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ANALYSIS OF STUDENT SELECTION CRITERIA FOR ERASMUS PROGRAM BY USING FUZZY-AHP

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Abstract

An analytical method to reach the best decision is one of the most preferable way in business platforms. Many times, beside the measurable variables, there exist qualitative variables, or people are supposed to prefer the best among the many choices. When an analytical way to make a successful decision is needed, Analytical Hierarchy Process (AHP) is one of the best ways for deciding among the complex criteria structure in different levels. Fuzzy-AHP is the extension of AHP that is used when uncertainty affects decision making process. In this study, the authors aim at developing a systematic solution approach utilizing Fuzzy-AHP on a decision-making problem described as “selecting the best student” in an institution for a student exchange program being applied in Europe called Socrates/Erasmus. Fuzzy-AHP approach is applied in a Faculty of a University, and evaluations are performed with the academicians in the selection commission as a decision group. Fuzzy-AHP calculations are performed on this data collected through a question-form, and relevant analysis are completed to obtain the important values of the selection criteria. Finally, a systematic approach is developed as decision support mechanism for the decision makers who are the members of selection commission.

Keywords: Analytical Hierarchy Process (AHP), Fuzzy Sets, Fuzzy analytical hierarchy process (Fuzzy – AHP), Erasmus Program, student selection.

Öz

Erasmus Programları için Öğrenci Seçim Kriterlerinin Bulanık AHS ile Analizi

En iyi karara ulaşmak için analitik bir yöntem kullanımı, işletme alanında en çok tercih edilen alternatiflerden biridir. Ölçülebilir değişkenlerin yanında,

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kalitatif değişkenler de bulunmakta ya da insanlar çok sayıda seçenek arasından seçim yapmak zorunluluğu ile karşılaşmaktadır. Başarılı bir karar için analitik bir yöntem tercih edilecekse ve karar değişkenlerini kalitatif olarak tanımlamak mümkün oluyorsa, Analitik Hiyerarşi Süreci (AHS) farklı seviyelerdeki karmaşık kriter yapıları arasında çözüm arayan, en iyi çözüm yollarından biridir. Bulanık AHS ise belirsizliğin karar problemi etkilediği durumlarda kullanılmak üzere geliştirilmiş bir yöntem olup, AHS'nin bir uzantısı olarak tanımlanabilir. Bu çalışmada, Erasmus Programı adı ile bilinen ve Avrupa'da uygulanan öğrenci değişim programı için "kurum içinde en iyi öğrenciyi seçmek" olarak tanımlanan karar verme probleminin çözümüne sistematik bir yaklaşım geliştirilmesi amaçlanmış ve bu sistematik çözümün geliştirilmesinde Bulanık AHS yönteminden yararlanılmıştır. Bulanık AHS, belirli bir üniversitenin bir fakültesinde uygulanmış ve karar grubu olarak seçim komitesindeki akademisyenler ile değerlendirmeler yapılmıştır. İhtiyaç duyulan veriler, bir soru formu yardımıyla toplanarak Bulanık AHS yöntemiyle gerekli hesaplamalar yapılmış ve belirlenen kriterlere ilişkin analizler gerçekleştirilerek bu kriterlerin ağırlıkları hesaplanmıştır. Sonuç olarak, seçim komisyonunda çalışan üyelerin seçim kararı vermesinde bir destek mekanizması oluşturacak sistematik bir çözüm elde edilmiştir.

Anahtar Sözcükler: Analitik hiyerarşi süreci (AHS), bulanık mantık, bulanık analitik hiyerarşi süreci (Bulanık AHS), Erasmus Programı, öğrenci seçimi.

INTRODUCTION

In their daily lives, people often have to make decisions. *When* a decision made is as important as *what* is being decided. Deciding too quickly can be hazardous; delaying too long can mean missed opportunities. What people need is a systematic and comprehensive approach to decision making. Decision-making is fundamental to furthering our goal of survival and ensuring the quality of human life (Saaty, 2001).

One of the decision making issues is to select the best decision among the alternatives and the criteria set is required for such a process. When the criteria and variable set are defined by numerically measures, then, according to the constraints and assumptions, many operational research techniques can be applied for the optimum solution. However, sometimes decision makers can not reach any quantitative values, or define the problem with mathematical equations which means that decision maker have to solve the problem with qualitative variables or linguistic evaluations. Inspite of these conditions, an analytical way providing systematic approach to obtain a successful solution is still possible. Analytical Hierarchy Process (AHP) is one of the best ways for deciding among the complex criteria structure in different levels especially for the selection problems. Fuzzy- AHP is the extension of AHP that is used when uncertainty affects decision making process. Both Fuzzy-AHP and AHP depend on the pairwise comparisons of all selection criteria in the hierarchy.

In evaluating *n* competing alternatives A_1, ... A_n under a given criterion, it is natural to use the framework of pairwise comparisons represented by an *n x n* square matrix from which a set of preference values for the alternatives is derived. Many methods for estimating the preference values from the pairwise comparison matrix have been proposed and their effectiveness comparatively evaluated. Some of the proposed estimating methods presume interval-scaled preference values. However, most of the estimating methods proposed and studied are within the paradigm of the Analytical Hierarchy Process (AHP) that presumes ratio-scaled preference values. The main challenge is how to reconcile the inevitable inconsistency of the pairwise comparison matrix elicited from the decision makers in real-world applications. When the decision maker is unable to rank the alternatives holistically and directly with respect to a criterion, pairwise comparisons are often used as intermediate decision support (Choo & Wedley, 2004: 894).

In this paper, the extent analysis method on Fuzzy-AHP is represented and then the method is applied to determine the importance level of the student selection criteria in a student exchange program, namely the Erasmus Program problem. Fuzzy-AHP approach is applied in a Faculty of a University, and evaluations are performed with the academicians in the selection commission as a decision group. Fuzzy-AHP calculations are performed on this data collected through a question-form, and relevant analyses are completed to obtain the importance values of the selection criteria.

In Part 2, the Socrates – Erasmus Education Program is introduced, and then, in Part 3 the conceptual framework of the study with the sub sections AHP, Fuzzy Logic, Fuzzy-AHP are represented respectively. After drawing the framework, in Part 4, the problem is defined and application steps are introduced with examples, then results are discussed in the conclusion part.

1. SOCRATES-ERASMUS EDUCATION PROGRAM

EU-European Commission plans and supports several education and training programs for European students. Erasmus is one of these programs that include short and long-term student exchanges between two European countries that have bilateral agreements. Actions of Erasmus include sub programs in several levels of education such as Erasmus, Comenius, Grundtvig, Lingua, Minerva, etc. In the scope of this study, only Erasmus ("European Community

Action Scheme for the Mobility of University Students") Program is considered which consists of the mobility and exchange of higher education students, teaching staff from universities, and establishment of thematic networks.

In 1995 Erasmus became incorporated into the new Erasmus Program which covers education from school to university to life long learning. Erasmus can involve student mobility, teaching staff mobility and curriculum development and is based on co-operation agreements between Higher Education Institutions in different participating states. (http://www.erasmus.ac.uk/whatis.html). It seeks to enhance the quality and reinforce the European dimension of higher education by encouraging transnational cooperation between universities, boosting European mobility and improving the transparency and full academic recognition of studies and qualifications throughout the Union. Erasmus action is targeted at higher education institutions and their students and staff in all 25 Member States of the European Union, the three countries of the European Economic Area (Iceland, Liechtenstein and Norway), and the three candidate countries (Bulgaria, Romania and Turkiye). Currently 2199 higher education institutions in 31 countries are participating in Erasmus. Since the creation of Erasmus in 1987, 1.2 million students have benefited of an Erasmus study period abroad, (http://europa.eu.int/comm/education/programmes/Socrates/Erasmus/erasmus_en.html).

Countries manage this mobility through their *national agencies* and Universities apply to these agencies according to their bilateral agreements with the Universities of other countries. In each country, the national agency determines the general criteria for student selection, because it is important to represent the culture and the success of the country. In Turkiye, some of the universities have many bilateral agreements with many other universities from Europe. Every year, students are exchanged so that they study for one semester or a year in different countries based on the bilateral agreements.

2. AHP AND FUZZY - AHP

AHP is a method for ranking decision alternatives and selecting the best one when the decision maker has multiple criteria (Taylor, 2004: 374). It answers the question, "Which one?" The decision maker will select the alternative that best meets his or her decision criteria. AHP is a process for developing a numerical score to rank each decision alternative based on how well each alternative meets the decision maker's criteria (Russell & Taylor, 2003: 321).

In AHP, preferences between alternatives are determined by making pairwise comparisons. In a pairwise comparison the decision maker examines two alternatives based on one criterion and indicates a preference. These comparisons are made using a preference scale, which assigns numerical values to different levels of preference (Taha, 2003: 522). The standard preference scale used for AHP is the Saaty's fundamental scale 1-9 that lies between "equal importance" to "extreme importance". The value of 1 indicates "equal importance", 3 "moderately more", 5 "strongly more", and 7 "very strongly" and 9 indicates "extremely more importance". The values of 2, 4, 6, and 8 are allotted to indicate compromise values of importance (Pohekar & Ramachandran, 2004: 369). In the pairwise comparison matrix, the value 9 indicates that one factor is "extremely more important than" the other, and the value 1/9 indicates that one factor is extremely less important than the other, and the value 1 indicates equal importance (Sarkis & Talluri, 2004: 322). Therefore, if the importance of one factor with respect to a second is given, then the importance of the second factor with respect to the first is the reciprocal. This means $a_{ij}=9 \Rightarrow a_{ji}=1/9$ (Sarkis & Talluri, 2004: 323). Ratio scale and the use of verbal comparisons are used for weighting of quantifiable and non-quantifiable elements (Pohekar & Ramachandran, 2004: 369).

In 1977, Saaty proposed AHP, as a decision aid to help solve unstructured problems in economics, social and management sciences. AHP has been applied in a variety of contexts: from the simple everyday problem of selecting a school to the complex problems of designing alternative future outcomes of a developing country, evaluating political candidacy, allocating energy resources, and so on. AHP enables the decision-makers to structure a complex problem in the form of a simple hierarchy and to evaluate a large number of quantitative and qualitative factors in a systematic manner under confliction of multiple criteria. The application of AHP to the complex problem usually involves four major steps (Cheng, et al, 1999: 424):

1. Break down the complex problem into a number of small constituent elements and then structure the elements in a hierarchical form.

2. Make a series of pair wise comparisons among the elements according to a ratio scale 1, 3, 5, 7 and 9

3. Use the Eigen value method to estimate the relative weights of the elements.

4. Aggregate these relative weights and synthesize them for the final measurement of given decision alternatives.

The essence of the process is decomposition of a complex problem into a hierarchy with goal (criterionive) at the top of the hierarchy, criteria and sub-criteria at levels and sub-levels of the hierarchy, and decision alternatives at the bottom of the hierarchy. Elements at given hierarchy levels are compared in pairs to assess their relative preference with respect to each of the elements at the next higher level. The method computes and aggregates their eigenvectors until the composite final vector of weight coefficients for alternatives is obtained. The entries of final weight coefficients vector reflect the relative importance (value) of each alternative with respect to the goal stated at the top of the hierarchy (Pohekar & Ramachandran, 2004, 369). A decision maker may use this vector according to his particular needs and interests. To elicit pairwise comparisons performed at a given level, a matrix *A* is created in turn by putting the result of pair wise comparison of element *i* with element *j* into the position a_{ji} as below.

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

Where

n = criteria number to be evaluated

C_i = i. criteria,

A_{ij} = importance of i. criteria according to j^{th}. Criteria

After obtaining the weight vector, it is then multiplied with the weight coefficient of the element at a higher level (that was used as criterion for pair wise comparisons). The procedure is repeated upward for each level, until the top of the hierarchy is reached. The overall weight coefficient, with respect to the goal for each decision alternative is then obtained. The alternative with the highest weight coefficient value should be taken as the best alternative (Pohekar & Ramachandran, 2004: 370). Saaty's AHP, is a well-known decision-making analytical tool used for modeling unstructured problems in various areas, e.g., social, economic, and management sciences (Bard & Sousk, 1990; Triantaphyllou & Mann, 1995; Wabalickis, 1988). The scope of this study consists of fuzzy-AHP application, thus, intensively fuzzy-AHP applications presented from literature. Before the concept of fuzzy-AHP, it would be relevant to see the basics of fuzzy logic.

In the classical AHP, the decision maker is asked to supply exact pair wise comparison ratios r_{ij} between sub-criteria $A_1; \ldots ; A_n$ for each criterion in each level of the hierarchy (Saaty, 1992; Saaty & Vargas, 1994; Saaty & Horman, 1996; Saaty, 1999). These comparison ratios form the comparison matrix whose principal eigenvector gives the relative weights of the sub-criteria. There is an extensive literature that addresses the situation where the comparison ratios are imprecise judgments (Leung & Chao, 2000: 102). In most of the real-world problems, some of the decision data can be precisely assessed while others cannot. Humans are unsuccessful in making quantitative predictions, whereas they are comparatively efficient in qualitative forecasting (Kulak & Kahraman, 2005: 192).Essentially, the uncertainty in the preference judgements give rise to uncertainty in the ranking of alternatives as well as difficulty in determining consistency of preferences (Leung & Chao, 2000: 102). These applications are performed with many different perspectives and proposed methods for Fuzzy-AHP. In this study, Chang's (1992) extent analysis on Fuzzy-AHP is formulated for a selection problem.

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

In complex systems, the experiences and judgments of humans are represented by linguistic and vague patterns. Therefore, a much better representation of these linguistics can be developed as quantitative data; this type of data set is then refined by the evaluation methods of fuzzy set theory. On the other hand, the AHP method is mainly used in nearly crisp (non-fuzzy) decision applications and creates and deals with a very unbalanced scale of judgement. Therefore, the AHP method does not take into account the uncertainty associated with the mapping. The AHP's subjective judgement, selection and preference of decision-makers have great influence on the success of the method. The conventional AHP still cannot reflect the human thinking style. Avoiding these risks on performance, the fuzzy - AHP, a fuzzy extension of AHP, was developed to solve the hierarchical fuzzy problems (Cheng, et al, 1999: 424).

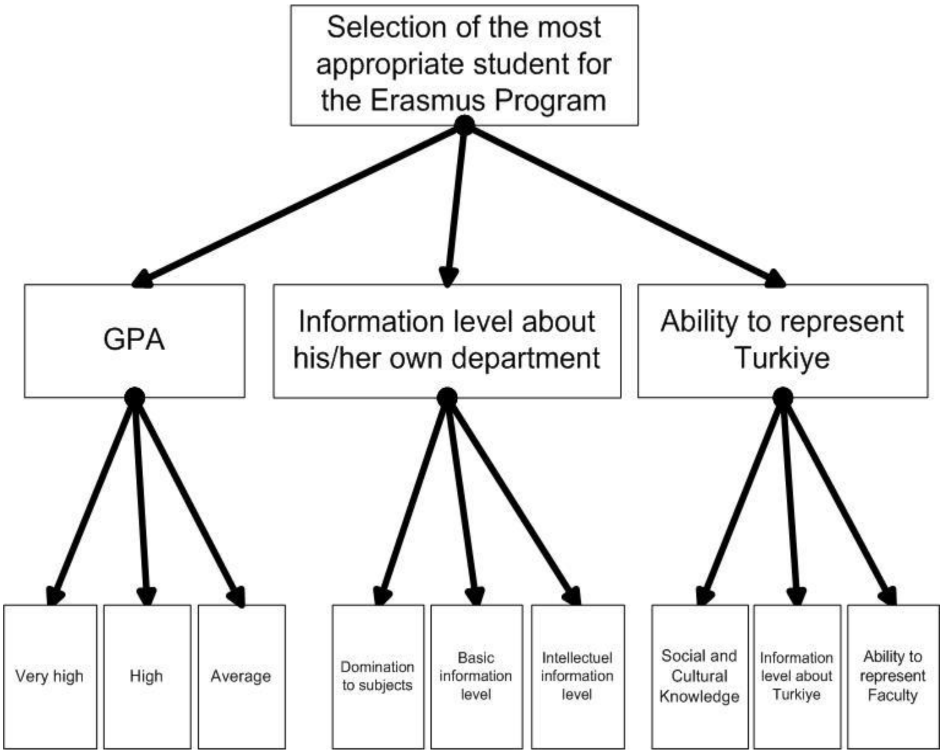
3. IMPLEMENTATION ON STUDENT SELECTION PROBLEM

In this part, firstly the outlines of Erasmus program and the extent analysis with fuzzy-AHP are given and then the method is applied to determine the importance level of the student selection criteria in the Erasmus Program problem.

Fuzzy-AHP Model and Numerical Results

A decision making process arises to select the student who will go abroad for the next year. There exist some standard criteria determined by the National Agency beside the private criteria of the Faculty of Business. For example, in Faculty of Business, the education language is English, and interviews with the candidate students are made in English, so there is no need for extra language exam and also language is not a major criteria for selection. According to the management board of faculty and university the following criteria set is constructed as given in Figure 1:

Figure 1: Hierarchy of Criteria



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

To apply the process depending on this hierarchy, according to the method of Chang's (1992) extent analysis, each criterion is taken and extent analysis for each criterion, g_i; is performed, on respectively. Therefore, *m extent* analysis values for each criterion can be obtained by using following notation (Kahraman, et al, 2004: 176):

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

where g_i is the goal set ($i = 1, 2, 3, 4, 5, ...n$) and all the $M_{g_i}^j$ ($j = 1, 2, 3, 4, 5, ..., m$) are Triangular Fuzzy Numbers *(TFNs)*. The steps of Chang's analysis can be given as in the following:

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

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

To obtain equation 2;

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

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

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

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

and to obtain equation 4;

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

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

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

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

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

Step 2: The degree of possibility $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is defined as equation 7:

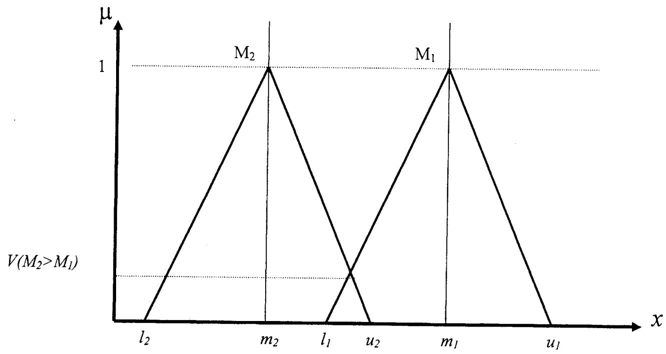
$$V(M_2 \geq M_1) = \sup_{y \geq x} [\min(\mu_{M_1}(x), \mu_{M_2}(y))] \tag{7}$$

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

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

where d is the highest intersection point μ_{M_1} and μ_{M_2} (see Figure 2) (Zhu et al, 1999: 451).

Figure 2. The Intersection Between M_1 and M_2



Reference: Zhu, et al, 1999: 452

To compare *M1* and *M2*; we need both the values of $V(M_2 \geq M_1)$ and $V(M_1 \geq M_2)$:

Step 3. The degree possibility for a convex fuzzy number to be greater than *k* convex fuzzy numbers M_i $(i = 1, 2, 3, 4, 5, ..., k)$ can be defined by

$V(M \geq M_1, M_2, M_3, M_4, M_5, M_6, ..., M_k) =$

$V[(M \geq M_1)$ and $(M \geq M_2)$ and $(M \geq M_3)$ and $(M \geq M_4)$ and ... and $(M \geq M_k)] =$

$\min V(M \geq M_i), i = 1, 2, 3, 4, 5, ..., k.$

Assume that $d'(A_i)$ in equation 9 is defined as follows:

$$d'(A_i) = \min V(S_i \geq S_k) \quad (9)$$

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

$$W' = (d'(A_1), d'(A_2), d'(A_3), d'(A_4), d'(A_5), ..., d'(A_n))^T \quad (10)$$

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

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

$$W = (d(A_1), d(A_2), d(A_3), d(A_4), d(A_5), d(A_6), ..., d(A_n))^T \quad (11)$$

Where *W* is non-fuzzy numbers.

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

Table 1. TFN Values

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

Reference: Tolga, et al, 2005: 22

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

Question 1: How important is "average grade" when it is compared with "information level about his/her own department"?

Question 2: How important is "average grade" when it is compared with "ability to represent Turkiye"?

Question 3: How important is "information level about his/her own department" when it is compared with "ability to represent Turkiye"?

The remaining questions are arranged in a form and represented in Appendix A. By starting with the first hierarchy level comparisons are performed to determine the local and global importance levels. As an example for comparison of the criteria in the first level , for only one person in decision group, the fuzzy evaluation matrix is obtained in the Table 2 below:

Table 2. Fuzzy Evaluation Matrix With Respect To The Goal

	GPA (G)	Information level about his/her own department (D)	Ability to represent Turkiye (T)
GPA (G)	(1,1,1)	(3/2,2,5/2)	(2/5,1/2,2/3)
Information level about his/her own department (D)	(2/5,1/2,2/3)	(1,1,1)	(2/5,1/2,2/3)
Ability to represent Turkiye (T)	(3/2,2,5/2)	(3/2,2,5/2)	(1,1,1)

From the fuzzy numbers in Table 2, following calculations are performed to reach the importance values of the first level (see equation 6) :

S_G = (2.9; 3.5; 4.17) $\otimes$ (1/12.5; 1/10.5; 1/8.7)

S_D = (1.8; 2; 2.33) $\otimes$ (1/12.5; 1/10.5; 1/8.7)

S_T = (4; 5; 6) $\otimes$ (1/12.5; 1/10.5; 1/8.7)

After the calculations from the vectors given above, following values are obtained according to the equation 8 ,

$V(S_G \geq S_D) = 1$

$V(S_G \geq S_T) = 0.53$

$V(S_D \geq S_T) = 0$

$V(S_D \geq S_G) = 0.2$

$V(S_T \geq S_G) = 1$

$V(S_T \geq S_D) = 1$

Finally, the weight vector from Table 2 is found after the normalization of possibility values of S_G, S_D, S_T as W_{Goal} given below:

$W_{Goal} = (0.34; 0; 0.66)^T$. This means according to this person, the most important criterion in the first level is "Ability to represent Turkiye" with 0.66 importance value, and the second one is "GPA score" with 0.34, where information about the department has not any importance.

The next step consists of operations to calculate the local importance values or weight vector of the second level in hierarchy with the same procedure. For each branch, each criteria group in the second level is subject to a pair wise comparison in itself. For example, the sub-criteria of the criterion “ability to represent Turkiye” are “social and cultural knowledge”, “information level about Turkiye”, “Ability to represent Faculty”, and the evaluation matrix is constructed in Table 3:

Table 3. Fuzzy Evaluation Matrix With Respect To The Ability to Represent Turkiye

	Social level (L)	Information level about Turkiye (T)	Ability to represent Faculty (F)
Social level (L)	(1,1,1)	(5/2,3,7/2)	(5/2,3,7/2)
Information level about Turkiye (T)	(2/7,1/3,2/5)	(1,1,1)	(5/2,3,7/2)
Ability to represent Faculty (F)	(2/7,1/3,2/5)	(2/7,1/3,2/5)	(1,1,1)

The weight vector from Table 3 is calculated as $W_G = (0.91; 0.09; 0)^T$.

Thus, this person thinks that the most important criterion is Social and Cultural Knowledge with the value 0.91 and remaining are less important than that. Other criteria sets are calculated with the same approach and procedure is ended when global and local importance levels are obtained. Table 4 shows the local importance levels and Table 5 shows overall or global importance levels for this decision making problem.

Table 4. Sub Criteria Importance Weightings for Committee Member1

Goal	Main Attribute 1	Main Attribute 2	Main Attribute 3
0.34	0.34	0.5	0.91
0	0.66	0	0.09
0.66	0	0.5	0

Table 5. Importance Weightings of All Main and Sub Criteria for Committee Member 1

Sub Attribute	Importance Weighting	Sub Attribute	Importance Weighting	Sub Attribute	Importance Weighting
Very High (V)	0.12	Domination to subjects (S)	0	Social level (L)	0.59
High (H)	0.22	Basic information level (B)	0	Information level about Turkiye (T)	0.07
Average (A)	0	Intellectual information level (I)	0	Ability to represent Faculty (F)	0

Overall importance values for the problem are calculated by multiplying the weight vectors, $W_G * W_{main\ criteria}$:

This example depends on the thought of one of the person in the commission, so others' thoughts are also evaluated and importance levels are calculated for each of them. Then, average of all people's evaluations determines the individual and overall importance levels or priorities of the commission. Table 6 shows the decision of each member of the commission and the overall decision about selecting the best student for the Erasmus Student Exchange Program.

The last part shows the averages and global weight values of the criteria in the last level. The quantitative values explain that the most important three criteria are "information level about Turkiye", "social and cultural knowledge", "very high GPA score", with the priorities: 0.2789, 0.2203, 0.1506, respectively, thus, the student who has a rich social and cultural knowledge, very high GPA and high information level about Turkiye would have a higher chance of being selected.

Some of the criteria are calculated as zero which is an interesting result, because, at the beginning of the study the given criteria set is assumed to be evaluated. This is not an extraordinary situation and a gap for the Fuzzy-AHP approach, and the situation in the case that the decision makers may not consider one or more of the criteria for the evaluation of the employees even if these criteria are placed in the hierarchy.

Table 6. Sub Criteria Importance Weightings for All Committee Members and Averages

Committee Member 1					
V	0.11900	S	0.00000	L	0.59444
H	0.22596	B	0.00000	T	0.06060
A	0.00000	I	0.00000	F	0.00000
Committee Member 2					
V	0.00000	S	0.00000	L	0.11445
H	0.00000	B	0.00000	T	0.56281
A	0.00000	I	0.00000	F	0.32275
Committee Member 3					
V	0.03815	S	0.107582	L	0.281403
H	0.03815	B	0.107582	T	0.281403
A	0.03815	I	0.107582	F	0
Committee Member 4					
V	0.333333	S	0	L	0.111111
H	0	B	0.166667	T	0.111111
A	0	I	0.166667	F	0.111111
Committee Member 5					
V	0.262274	S	0	L	0
H	0.188382	B	0	T	0.378523
A	0.131276	I	0	F	0.039545
Average					
V	0.150551	S	0.021516	L	0.220281
H	0.090499	B	0.054850	T	0.278888
A	0.033885	I	0.054850	F	0.094680

This study indicates which criteria are important with which importance level or weights, so that the best students for the Erasmus Program are selected. During the evaluation phase, the weights of some criteria in the hierarchy are obtained as zero. This is not an extraordinary situation and a gap for the Fuzzy-AHP approach, and the situation in the case that the decision makers may not consider one or more of the criteria for the evaluation of the students even if these criteria are placed in the hierarchy. Therefore, the Fuzzy-AHP approach provides to eliminate the unnecessary criterion or criteria if all of the decision makers assign “absolutely not important” value when compared with the other criteria.

Using the selection criteria weights, performance point for any candidate student can be calculated as the weighted sum of all points as given in equation 12:

$$P= p_1*w_1+p_2*w_2+p_3*w_3+\ldots\ldots\ldots.+p_n*w_n \quad (12)$$

Where

p_i: performance point for the criterion $i.$ $(i=1,\ldots,n)$

w_i: weight of the criterion $i.$ $(i=1,\ldots,n)$

P: overall performance point for each student.

For this study, as an example; one of the students called A evaluated by the committee and obtained the following points from each criterion over 100 points and weights are used as given in the last part of Table 6:

c_1=50 c_2=90 c_3=60 c_4=70 c_5=40 c_6=65 c_7=70 c_8=80 c_9=75

The overall performance is then calculated as:

P=50*0.150551+90*0.090499+60*0.033885+70*0.021516+40*0.054850+65*0.054850+70*0.220281+80*0.28888+75*0.094680

P= 70.6 gives the evaluation performance of student A among the other candidate students. Therefore, according to the restrictions, students with the highest points according to all of the criteria would be selected for exchanging with other universities who are the memberships of Erasmus Program.

CONCLUSION

This paper presented a sample study of analytical decision-making process under qualitative criteria and uncertainty with linguistic variables. When some or all of the criteria are qualitative, linguistic variables are needed and supposed to be modeled by specific methods processing with these linguistic variables whereas quantitative variables and criteria can be modeled with many mathematical programming or heuristic methods. For the selection problems with qualitative criteria, there exists a method, namely, "Analytical Hierarchy Process" depends on pair wise comparisons of all criteria leveled in a hierarchy. Even if many criteria arise during the decision making process, AHP provides constructing the relevant tree structure, and for each level finds the local priorities, which are going to be used at the end of this process to reach the global priorities. When the uncertainties are concerned within the decision, then fuzzy extension of AHP, namely, Fuzzy-AHP method is needed for a successful question. In the scope of this study, these uncertainties are considered and Fuzzy AHP was applied for the problem to obtain the important values for selecting the best student in Erasmus Program.

The aim of this study was to develop an analytical way to make the best decision for the selection of the students to participate in an exchange program, namely Erasmus Program. Erasmus Program is organized by the European Commission and supports student mobility among the European countries that have institutional agreements with each other and also national agencies were established in each country for the national arrangements. The students selected for this program should have adequate knowledge, behavior and attitudes to represent his/her country and university. Thus, the decision making process should be efficient and objective.

In summary, this decision making process was modeled depending on Fuzzy - AHP under pre-determined criteria for the selection commission in the Faculty of Business. All members joined the evaluation and two-leveled hierarchy was obtained after interviewing with the group members, then for each level and criterion, global and local priorities were calculated. For the top level, the criteria were “GPA”, “Information level about his/her own department” and “ability to represent Turkiye”. Among these major criteria the most important one is and “ability to represent Turkiye” with 59.2 % importance level. When these weights are distributed on the sub level, the most important criteria were obtained as, “information level about Turkiye”, “social and cultural knowledge”, “very high GPA score”, respectively. the student who has a rich social and cultural knowledge, “very high GPA” and “high information level about Turkiye” would have a higher chance to be chosen.

Consequently, this study indicates which criteria were important with which importance level or weights, so that the best students for the Erasmus Program were selected. This process will help the commission members during the evaluation of the candidate students. For further work, they can either give points to the students for each criterion then calculate the weighted sum, or they can continue using AHP by pair wise comparison of students with respect to each criterion in the bottom level. Further studies can be performed utilizing the advantages of both AHP and Fuzzy AHP, for selection problem in any decision making problem considering the constraints, variables and assumptions of the decision making environment.

Weights of some criteria are calculated as zero which was an interesting result for the commission members at the beginning of the study, because they saw that they did not pay attention of some of the criteria they used for evalution. This is not an extraordinary situation and a gap for the Fuzzy-AHP approach, and the situation in the case that the decision makers may not consider one or more of the criteria for the evaluation of the employees even if these criteria are placed in the hierarchy. Therefore, the Fuzzy-AHP approach provides some hints to eliminate a criterion or criteria if all of the decision makers assign "absolutely not important" value when compared with the other criteria and expresses the more important criteria. In other words, this situation means that when some of the criteria are especially important for the selection, then one or some of the others are nearly zero affect on the decision. Some expertise does not accept this result whereas some thinks it is natural. Due to the fact that some cultures are affected by the logic based on existence – nonexistence, which is called 0-1 logic, some researchers deny the fuzzy set theory. But, Japan scientists adapt to the fuzzy set theory and they use fuzzy logic in many different areas.

APPENDIX A. QUESTIONNAIRE

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

With respect to the main criterion "average grade"

Question 1: How important is "very high" when it is compared with "high"?

Question 2: How important is "very high" when it is compared with "average"?

Question 3: How important is "high" when it is compared with "average"?

With respect to: "average grade"	Importance (or preference) of one sub-criterion over another										
Questions	Criteria	Absolute	Very strong	Fairly strong	Weak	Equal	Weak	Fairly strong	Very strong	Absolute	Criteria
1	Very high										High
2	Very high										Average
3	High										Average

With respect to the main criterion "information level about his/her own department"

Question 1: How important is "domination to subjects" when it is compared with "basic information level"?

Question 2: How important is "domination to subjects" when it is compared with "intellectual information level"?

Question 3: How important is "basic information level" when it is compared with "intellectual information level"?

With respect to: "information level about his/her own department"	Importance (or preference) of one sub-criterion over another										
Questions	Criteria	Absolute	Very strong	Fairly strong	Weak	Equal	Weak	Fairly strong	Very strong	Absolute	Criteria
1	Domination to subjects										Basic information level
2	Domination to subjects										Intellectual information level
3	Basic information level										Intellectual information level

With respect to the main criterion “ability to represent Turkiye”

Question 1: How important is “social level” when it is compared with “information level about Turkiye”?

Question 2: How important is “social level” when it is compared with “ability to represent Faculty”?

Question 3: How important is “information level about Turkiye” when it is compared with “ability to represent Faculty”?

With respect to: “ability to represent Turkiye”	Importance (or preference) of one sub-criterion over another										
Questions	Criteria	Absolute	Very strong	Fairly strong	Weak	Equal	Weak	Fairly	Very strong	Absolute	Criteria
1	Social level										Information level about Turkiye
2	Social level										Ability to represent Faculty
3	Information level about Turkiye										Ability to represent Faculty

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