A Type-2 Fuzzy MCDM Method for Ranking Private Universities in İstanbul

Melike Erdoğan, İhsan Kaya

***Abstract*— Choosing a university is one of the most important decisions that affects future of young student. This decision requires considering a number of criteria not only numerical but also linguistic. Istanbul is the first alternative for young students' university choice in Turkey. As well as the state universities, the private universities are also so popular in this city. In this paper, a ranking method that manages to choice of university selection is created by using technique for order preference by similarity to ideal solution (TOPSIS) method based on type-2 fuzzy set. This method has been used for ranking private universities in Istanbul.**

***Index Terms*— Interval Type-2 Fuzzy Numbers, Multi Criteria Decision Making, Private Universities**

I. Introduction

With the continuing increase in the number of private universities in Turkey, the alternatives that are considered when choosing university are increased too. Many factors must be considered in the process of making decision regarding university selection. These factors could be the quality of academics, university facilities or the district that lies within university and they can be analyzed from many different perspectives. With the introduction of private universities between university alternatives, the factors that not normally considered as cost should be taken into account during choosing process. As seen, there are both qualitative and quantitative criteria that should be considered in this decision making process. In particular, besides a large number of objective criteria must be taken into account with subjective criteria for the preference for private universities. Choosing a university is a multi-criteria decision making problem [1].

URAP (University Ranking by Academic Performance) Research Laboratory is established in 2009 within Middle East Technical University Information Institute. The purpose of URAP is to develop the scientific method in order to assess higher education institutions in accordance with their academic achievement and to share the results of studies with the public [2]. According to URAP, general ranking of private universities in 2013 are shown in Table 1.

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TABLE I.
PRIVATE UNIVERSITY RANKING IN TURKEY-
ACCORDING TO URAP

Ranking	University	Ranking	University
1	SABANCI UNIVERSITY	**16**	MALTEPE UNIVERSITY
2	İ.D.BİLKENT UNIVERSITY	**17**	İSTANBUL KÜLTÜR UNIVERSITY
3	KOÇ UNIVERSITY	**18**	IŞIK UNIVERSITY
4	TOBB UNIVERSITY OF ECONOMICS AND TECHNOLOGY	**19**	UFUK UNIVERSITY
5	FATİH UNIVERSITY	**20**	İSTANBUL TİCARET UNIVERSITY
6	BAŞKENT UNIVERSITY	**21**	YAŞAR UNIVERSITY
7	DOĞUŞ UNIVERSITY	**22**	İSTANBUL BİLGİ UNIVERSITY
8	YEDİTEPE UNIVERSITY	**23**	HALİÇ UNIVERSITY
9	ATILIM UNIVERSITY	**24**	OKAN UNIVERSITY
10	ÇANKAYA UNIVERSITY	**25**	BEYKENT UNIVERSITY
11	ÖZYEĞİN UNIVERSITY	**26**	ÇAĞ UNIVERSITY
12	İSTANBUL BİLİM UNIVERSITY	**27**	İZMİR UNIVERSITY
13	İZMİR EKONOMİ UNIVERSITY	**28**	İSTANBUL AYDIN UNIVERSITY
14	BAHÇEŞEHİR UNIVERSITY	**29**	İSTANBUL AREL UNIVERSITY
15	KADİR HAS UNIVERSITY		

In this paper, we propose a methodology rank four of the leading private universities in Istanbul. For this aim, we propose a fuzzy multi criteria decision making method to consider both qualitative and quantitative criteria to evaluate the alternatives. We used TOPSIS MCDM method based on type-2 fuzzy sets The criteria are determined with reviewing relative literature and the alternatives are clarified by URAP. The rest of this paper is organized as follows: Section 2 summarizes the related literature. Section 3 presents details of proposed fuzzy MCDM method. Section 4 includes a real case study in İstanbul. Finally, Section 5 discusses results and future research suggestions.

II. Literature Review

It is possible to meet some papers that analyze selection of private universities. Some of the can be shown as follow: Wu et al.[3] aimed to weight the performance evaluation indices for higher education based on the official

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performance evaluation structure developed by Taiwan Assessment and Evaluation Association (TWAEA) and to rank 12 private universities listed by the Ministry of Education as a case study. They applied a hybrid multiple-criteria decision making (MCDM) model to accomplish these objectives. Specifically, they utilized the analytic hierarchy process (AHP) to accomplish their first aim, but also adopted the VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method for the second aim. Webster [4] presented principal component regression analysis to examine the relative contributions of 11 ranking criteria used to construct the U.S. News & World Report (USNWR) tier rankings of national universities. The main finding of his study was that the actual contributions of the 11 ranking criteria examined differ substantially from the explicit USNWR weighting scheme because of severe and pervasive multicollinearity among the ranking criteria. Giannoulis and Ishizaka [5] described a three-tier Web-system, which produced a customized ranking of British Universities with ELECTRE III reflecting personal preferences, where information was uncertain and vague. Using this case study, the benefits of ELECTRE III in the ranking process were illustrated. Göksu [6] investigated fuzzy AHP to apply university preference ranking.

III. The Proposed Type-2 Fuzzy Based Method

In this paper, we use a fuzzy MCDM method to rank the private universities in Istanbul. To get more realistic results, we used TOPSIS method with type-2 fuzzy sets. This method gives a useful way to handle fuzzy MCDM problem in a more and more flexible [7].

Lee and Chen [8] present the TOPSIS method for handling fuzzy multiple attributes group decision-making problems based on interval type-2 fuzzy sets. Assume that there is a set X of alternatives, where $X = \{x_1, x_2, ..., x_n\}$, and assume that there is a set F of attributes, where $F = \{f_1, f_2, ..., f_m\}$. Assume that there are k decision-makers D1,D2,… and Dk. The set F of attributes can be divided into two sets F1 and F2, where F1 denotes the set of benefit attributes, F2 denotes the set of cost attributes, $F_1 \cap F_2 = \phi$, and $F_1 \cup F_2 = F$. The details of proposed method are presented as follows [8].

Step 1: Construct the decision matrix Y_p of the p^{th} decision-maker and construct the average decision matrix $\overline{Y}$, respectively, shown as follows:

$$Y_p = (\tilde{f}_{ij}^{\,p})_{mxn} = \begin{array}{c} \\ f_1 \\ f_2 \\ \vdots \\ \vdots \\ f_m \end{array} \begin{array}{c} \begin{array}{cccccc} x_1 & x_2 & x_3 & ..... & x_n \end{array} \\ \begin{bmatrix} \tilde{f}_{11}^{\,p} & \tilde{f}_{12}^{\,p} & \tilde{f}_{13}^{\,p} & .... & \tilde{f}_{1n}^{\,p} \\ \tilde{f}_{21}^{\,p} & \tilde{f}_{21}^{\,p} & ... & ... & \tilde{f}_{2n}^{\,p} \\ \vdots & \vdots & ... & ... & \\ \vdots & \vdots & ... & ... & \\ \tilde{f}_{m1}^{\,p} & \tilde{f}_{m2}^{\,p} & & & \tilde{f}_{mn}^{\,p} \end{bmatrix} \end{array} \quad (2)$$

$$\overline{Y} = (\tilde{f}_{ij}^{\,p})_{mxn}, \quad (3)$$

where $\tilde{f}_{ij} = \left(\frac{\tilde{f}_{ij}^{1} \oplus \tilde{f}_{ij}^{2} ... \oplus \tilde{f}_{ij}^{k}}{k} \right)$, $\tilde{f}_{ij}$ is an interval type-2 fuzzy set, $1 \le i \le m$, $1 \le j \le n$, $1 \le p \le k$, and k denotes the number of decision-makers.

Step 2: Construct the weighting matrix W_p of the attributes of the p^{th} decision-maker and construct the average weighting matrix $\overline{W}$, respectively, shown as follows:

$$W_p = (\tilde{w}_i^p)_{1xm} = \begin{array}{c} \begin{array}{cccc} f_1 & f_1 & & fm \end{array} \\ \begin{bmatrix} \tilde{w}_1^p & \tilde{w}_1^p & ... & \tilde{w}_n^p \end{bmatrix} \end{array}, \quad (4)$$

$$\overline{W} = (\tilde{w}_i)_{1xm}, \quad (5)$$

$\tilde{w}_i = \frac{\tilde{w}_i^1 \oplus \tilde{w}_i^2 \oplus ... \oplus \tilde{w}_i^k}{k}$, $\tilde{w}_i$ is an interval type-2 fuzzy set, $1 \le i \le m$, $1 \le p \le k$, and k denotes the number of decision makers.

Step 3: Construct the weighted decision matrix $\overline{Y}_w$,

$$\overline{Y}_w = (\tilde{v}_{ij})_{mxn} = \begin{array}{c} \\ f_1 \\ f_2 \\ \vdots \\ \vdots \\ f_m \end{array} \begin{array}{c} \begin{array}{ccccc} x_1 & x_2 & x_3 & ..... & x_n \end{array} \\ \begin{bmatrix} \tilde{v}_{11} & \tilde{v}_{12} & \tilde{v}_{13} & .... & \tilde{v}_{1n} \\ \tilde{v}_{21} & \tilde{v}_{22} & ... & ... & \tilde{v}_{2n} \\ \vdots & \vdots & ... & ... & \\ \vdots & \vdots & ... & ... & \\ \tilde{v}_{m1} & \tilde{v}_{m1} & & & \tilde{v}_{m1} \end{bmatrix} \end{array}, \quad (6)$$

Step 4: Calculate the ranking value $Rank(\tilde{v}_{ij})$ of the interval type-2 fuzzy set $\tilde{v}_{ij}$, where $1 \le j \le n$. Construct the ranking weighted decision matrix $\overline{Y}_w^*$,

$$\overline{Y}_w^* = (Rank(\tilde{v}_{ij}))_{mxn}, \quad (7)$$

where $1 \le i \le m$ and $1 \le j \le n$.

Step 5: Determine the positive ideal solution $x^+ = (v_1^+, v_2^+, ..., v_m^+)$ and the negative-ideal solution $x^- = (v_1^-, v_2^-, ..., v_m^-)$, where

$$v_i^+ = \begin{cases} \max\limits_{1 \le j \le n} \{Rank(\tilde{v}_{ij})\}, & \text{if } f_i \in F_1 \\ \min\limits_{1 \le j \le n} \{Rank(\tilde{v}_{ij})\}, & \text{if } f_i \in F_2 \end{cases} \quad (8)$$

$$v_i^- = \begin{cases} \min\limits_{1 \le j \le n} \{Rank(\tilde{v}_{ij})\}, & \text{if } f_i \in F_1 \\ \max\limits_{1 \le j \le n} \{Rank(\tilde{v}_{ij})\}, & \text{if } f_i \in F_2 \end{cases} \quad (9)$$

where F_1 denotes the set of benefit attributes, F_2 denotes the set of cost attributes, and $1 \le i \le m$.

Step 6: Calculate the distance $d^+(x_j)$ between each alternative x_j and the positive ideal solution x^+, shown as follows:

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$$d^{+}(x_j)=\sqrt{\sum_{i=1}^{m}(Rank(\tilde{v}_{ij})-v_i^{+})^2}, \quad (10)$$

where $1 \le j \le n$. Calculate the distance $d^{-}(x_j)$ between each alternative x_j and the negative-ideal solution x^{-}, shown as follows:

$$d^{-}(x_j)=\sqrt{\sum_{i=1}^{m}(Rank(\tilde{v}_{ij})-v_i^{-})^2}, \quad (11)$$

where $1 \le j \le n$.

Step 7: Calculate the relative degree of closeness $C(x_j)$ of x_j with respect to the positive ideal solution x^{+}, shown as follows:

$$C(x_j)=\frac{d^{-}(x_j)}{d^{-}(x_j)+d^{+}(x_j)}, \quad (12)$$

where $1 \le j \le n$.

Step 8: Sort the values of $C(x_j)$ in a descending sequence, where $1 \le j \le n$. The larger the value of $C(x_j)$ means the higher the preference of the alternative x_j, where $1 \le j \le n$.

IV. A Real Case Study

There are 9 state universities and 40 private universities in İstanbul. The population is about 12 million in this city. There are about two and a half million elementary and high school students [9]. Because of Istanbul is the most beautiful city in the country, many students outside of the city also prefer university education this city. Dense population and desirability of the city private universities have made it popular to be preferred.

As a real case study, we aim to rank top four private universities in İstanbul. Firstly, we prepared a survey to get the linguistic scores from the experts. Three experts who lecture in private studies and have an experience on this area are chosen from academic community to score the criteria and alternatives. The evaluation criteria are determined from the related literature and experts' idea. Table 2 shows the criteria that are used to evaluate the alternatives.

In order to obtain results closer to reality, interval type-2 fuzzy sets are used in this paper. To reduce the level of uncertainty and obtain results closer to the truth, type-2 fuzzy sets are often applied. Type-2 fuzzy sets are the extension of type-1 fuzzy sets and have fuzzy membership function itself. The scale to evaluate the criteria and alternatives are taken from the paper of Chen and Lee [8]. The scale in interval type-2 fuzzy sets that we used to score and evaluate the criteria and alternatives is shown in Table 3.

Alternatives are named as University 1, University 2, University 3, and University 4. According to experts' evaluation, criteria weights are calculated as shown in Table 4.

TABLE II.
THE EVALUATION CRITERIA

Main Criteria	**Sub Criteria**
Social (C1)	C_{11}: Effectiveness of Student Clubs
	C_{12}:University festivals
International (C2)	C_{21}:Foreign Language Education
	C_{22}:International Activities
	C_{23}:Foreign Faculty and Students
	C_{24}:Foreign Instructors
Technological Competencies(C3)	C_{31}:University Infrastructure
	C_{32}:Laboratories and Tools
Educational (C4)	C_{41}:Education & Training Facilities
	C_{42}:Quality of Teaching Stuff
	C_{43}:Capacity of the university to Produce a project on national and international level
	C_{44}:Success Rating of University
	C_{45}:Library Services
Student Perspective (C5)	C_{51}:Dormitory Facilities
	C_{52}:Internship Opportunities
	C_{53}:Scholarships
	C_{54}:Price
	C_{55}:Location

TABLE III
LINGUISTIC SCALE AND INTERVAL TYE-2 CORRESPONDINGS

Linguistic Terms	*Interval Type-2 Fuzzy Sets*
Very Low	((0,0,0,0.1;1,1),(0,0,0,0.05;0.9,0.9))
Low	((0,0.1,0.1,0.3;1,1),(0.05,0.1,0.1,0.2;0.9,0.9))
Medium Low	((0.1,0.3,0.3,0.5;1,1),(0.2,0.3,0.3,0.4;0.9,0.9))
Medium	((0.3,0.5,0.5,0.7;1,1),(0.4,0.5,0.5,0.6;0.9,0.9))
Medium High	((0.5,0.7,0.7,0.9;1,1),(0.6,0.7,0.7,0.9;0.9,0.9))
High	((0.7,0.9,0.9,1;1,1),(0.8,0.9,0.9,0.95;0.9,0.9))
Very High	((0.9,1,1,1;1,1),(0.95,1,1,1;0.9,0.9))

TABLE IV.
CRITERIA WEIGHTS

Criteria	***Weights***
C_{11}	((0.57,0.73,0.73,0.83;1,1),(0.57,0.73,0.73,0.83;1,1))
C_{12}	((0.43,0.63,0.63,0.8;1,1),(0.43,0.63,0.63,0.8;1,1))
C_{21}	((0.57,0.77,0.77,0.9;1,1),(0.57,0.77,0.77,0.9;1,1))
C_{22}	((0.77,0.93,0.93,1;1,1),(0.77,0.93,0.93,1;1,1))
C_{23}	((0.37,0.57,0.57,0.73;1,1),(0.37,0.57,0.57,0.73;1,1))
C_{24}	((0.63,0.8,0.8,0.9;1,1),(0.63,0.8,0.8,0.9;1,1))
C_{31}	((0.83,0.97,0.97,1;1,1),(0.83,0.97,0.97,1;1,1))
C_{32}	((0.83,0.97,0.97,1;1,1),(0.83,0.97,0.97,1;1,1))
C_{41}	((0.37,0.57,0.57,0.73;1,1),(0.37,0.57,0.57,0.73;1,1))
C_{42}	((0.43,0.6,0.6,0.73;1,1),(0.43,0.6,0.6,0.73;1,1))
C_{43}	((0.5,0.67,0.67,0.8;1,1),(0.5,0.67,0.67,0.8;1,1))
C_{44}	((0.5,0.7,0.7,0.83;1,1),(0.5,0.7,0.7,0.83;1,1))
C_{45}	((0.77,0.93,0.93,1;1,1),(0.77,0.93,0.93,1;1,1))
C_{51}	((0.63,0.8,0.8,0.9;1,1),(0.63,0.8,0.8,0.9;1,1))
C_{52}	((0.37,0.57,0.57,0.73,1,1),(0.37,0.57,0.57,0.73;1,1))
C_{53}	((0.77,0.93,0.93,1;1,1),(0.77,0.93,0.93,1;1,1))
C_{54}	((0.37,0.57,0.57,0.73;1,1),(0.37,0.57,0.57,0.73;1,1))
C_{55}	((0.57,0.77,0.77,0.9;1,1),(0.57,0.77,0.77,0.9;1,1))

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When the table 4 is analyzed, the most important criteria are cleared as the price and scholarship. The criteria location of the school Foreign Faculty and Students are identified as the least affecting criteria when choosing a private university. After the criteria weights are determined, the ranking of the universities is obtained by applying type-2 fuzzy interval TOPSIS steps. The closeness coefficients of the alternatives are shown in Table 5.

TABLE V.
RANKING OF THE UNIVERSITIES

Alternatives	Cc_i	Rank
University 1	0.55	1
University 4	0.47	2
University 2	0.39	3
University 3	0.38	4

According to Table 5, the alternative university 1 is determined as the first alternative with the 0.55 coefficient of closeness. Then it is followed by the alternatives of University 4, University 2 and University 3, respectively. It means that university 1 should be preferred firstly when choosing private universities. University 2 and university 3 have relatively low scores and students should pay attention to the this two alternatives if they want to select the most preferred universities.

V. Conclusion

Choice of university is an important decision that affects future life of people and their economic career. Many factors should be considered when this decision is analyzed. Recently, it is observed that the number of private universities has been increased. This indicates that making choose, many criteria need to consider to make a right selection between alternatives. Multi-criteria decision making is an effective method that evaluates the quantitative and qualitative criteria when it is used with fuzzy set theory. Fuzzy numbers make the results more close to reality. Especially type-2 fuzzy sets reduce the level of uncertainty and MCDM methods when used with the type-2 fuzzy set, results are closer more to the truth.

In this paper, we use TOPSIS multi criteria decision making method with interval type -2 fuzzy set to make a chose between private university alternatives. For this aim, five main criteria and eighteen sub criteria are used to evaluate alternatives. The criteria and the alternatives have been evaluated by three experts. Finally, four private universities are ranked according to their closeness factors. The most important criteria are determined which affects the decision making process and the recommendations are made about which factors should be given more importance to be more preferably universities.

As future suggestions, different fuzzy MCDM method can be used - or state universities be taken into consideration in decision making process. By the way, a sensitivity analysis can be applied to observe the changes in parameters.

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