0.95*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.90*	*1.00*	*1.00)*
A_3	*(0.40*	*0.60*	*0.80)*	*(0.70*	*0.90*	*1.00)*	*(0.90*	*1.00*	*1.00)*	*(0.70*	*0.90*	*1.00)*	*(0.70*	*0.90*	*1.00)*

The Fuzzy Weighted Normalized Matrix

	C11			C12			C13			C14			C21		
A_1	(0,00	0,02	0,12)	(0,00	0,00	0,02)	(0,00	0,02	0,12)	(0,00	0,01	0,05)	(0,00	0,01	0,07)
A_2	(0,01	0,04	0,15)	(0,00	0,00	0,02)	(0,01	0,03	0,15)	(0,00	0,01	0,05)	(0,00	0,01	0,10)
A_3	(0,01	0,03	0,15)	(0,00	0,00	0,02)	(0,01	0,03	0,15)	(0,00	0,00	0,03)	(0,00	0,02	0,10)

	C22			C23			C24			C25			C26		
A_1	(0,01	0,06	0,40)	(0,00	0,01	0,07)	(0,01	0,05	0,38)	(0,00	0,02	0,16)	(0,03	0,17	0,84)
A_2	(0,01	0,06	0,40)	(0,00	0,01	0,07)	(0,01	0,08	0,47)	(0,01	0,04	0,23)	(0,03	0,17	0,84)
A_3	(0,01	0,06	0,42)	(0,00	0,01	0,06)	(0,01	0,07	0,47)	(0,00	0,03	0,21)	(0,02	0,13	0,75)

	C27			C28			C31			C32			C33		
A_1	(0,01	0,08	0,48)	(0,00	0,03	0,23)	(0,02	0,12	0,52)	(0,01	0,09	0,52)	(0,02	0,13	0,49)
A_2	(0,02	0,10	0,57)	(0,00	0,03	0,23)	(0,02	0,12	0,52)	(0,01	0,10	0,54)	(0,02	0,17	0,52)
A_3	(0,01	0,06	0,45)	(0,00	0,03	0,23)	(0,02	0,14	0,52)	(0,01	0,10	0,54)	(0,02	0,15	0,52)

The Distance Measurement

	A^*	A^-
A_1	3.61	2.56
A_2	3.52	2.77
A_3	3.59	2.66

CURRICULUM VITAE

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Publications	:	-
Work Life	:	Bahçeşehir University, Faculty of Engineering, Industrial Engineering Department, Teaching Assistant (2010, 2012)

EXCEL CALCULATIONS

Fuzzy Decision Matrix by 1st Decision Maker

	Knowledge			Skills			Abilities		
Knowledge	1,00	1,00	1,00	0,11	0,14	0,20	0,14	0,20	0,33
Skills	5,00	7,00	9,00	1,00	1,00	1,00	1,00	1,00	3,00
Abilities	3,00	5,00	7,00	0,33	1,00	1,00	1,00	1,00	1,00

Fuzzy Decision Matrix by 2nd Decision Maker

	Knowledge			Skills			Abilities		
Knowledge	1,00	1,00	1,00	0,14	0,20	0,33	0,20	0,33	1,00
Skills	3,00	5,00	7,00	1,00	1,00	1,00	1,00	1,00	3,00
Abilities	1,00	3,00	5,00	0,33	1,00	1,00	1,00	1,00	1,00

Fuzzy Aggregated Decision Matrix

	Knowledge			Skills			Abilities		
Knowledge	1,00	1,00	1,00	0,12	0,17	0,26	0,17	0,26	0,57
Skills	3,87	5,92	7,94	1,00	1,00	1,00	1,00	1,00	3,00
Abilities	1,73	3,87	5,92	0,33	1,00	1,00	1,00	1,00	1,00

r_i			
0,27	0,35	0,53	$\tilde{r}_1$
1,57	1,81	2,88	$\tilde{r}_2$
0,83	1,57	1,81	$\tilde{r}_3$

$\tilde{w}_i$			
0,05	0,09	0,20	$\tilde{w}_1$
0,30	0,48	1,08	$\tilde{w}_2$
0,16	0,42	0,68	$\tilde{w}_3$

$\tilde{w}_r$			
0,10			**Knowledge**
0,54			**Skills**
0,36			**Abilities**

Fuzzy Decision Matrix by 1st Decision Maker

	Occupational			Foreign Language			Graduated School			Academic		
Occupational Knowledge	1,00	1,00	1,00	7,00	9,00	9,00	0,14	0,20	0,33	3,00	5,00	7,00
Foreign Language Knowledge	0,11	0,11	0,14	1,00	1,00	1,00	0,11	0,14	0,20	0,14	0,20	0,33
Graduated School	3,00	5,00	7,00	5,00	7,00	9,00	1,00	1,00	1,00	5,00	7,00	9,00
Academic Publishing	0,14	0,20	0,33	3,00	5,00	7,00	0,11	0,14	0,20	1,00	1,00	1,00

Fuzzy Decision Matrix by 2nd Decision Maker

	Occupational			Foreign Language			Graduated School			Academic		
Occupational Knowledge	1,00	1,00	1,00	3,00	5,00	7,00	3,00	5,00	7,00	3,00	5,00	7,00
Foreign Language Knowledge	0,14	0,20	0,33	1,00	1,00	1,00	0,14	0,20	0,33	0,20	0,33	1,00
Graduated School	0,14	0,20	0,33	3,00	5,00	7,00	1,00	1,00	1,00	1,00	3,00	5,00
Academic Publishing	0,14	0,20	0,33	1,00	3,00	5,00	0,20	0,33	1,00	1,00	1,00	1,00

Fuzzy Aggregated Decision Matrix

	Knowledge			Knowledge			Graduated School			Publishing		
Occupational Knowledge	1,00	1,00	1,00	4,58	6,71	7,94	0,65	1,00	1,52	3,00	5,00	7,00
Foreign Language Knowledge	0,12	0,15	0,21	1,00	1,00	1,00	0,12	0,17	0,26	0,17	0,26	0,57
Graduated School	0,65	1,00	1,52	3,87	5,92	7,94	1,00	1,00	1,00	2,24	4,58	6,71
Academic Publishing	0,14	0,20	0,33	1,73	3,87	5,92	0,15	0,21	0,45	1,00	1,00	1,00

$\tilde{r}_i$			
1,73	2,41	3,03	$\tilde{r}_1$
0,23	0,28	0,42	$\tilde{r}_2$
1,54	2,28	3,00	$\tilde{r}_3$
0,44	0,64	0,97	$\tilde{r}_4$
$\tilde{w}_i$			
0,23	0,43	0,77	$\tilde{w}_1$
0,03	0,05	0,11	$\tilde{w}_2$
0,21	0,41	0,76	$\tilde{w}_3$
0,06	0,11	0,25	$\tilde{w}_4$
$\tilde{w}_r$			
0,42			**Occupational Knowledge**
0,06			**Foreign Language Knowledge**
0,40			**Graduated School**
0,12			**Academic Publishing**

Fuzzy Decision Matrix by 1st Decision Matrix

	Basic Skills			Complex Problem			System Skills			Experience			Number of Case			Success rate of			Stabilisation			Reference		
Basic Skills	1,00	1,00	1,00	1,00	3,00	5,00	3,00	5,00	7,00	0,14	0,20	0,33	1,00	1,00	3,00	0,11	0,14	0,20	0,14	0,20	0,33	0,20	0,33	1,00
Complex Problem Solving Skills	0,20	0,33	1,00	1,00	1,00	1,00	5,00	7,00	9,00	0,14	0,20	0,33	3,00	5,00	7,00	0,11	0,14	0,20	0,14	0,20	0,33	1,00	1,00	3,00
System Skills	0,14	0,20	0,33	0,11	0,14	0,20	1,00	1,00	1,00	0,11	0,14	0,20	0,20	0,33	1,00	0,11	0,14	0,20	0,14	0,20	0,33	0,11	0,14	0,20
Experience	3,00	5,00	7,00	3,00	5,00	7,00	5,00	7,00	9,00	1,00	1,00	1,00	1,00	1,00	3,00	0,11	0,14	0,20	0,14	0,20	0,33	3,00	5,00	7,00
Number of Case	0,33	1,00	1,00	0,14	0,20	0,33	1,00	3,00	5,00	0,33	1,00	1,00	1,00	1,00	1,00	0,14	0,20	0,33	0,20	0,33	1,00	0,14	0,20	0,33
Success rate of Cases	5,00	7,00	9,00	5,00	7,00	9,00	7,00	9,00	9,00	5,00	7,00	9,00	3,00	5,00	7,00	1,00	1,00	1,00	0,11	0,14	0,20	1,00	3,00	5,00
Stabilisation	3,00	5,00	7,00	3,00	5,00	7,00	3,00	5,00	7,00	3,00	5,00	7,00	1,00	3,00	5,00	5,00	7,00	9,00	1,00	1,00	1,00	3,00	5,00	7,00
Reference	1,00	3,00	5,00	0,33	1,00	1,00	5,00	7,00	9,00	0,14	0,20	0,33	3,00	5,00	7,00	0,20	0,33	1,00	0,14	0,20	0,33	1,00	1,00	1,00

Fuzzy Decision Matrix by 2nd Decision Matrix

	Basic Skills			Complex Problem			System Skills			Experience			Number of Case			Success rate of			Stabilisation			Reference		
Basic Skills	1,00	1,00	1,00	0,14	0,20	0,33	0,20	0,33	1,00	0,11	0,14	0,20	0,11	0,14	0,20	0,11	0,14	0,20	0,11	0,14	0,20	0,20	0,33	1,00
Complex Problem Solving Skills	3,00	5,00	7,00	1,00	1,00	1,00	3,00	5,00	7,00	1,00	3,00	5,00	1,00	3,00	5,00	1,00	1,00	3,00	1,00	3,00	5,00	1,00	3,00	5,00
System Skills	1,00	3,00	5,00	0,14	0,20	0,33	1,00	1,00	1,00	0,20	0,33	1,00	0,14	0,20	0,33	0,14	0,20	0,33	0,14	0,20	0,33	0,20	0,33	1,00
Experience	5,00	7,00	9,00	0,20	0,33	1,00	1,00	3,00	5,00	1,00	1,00	1,00	1,00	1,00	3,00	0,20	0,33	1,00	1,00	3,00	5,00	1,00	3,00	5,00
Number of Case	5,00	7,00	9,00	0,20	0,33	1,00	3,00	5,00	7,00	0,33	1,00	1,00	1,00	1,00	1,00	0,11	0,14	0,20	3,00	5,00	7,00	3,00	5,00	7,00
Success rate of Cases	5,00	7,00	9,00	0,33	1,00	1,00	3,00	5,00	7,00	1,00	3,00	5,00	5,00	7,00	9,00	1,00	1,00	1,00	3,00	5,00	7,00	3,00	5,00	7,00
Stabilisation	5,00	7,00	9,00	0,20	0,33	1,00	3,00	5,00	7,00	0,20	0,33	1,00	0,14	0,20	0,33	0,14	0,20	0,33	1,00	1,00	1,00	1,00	3,00	5,00
Reference	1,00	3,00	5,00	0,20	0,33	1,00	1,00	3,00	5,00	0,20	0,33	1,00	0,14	0,20	0,33	0,14	0,20	0,33	0,20	0,33	1,00	1,00	1,00	1,00

Fuzzy Aggregated Decision Matrix

	Basic Skills			Complex Problem			System Skills			Experience			Number of Case			Success rate of			Stabilisation			Reference		
Basic Skills	1,00	1,00	1,00	0,37	0,77	1,28	0,77	1,28	2,65	0,12	0,17	0,26	0,33	0,37	0,77	0,11	0,14	0,20	0,12	0,17	0,26	0,20	0,33	1,00
Complex Problem Solving Skills	0,77	1,28	2,65	1,00	1,00	1,00	3,87	5,92	7,94	0,37	0,77	1,28	1,73	3,87	5,92	0,33	0,37	0,77	0,37	0,77	1,28	1,00	1,73	3,87
System Skills	0,37	0,77	1,28	0,12	0,17	0,26	1,00	1,00	1,00	0,15	0,21	0,45	0,17	0,26	0,57	0,12	0,17	0,26	0,14	0,20	0,33	0,15	0,21	0,45
Experience	3,87	5,92	7,94	0,77	1,28	2,65	2,24	4,58	6,71	1,00	1,00	1,00	1,00	1,00	3,00	0,15	0,21	0,45	0,37	0,77	1,28	1,73	3,87	5,92
Number of Case	1,28	2,65	3,00	0,17	0,26	0,57	1,73	3,87	5,92	0,33	1,00	1,00	1,00	1,00	1,00	0,12	0,17	0,26	0,77	1,28	2,65	0,65	1,00	1,52
Success rate of Cases	5,00	7,00	9,00	1,28	2,65	3,00	4,58	6,71	7,94	2,24	4,58	6,71	3,87	5,92	7,94	1,00	1,00	1,00	0,57	0,84	1,18	1,73	3,87	5,92
Stabilisation	3,87	5,92	7,94	0,77	1,28	2,65	3,00	5,00	7,00	0,77	1,28	2,65	0,37	0,77	1,28	0,84	1,18	1,72	1,00	1,00	1,00	1,73	3,87	5,92
Reference	1,00	3,00	5,00	0,26	0,57	1,00	2,24	4,58	6,71	0,17	0,26	0,57	0,65	1,00	1,52	0,17	0,26	0,57	0,17	0,26	0,57	1,00	1,00	1,00

r_i			
0,23	0,34	0,62	$\tilde{r}_1$
0,82	1,42	2,50	$\tilde{r}_2$
0,16	0,24	0,44	$\tilde{r}_3$
0,94	1,56	2,83	$\tilde{r}_4$
0,50	0,92	1,40	$\tilde{r}_5$
2,21	3,77	5,02	$\tilde{r}_6$
1,21	2,09	3,39	$\tilde{r}_7$
0,40	0,75	1,38	$\tilde{r}_8$

$\tilde{w}_i$			
0,01	0,03	0,10	$\tilde{w}_1$
0,05	0,13	0,39	$\tilde{w}_2$
0,01	0,02	0,07	$\tilde{w}_3$
0,05	0,14	0,44	$\tilde{w}_4$
0,03	0,08	0,22	$\tilde{w}_5$
0,13	0,34	0,78	$\tilde{w}_6$
0,07	0,19	0,52	$\tilde{w}_7$
0,02	0,07	0,21	$\tilde{w}_8$

$\tilde{w}_r$			
0,03			**Basic Skills**
0,14			**Complex Problem Solving Skills**
0,02			**System Skills**
0,15			**Experience**
0,08			**Number of Case**
0,30			**Success rate of Cases**
0,19			**Stabilisation**
0,07			**Reference**

Fuzzy Decision Matrix by 1st Decision Matrix

	Psychomotor			Cognitive Abilities			Managerial		
Psychomotor Abilities	1,00	1,00	1,00	0,20	0,33	1,00	0,14	0,20	0,33
Cognitive Abilities	1,00	3,00	5,00	1,00	1,00	1,00	0,20	0,33	1,00
Managerial Competence	3,00	5,00	7,00	1,00	3,00	5,00	1,00	1,00	1,00

Fuzzy Decision Matrix by 2nd Decision Maker

	Psychomotor			Cognitive Abilities			Managerial		
Psychomotor Abilities	1,00	1,00	1,00	1,00	3,00	5,00	3,00	5,00	7,00
Cognitive Abilities	0,20	0,33	1,00	1,00	1,00	1,00	1,00	1,00	3,00
Managerial Competence	0,14	0,20	0,33	0,33	1,00	1,00	1,00	1,00	1,00

Fuzzy Aggregated Decision Matrix

	Psychomotor			Cognitive Abilities			Managerial		
Psychomotor Abilities	1,00	1,00	1,00	0,45	0,99	2,24	0,65	1,00	1,52
Cognitive Abilities	0,45	0,99	2,24	1,00	1,00	1,00	0,45	0,57	1,73
Managerial Competence	0,65	1,00	1,52	0,57	1,73	2,24	1,00	1,00	1,00

r̃i			
0,66	1,00	1,50	r̃1
0,58	0,83	1,57	r̃2
0,72	1,20	1,50	r̃3

w̃i			
0,14	0,33	0,76	w̃1
0,13	0,27	0,80	w̃2
0,16	0,40	0,76	w̃3

w̃r			
0,33			Psychomotor Abilities
0,32			Cognitive Abilities
0,35			Managerial Competence

Occupational Knowledge	0,23	0,43	0,77	0,05	0,09	0,20	0,01	0,04	0,15
Foreign Language Knowledge	0,03	0,05	0,11	0,05	0,09	0,20	0,00	0,00	0,02
Graduated School	0,21	0,41	0,76	0,05	0,09	0,20	0,01	0,04	0,15
Academic Publishing	0,06	0,11	0,25	0,05	0,09	0,20	0,00	0,01	0,05
Basic Skills	0,01	0,03	0,10	0,30	0,54	1,08	0,00	0,02	0,10
Complex Problem Solving Skills	0,05	0,13	0,39	0,30	0,54	1,08	0,01	0,07	0,42
System Skills	0,01	0,02	0,07	0,30	0,54	1,08	0,00	0,01	0,07
Experience	0,05	0,14	0,44	0,30	0,54	1,08	0,02	0,08	0,47
Number of Case	0,03	0,08	0,22	0,30	0,54	1,08	0,01	0,04	0,23
Success rate of Cases	0,13	0,34	0,78	0,30	0,54	1,08	0,04	0,18	0,84
Stabilisation	0,07	0,19	0,52	0,30	0,54	1,08	0,02	0,10	0,57
Reference	0,02	0,07	0,21	0,30	0,54	1,08	0,01	0,04	0,23
Psychomotor Abilities	0,14	0,33	0,76	0,16	0,42	0,68	0,02	0,14	0,52
Cognitive Abilities	0,13	0,27	0,80	0,16	0,42	0,68	0,02	0,12	0,54
Managerial Competence	0,16	0,40	0,76	0,16	0,42	0,68	0,03	0,17	0,52

Occupational Knowledge	1st DM			2nd DM		
A_1	5,00	7,00	9,00	3,00	5,00	7,00
A_2	9,00	10,00	10,00	9,00	10,00	10,00
A_3	7,00	9,00	10,00	5,00	7,00	9,00

Foreign Language Knowledge	1st DM			2nd DM		
A_1	3,00	5,00	7,00	7,00	9,00	10,00
A_2	7,00	9,00	10,00	9,00	10,00	10,00
A_3	3,00	5,00	7,00	3,00	5,00	7,00

Graduated School	1st DM			2nd DM		
A_1	3,00	5,00	7,00	5,00	7,00	9,00
A_2	9,00	10,00	10,00	7,00	9,00	10,00
A_3	7,00	9,00	10,00	7,00	9,00	10,00

Academic Publishing	1st DM			2nd DM		
A_1	7,00	9,00	10,00	7,00	9,00	10,00
A_2	9,00	10,00	10,00	9,00	10,00	10,00
A_3	3,00	5,00	7,00	1,00	3,00	5,00

Basic Skills	1st DM			2nd DM		
A_1	3,00	5,00	7,00	3,00	5,00	7,00
A_2	7,00	9,00	10,00	7,00	9,00	10,00
A_3	9,00	10,00	10,00	7,00	9,00	10,00

Complex Problem Solving Skills	1st DM			2nd DM		
A_1	5,00	7,00	9,00	9,00	10,00	10,00
A_2	7,00	9,00	10,00	5,00	7,00	9,00
A_3	7,00	9,00	10,00	7,00	9,00	10,00

System Skills	1st DM			2nd DM		
A_1	7,00	9,00	10,00	7,00	9,00	10,00
A_2	5,00	7,00	9,00	7,00	9,00	10,00
A_3	5,00	7,00	9,00	3,00	5,00	7,00

Experience	1st DM			2nd DM		
A_1	3,00	5,00	7,00	5,00	7,00	9,00
A_2	9,00	10,00	10,00	9,00	10,00	10,00
A_3	7,00	9,00	10,00	7,00	9,00	10,00

Number of Case	1st DM			2nd DM		
A_1	3,00	5,00	7,00	3,00	5,00	7,00
A_2	7,00	9,00	10,00	7,00	9,00	10,00
A_3	5,00	7,00	9,00	5,00	7,00	9,00

Success rate of Cases	1st DM			2nd DM		
A_1	7,00	9,00	10,00	7,00	9,00	10,00
A_2	7,00	9,00	10,00	7,00	9,00	10,00
A_3	5,00	7,00	9,00	5,00	7,00	9,00

Stabilisation	1st DM			2nd DM		
A_1	3,00	5,00	7,00	9,00	10,00	10,00
A_2	9,00	10,00	10,00	7,00	9,00	10,00
A_3	3,00	5,00	7,00	5,00	7,00	9,00

Reference	1st DM			2nd DM		
A_1	7,00	9,00	10,00	7,00	9,00	10,00
A_2	7,00	9,00	10,00	7,00	9,00	10,00
A_3	7,00	9,00	10,00	7,00	9,00	10,00

Psychomotor Abilities	1st DM			2nd DM		
A_1	7,00	9,00	10,00	7,00	9,00	10,00
A_2	7,00	9,00	10,00	7,00	9,00	10,00
A_3	9,00	10,00	10,00	9,00	10,00	10,00

Cognitive Abilities	1st DM			2nd DM		
A_1	7,00	9,00	10,00	5,00	7,00	9,00
A_2	7,00	9,00	10,00	7,00	9,00	10,00
A_3	7,00	9,00	10,00	7,00	9,00	10,00

Managerial Competence	1st DM			2nd DM		
A_1	7,00	9,00	10,00	5,00	7,00	9,00
A_2	9,00	10,00	10,00	9,00	10,00	10,00
A_3	7,00	9,00	10,00	7,00	9,00	10,00

The ratings of the three candidates by 1st decision maker under all criteria

	C_{11}			C_{12}			C_{13}			C_{14}			C_{21}			C_{22}			C_{23}		
A_1	5,00	7,00	9,00	3,00	5,00	7,00	3,00	5,00	7,00	7,00	9,00	10,00	3,00	5,00	7,00	5,00	7,00	9,00	7,00	9,00	10,00
A_2	9,00	10,00	10,00	7,00	9,00	10,00	9,00	10,00	10,00	9,00	10,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	5,00	7,00	9,00
A_3	7,00	9,00	10,00	3,00	5,00	7,00	7,00	9,00	10,00	3,00	5,00	7,00	9,00	10,00	10,00	7,00	9,00	10,00	5,00	7,00	9,00

	C_{24}			C_{25}			C_{26}			C_{27}			C_{28}			C_{31}			C_{32}			C_{33}		
A_1	3,00	5,00	7,00	3,00	5,00	7,00	7,00	9,00	10,00	3,00	5,00	7,00	7,00	9,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00
A_2	9,00	10,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	9,00	10,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	9,00	10,00	10,00
A_3	7,00	9,00	10,00	5,00	7,00	9,00	5,00	7,00	9,00	3,00	5,00	7,00	7,00	9,00	10,00	9,00	10,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00

The ratings of the three candidates by 2nd decision maker under all criteria

	C_{11}			C_{12}			C_{13}			C_{14}			C_{21}			C_{22}			C_{23}		
A_1	3,00	5,00	7,00	7,00	9,00	10,00	5,00	7,00	9,00	7,00	9,00	10,00	3,00	5,00	7,00	9,00	10,00	10,00	7,00	9,00	10,00
A_2	9,00	10,00	10,00	9,00	10,00	10,00	7,00	9,00	10,00	9,00	10,00	10,00	7,00	9,00	10,00	5,00	7,00	9,00	7,00	9,00	10,00
A_3	5,00	7,00	9,00	3,00	5,00	7,00	7,00	9,00	10,00	1,00	3,00	5,00	7,00	9,00	10,00	7,00	9,00	10,00	3,00	5,00	7,00

	C_{24}			C_{25}			C_{26}			C_{27}			C_{28}			C_{31}			C_{32}			C_{33}		
A_1	5,00	7,00	9,00	3,00	5,00	7,00	7,00	9,00	10,00	9,00	10,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	5,00	7,00	9,00	5,00	7,00	9,00
A_2	9,00	10,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	9,00	10,00	10,00
A_3	7,00	9,00	10,00	5,00	7,00	9,00	5,00	7,00	9,00	5,00	7,00	9,00	7,00	9,00	10,00	9,00	10,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00

Aggregated Fuzzy Decision Matrix

	C_{11}			C_{12}			C_{13}			C_{14}			C_{21}			C_{22}			C_{23}		
A_1	4,00	6,00	8,00	5,00	7,00	8,50	4,00	6,00	8,00	7,00	9,00	10,00	3,00	5,00	7,00	7,00	8,50	9,50	7,00	9,00	10,00
A_2	9,00	10,00	10,00	8,00	9,50	10,00	8,00	9,50	10,00	9,00	10,00	10,00	7,00	9,00	10,00	6,00	8,00	9,50	6,00	8,00	9,50
A_3	6,00	8,00	9,50	3,00	5,00	7,00	7,00	9,00	10,00	2,00	4,00	6,00	8,00	9,50	10,00	7,00	9,00	10,00	4,00	6,00	8,00

	C_{24}			C_{25}			C_{26}			C_{27}			C_{28}			C_{31}			C_{32}			C_{33}		
A_1	4,00	6,00	8,00	3,00	5,00	7,00	7,00	9,00	10,00	6,00	7,50	8,50	7,00	9,00	10,00	7,00	9,00	10,00	6,00	8,00	9,50	6,00	8,00	9,50
A_2	9,00	10,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	8,00	9,50	10,00	7,00	9,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00	9,00	10,00	10,00
A_3	7,00	9,00	10,00	5,00	7,00	9,00	5,00	7,00	9,00	4,00	6,00	8,00	7,00	9,00	10,00	9,00	10,00	10,00	7,00	9,00	10,00	7,00	9,00	10,00

Normalized Fuzzy Decision Matrix

	C_{11}			C_{12}			C_{13}			C_{14}			C_{21}			C_{22}			C_{23}		
A_1	0,40	0,60	0,80	0,50	0,70	0,85	0,40	0,60	0,80	0,70	0,90	1,00	0,30	0,50	0,70	0,70	0,85	0,95	0,70	0,90	1,00
A_2	0,90	1,00	1,00	0,80	0,95	1,00	0,80	0,95	1,00	0,90	1,00	1,00	0,70	0,90	1,00	0,60	0,80	0,95	0,60	0,80	0,95
A_3	0,60	0,80	0,95	0,30	0,50	0,70	0,70	0,90	1,00	0,20	0,40	0,60	0,80	0,95	1,00	0,70	0,90	1,00	0,40	0,60	0,80

	C_{24}			C_{25}			C_{26}			C_{27}			C_{28}			C_{31}			C_{32}			C_{33}		
A_1	0,40	0,60	0,80	0,30	0,50	0,70	0,70	0,90	1,00	0,60	0,75	0,85	0,70	0,90	1,00	0,70	0,90	1,00	0,60	0,80	0,95	0,60	0,80	0,95
A_2	0,90	1,00	1,00	0,70	0,90	1,00	0,70	0,90	1,00	0,80	0,95	1,00	0,70	0,90	1,00	0,70	0,90	1,00	0,70	0,90	1,00	0,90	1,00	1,00
A_3	0,70	0,90	1,00	0,50	0,70	0,90	0,50	0,70	0,90	0,40	0,60	0,80	0,70	0,90	1,00	0,90	1,00	1,00	0,70	0,90	1,00	0,70	0,90	1,00

Fuzzy Weighted Matrix

C_{11}	0,01	0,04	0,15
C_{12}	0,00	0,00	0,02
C_{13}	0,01	0,04	0,15
C_{14}	0,00	0,01	0,05
C_{21}	0,00	0,02	0,10
C_{22}	0,01	0,07	0,42
C_{23}	0,00	0,01	0,07
C_{24}	0,02	0,08	0,47
C_{25}	0,01	0,04	0,23
C_{26}	0,04	0,18	0,84
C_{27}	0,02	0,10	0,57
C_{28}	0,01	0,04	0,23
C_{31}	0,02	0,14	0,52
C_{32}	0,02	0,12	0,54
C_{33}	0,03	0,17	0,52

Weighted Normalized Fuzzy Decision Matrix

	C_{11}			C_{12}			C_{13}			C_{14}			C_{21}			C_{22}			C_{23}		
A_1	0,00	0,02	0,12	0,00	0,00	0,02	0,00	0,02	0,12	0,00	0,01	0,05	0,00	0,01	0,07	0,01	0,06	0,40	0,00	0,01	0,07
A_2	0,01	0,04	0,15	0,00	0,00	0,02	0,01	0,03	0,15	0,00	0,01	0,05	0,00	0,01	0,10	0,01	0,06	0,40	0,00	0,01	0,07
A_3	0,01	0,03	0,15	0,00	0,00	0,02	0,01	0,03	0,15	0,00	0,00	0,03	0,00	0,02	0,10	0,01	0,06	0,42	0,00	0,01	0,06
A*	0,15	0,15	0,15	0,02	0,02	0,02	0,15	0,15	0,15	0,05	0,05	0,05	0,10	0,10	0,10	0,40	0,40	0,40	0,07	0,07	0,07
A-	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,01	0,00	0,00	0,00

	C_{24}			C_{25}			C_{26}			C_{27}			C_{28}			C_{31}			C_{32}			C_{33}		
A_1	0,01	0,05	0,38	0,00	0,02	0,16	0,03	0,17	0,84	0,01	0,08	0,48	0,00	0,03	0,23	0,02	0,12	0,52	0,01	0,09	0,52	0,02	0,13	0,49
A_2	0,01	0,08	0,47	0,01	0,04	0,23	0,03	0,17	0,84	0,02	0,10	0,57	0,00	0,03	0,23	0,02	0,12	0,52	0,01	0,10	0,54	0,02	0,17	0,52
A_3	0,01	0,07	0,47	0,00	0,03	0,21	0,02	0,13	0,75	0,01	0,06	0,45	0,00	0,03	0,23	0,02	0,14	0,52	0,01	0,10	0,54	0,02	0,15	0,52
A*	0,47	0,47	0,47	0,23	0,23	0,23	0,84	0,84	0,84	0,57	0,57	0,57	0,23	0,23	0,23	0,52	0,52	0,52	0,54	0,54	0,54	0,52	0,52	0,52
A-	0,01	0,01	0,01	0,00	0,00	0,00	0,02	0,02	0,02	0,01	0,01	0,01	0,00	0,00	0,00	0,02	0,02	0,02	0,01	0,01	0,01	0,02	0,02	0,02

Distance from FPIS

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{31}	C_{32}	C_{33}	Sum
A_1	0,11	0,01	0,11	0,04	0,08	0,30	0,05	0,37	0,18	0,61	0,43	0,17	0,37	0,40	0,37	3,61
A_2	0,10	0,01	0,11	0,04	0,07	0,30	0,05	0,35	0,17	0,61	0,42	0,17	0,37	0,39	0,35	3,52
A_3	0,11	0,02	0,11	0,04	0,07	0,30	0,05	0,35	0,17	0,63	0,44	0,17	0,36	0,39	0,36	3,59

Distance from FNIS

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{31}	C_{32}	C_{33}	Sum
A_1	0,07	0,01	0,07	0,03	0,04	0,23	0,04	0,21	0,10	0,48	0,27	0,13	0,29	0,30	0,28	2,56
A_2	0,05	0,01	0,09	0,03	0,06	0,23	0,04	0,27	0,14	0,48	0,32	0,13	0,29	0,31	0,30	2,77
A_3	0,09	0,01	0,09	0,02	0,06	0,24	0,03	0,27	0,12	0,43	0,26	0,13	0,30	0,31	0,30	2,66

The closeness coefficient of each alternative

A_1	0,42
A_2	0,44
A_3	0,43