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Incorporating Fuzzy AHP and PROMETHEE for Clssification of Student Dormitories in Iran

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Abstract

In this research a discipline for grading of country's student dormitory will be designed. The major goal of classification is to promote the quality of student dormitories, and results of this grading in addition of creating a healthy competitive space between universities for promotion, will have important consequence of equating the rental money of dormitories proportionate with dormitories grade. Also with respect to appendix policies of article 44 of constitutional law and 5th program of development sentences, ministry of science, research and technology shall give welfare services to nongovernmental companies. So existing of such systems for grading of dormitories, will obviously invigorate the supervising dimension of ministry of science, student welfare fund and universities on given dormitories. Although there are several evaluation methods for universities and centers for higher education, but no method for grading of dormitories in international level has been reported up to now. Therefore in this paper, with different beneficiaries corporation, important dimensions and measures for grading of dormitories has been determined and with help of designed system, student dormitories are classifying to four classes.

Keywords: *classification, dormitories, analytical hierarchic process, PROMETHEE.*

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Introduction

Considering that the students are major addressees of higher education system, so today grading of presented capabilities from higher education institutes to students seems to be necessary. Also in our country on evaluation and grading of higher education institutes from educational, investigational and research services aspect some actions has been done. But considering ministry of science students welfare fund statistics, based on population of 145 thousand persons of resident student at governmental dormitories, for grading of presented services by higher education institutes, no actions has been done up to now. Hence, in this research the goal is to grading dormitories based on some standards and measures for equating students paid tuition and also preparing the competitive space to promote the quality level. For this purpose, according to reaching this goal, by using weighing and classification methods or using phased numbers, a suitable frame will be presented. In fact, from one point of view the grading of dormitories quality, will cause specifying the condition of dormitories for responsible and involves and realizing weakness and strength points of student dormitories, and from another point of view causing equating and targeting the students paid costs.

Literature and subjective history of the research

In the different European and North American countries, the performance evaluation of the universities by the manner of grading and ranking has the background of several decades. About grading in The USA, the Carnegie Community Center is caretaker for this work, and began grading of universities since 1970, and has published the results several times up to now and each time established some collections on grading method and methodology. For example, these results had been published in 1971, 1976, 1978, 1994 and 2000 and the latest one in 2005, the results can be seen in the respective website. The QS ranking is somehow similar to Carnegie grading, but it have simpler administrative basis. In this kind of grading, three following key aspects are using: area, fields of study limits, research activities level. Other categorization methods are exist that they're distant basic; like Chang and Liu method that sorted 500 of best universities in ranking list based on scientometrics and classified them in 21 classes. Most of performance evaluation methods for universities and higher education institutes are by the method of ranking. The ranking methods of Times Institute, Jiang Tong

University, Web Science Research Institute, Maine University of Technology, Macleans in Canada and …. `can be named. For example, Macleans, divides Canada higher educational institutes to 3 wide kinds. These 3 groups are defining as follows: undergraduate universities that concentrate on graduate education with rather limited courses, universities of comprehensive group that have considerable research level and cover wide area of undergraduate and graduate courses and doctorate/medical universities that offer wide area of PhD courses and research. In Britain, the Higher Education Funding Council for England (HEFCE), usually categorizes institutes into 3 groups: before 1992 (higher education institutes that they were universities before the1992 laws of higher education had been carried out), after 1992 (higher education institutes that after enacting the 1992 laws of higher education, found the state of being universities) and the specialized institutes that at least 60% of their courses are only on one or two subjects, like the faculties of art and music. The Center is a research institute that has the mission of measuring and promoting the performance of The USA research universities. The Center annual report from the best USA research universities includes ranking and grading of research universities. The area of this study includes all universities that their federal research expenses are 20 million dollars based NFS report. Used data in this report are providing by its peer institutes all over the country. Ranking could provide information source for performing performance and interior and exterior effectiveness evaluation and analysis and giving credits to higher education institutes in a more extended measure. Institutes like US News and World Report in The USA, THES and Guardian in The UK, Der Spiegel in Germany, Maclean Magazine in Canada, Asia's Best Universities in Asia and many other institutes are working in this field and publishing annual universities ranking reports. Also in our country about evaluation and grading of higher education institutes from educational, research and research services aspect, some activities has been done. For example: "Evaluation of Universities" by Azizollah Memariani (2008), "Performance Evaluation of Higher Education, Subjective Study of Sistan and Balouchestan" by Mohammad Javad Hosseinzadeh Saljoughi (2004), "Comparing the performance of universities by using data envelopment analysis (DEA) model and Malmquist index" by Behrouz Daneshian (2005),

"Evaluation and grading of nongovernmental – nonprofit institutes" by Reza Ameri and also in the research that has been done by Khodabakhshi and Ferasatkhah in 2010, educational departments (experimentally mathematics departments) have been graded.

Research Method

This research, according to its purpose, takes a place in domain of applied research. Because it engage to find field for solving a problem in real world and grading student dormitories of country based on some dimensions. By this manner it will be done like hotels grading system and dormitories will be classified in four, three, two and one star classes based on their quality and capabilities. In this way, two methods for grading, weighing and classifying with use of fuzzy, had been used; the weighing method that is simple and similarly understandable method, on the other side, in innovative and actually exact approach by classifying in fuzzy method, we'll reach this goal.

Weighing Method

Since considered dimensions and indexes are qualitative and also considering that dimensions and indexes have not the same importance, hence a proper criterion for measuring is a qualitative dimensions the weighing method is being used; on the other side, by distinguishable scoring to different dimensions and indexes, it keeps their importance. For this reason using pundit and expert persons, some dimensions and indexes for dormitories quality and capabilities has been composed; that for dimensions by using FAHP method and for indexes by distributing 120 questionnaires and polling from students and beneficiaries, some weights has been determined. Schedule 1, is 7 dimensions by 21 indexes and 62 indicators for dormitories evaluation. First column is dimensions and general components, second column is dimensions measuring indexes, third column is indexes measuring indicators, fourth column is indicator weight, fifth column is index weight, the method of calculating index score has position in sixth column and the method of calculating dimension score has position in last column.

Then, given score for each dimension will be multiplied to its weight. Hence according to total scores of dimensions, if a dormitory have high level of quality, it means that it earns maximum score of each dimension, it'll have score of 10535 and if it earns minimum score of each dimension, its score will be 482. So each dormitory score will be between 482 and 10535.

Schedule 1, Dimensions and Indexes

	Indexes	Indicators	Z_i	Y_i	Index Score	Dimension Score
1st Dimension: Dormitory accessibility	x_1: Distance to university	x_{11}: Near x_{12}: Far x_{13}: Very far	5 3 1	6	If x_{1i} is true then $w_1 = z_i \times y_1$ j = 1, 2, 3	$w_1 + w_2 + w_3$
	x_2: Distance to self service mess hall	x_{21}: Near x_{22}: Far x_{23}: Very far	5 3 1	5	If x_{1i} is true then $w_2 = z_i \times y_2$ j = 1, 2, 3	
	x_3: Distance to city center	x_{31}: Near x_{32}: Far x_{33}: Very far	5 3 1	6	If x_{1i} is true then $w_3 = z_i \times y_3$ j = 1, 2, 3	
2nd Dimension: Dormitory Building Quality	x_1: Building age	x_{11}: less than 5 years x_{12}: 5 to 10 years x_{13}: 10 to 15 years x_{14}: 15 to 20 years x_{15}: more than 20 years	5 4 3 2 1	5	If x_{1j} is true then $w_1 = z_j \times y_1$ j = 1,2,3	$w_1 + w_2$
	x_2: Qualitative condition of building	x_{21}: completely appropriate x_{22}: in need of slightly maintenance x_{23}: in need of basic maintenance	5 3 1	6	If x_{2j} is true then $w_2 = z_j \times y_2$ j = 1,2,3	
3rd Dimension: General Space of Dormitory	x_1: Study room	x_{11}: Appropriate surface x_{12}: Enough number of tables and chairs x_{13}: Having hitter and cooler systems	1 1 1	6	$w_1 = (\sum_{j=1}^{3} z_j)\, y_1$	$\sum_{k=1}^{5} w_k$
	x_2: Chapel	x_{21}: Appropriate surface x_{22}: Being carpeted and appropriate color scheme x_{23}: Hitter and cooler systems	1 1 1	4	$w_2 = (\sum_{j=1}^{3} z_j)\, y_2$	
	x_3: Sport hall	x_{31}: Appropriate surface x_{32}: Having sport equipments	1 1	5	$w_3 = (\sum_{j=1}^{2} z_j)\, y_3$	
	x_4: TV hall	x_{41}: Appropriate surface x_{42}: Having appropriate TV	1 1	5	$w_4 = (\sum_{j=1}^{2} z_j)\, y_4$	
	x_5: Computer site	x_{21}: Having enough number of computers x_{21}: Being computers updated x_{21}: Network connection	1 1 1	7	$w_5 = (\sum_{j=1}^{3} z_j)\, y_5$	
4th Dimension: Kind of Dormitory Rooms	x_1: Suit	-	-	7	-	if x_i is true then y_i i = 1,2,3
	x_2: Suit-Hall	-	-	5	-	
	x_3: Hall	-	-	3	-	

5th Dimension: Capacity and Capitation of Each Student's Room	x_1: 2 or 3 persons	x_{11}: Room surface is more than 15 m^2 x_{12}: Room surface is between 10 to 15 m^2 x_{13}: Room surface is less than 10 m^2	5 3 1	7	If x_{1j} is true then $w_1 = z_j \times y_1$ j = 1,2,3	p_1: Percent of 2 or 3 persons rooms p_2: Percent of 4 or 5 persons rooms p_3: Percent of 6 or 7 persons rooms p_4: Percent of more than 7 persons rooms $P_k = \frac{the\ number\ of\ k\ p}{Total\ number}$ $\sum_{k=1}^{4} p_k w_k$
	x_2: 4 or 5 persons	x_{21}: Room surface is more than 25 m^2 x_{22}: Room surface is between 20 to 25 m^2 x_{23}: Room surface is less than 20 m^2	5 3 1	5	If x_{2j} is true then $w_2 = z_j \times y_2$ j = 1,2,3	
	x_3: 6 or 7 persons	x_{31}: Room surface is more than 35 m^2 x_{32}: Room surface is between 30 to 35 m^2 x_{33}: Room surface is less than 30 m^2	5 3 1	3	If x_{3j} is true then $w_3 = z_j \times y_3$ j = 1,2,3	
	x_4: more than 7 persons	x_{41}: Room surface is more than 5 m^2 for each person x_{42}: Room surface is less than 3 m^2 for each person	4 2	2	If x_{4j} is true then $w_4 = z_j \times y_4$ j = 1,2	
6th Dimension: Dormitory Equipments and Capabilities	x_1: Dormitory room equipments	x_{11}: Bed x_{12}: Refrigerator x_{13}: Carpet x_{14}: Commode x_{15}: Shoe cabinet x_{16}: Appropriate color scheme x_{17}: Hitter and cooler system	5 5 5 4 3 3 4	6	$w_1 = (\sum_{j=1}^{7} z_j)\ y_1$	
	x_2: Dormitory general equipments	x_{21}: Oven x_{22}: Fire extinguishing equipments x_{23}: Water cooler x_{24}: Library x_{25}: Transporting services	4 5 5 3 5	5	$w_2 = (\sum_{j=1}^{5} z_j)\ y_2$	$w_1 + w_2$
7th Dimension: Dormitory Welfare/Medical Services	x_1: Welfare capabilities	x_{11}: Shopping center x_{12}: Buffet or restaurant x_{13}: Bakery x_{14}: Barber shop x_{15}: Laundry	3 3 4 2 3	5	$w_1 = (\sum_{j=1}^{5} z_j)\ y_1$	$w_1 + w_2$
	x_2: Medical Capabilities	x_{21}: Separate room for medical services x_{22}: General practitioner x_{23}: Ambulance x_{24}: Consultant	4 5 4 3	5	$w_2 = (\sum_{j=1}^{4} z_j)\ y_2$	

Schedule 2, Dimensions Scores

Dimensions	Normalized weight of dimensions	Weighing percent	Minimum score	Maximum score
Dormitory accessibility	0.18	18	306	1530
Dormitory building quality	0.10	10	110	550
General space of dormitory	0.15	15	0	1065
Kind of dormitory rooms	0.02	2	6	14
Capacity and capitation of each student's room	0.30	30	60	1050
dormitory equipments and capabilities	0.19	19	0	5396
Dormitory welfare/medical services	0.06	6	0	930
Total	1	100	482	10535

Limits of categories: $\frac{10535-482}{4} = 2513.25$

Schedule 3, Weighing Classification

Grade	Scores Level
4 Stars ****	Dormitories that their total score is between 8021.78 and 10535.
3 Stars ***	Dormitories that their total score is between 5508.52 and 8021.77.
2 Stars **	Dormitories that their total score is between 2995.26 and 5508.51.
1 Star *	Dormitories that their total score is between 482 and 2995.25.

Method of Classifying by Using Fuzzy Numbers

At first, by using merging approach of Fuzzy Analytical Hierarchical Process (FAHP) and PROMETHEE, dormitories will be ranked in each dimension. Then by combining this ranking and each dimension weights, a score will be given to each dormitory. In the end, according to the earned scores, by using offered methods, the grading of dormitories will be discussed. Hence in next chapters this importance will be discussed.

FAHP Algorithm by Chang Analysis of Development Method

Before explanation of Chang Analysis of Development method, we will explain THE Fuzzy Analytical Hierarchical Process method:

1. To Construct the hierarchic for assumed problem

2. Determining the Pairwise comparison of matrix and implementing judges

For the first time the fuzzy analytical hierarchical process method was suggested by Thomas L. Saaty in 1997. In the classic

mode, corresponding number with the order of preference will be inserted in pairwise comparison matrices. But in the fuzzy mode, we'll insert corresponding quantity with the order of preference by triangular fuzzy numbers in pairwise comparison matrices. By this means we can use following schedule:

These presented fuzzy numbers are not equal with 1 to 9 usual language indexes; but they are appropriate for fuzzy analytical hierarchical process and they will be used. It is noticeable that all elements on main diagonal of pairwise comparison matrix are equal to (1, 1, 1) and meanwhile if elements of i^{th} row and j^{th} column of pairwise comparison matrix are equal to $M_{g_i}^j = (l_{ij}, m_{ij}, u_{ij})$, elements of i^{th} row and j^{th} column of pairwise comparison matrix are equal to:

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

3. Calculating proportional weight of indexes and choices. For calculating proportional weight of choices toward each indexes and proportional weight of indexes toward the purpose, we'll use Chang Analysis of Development method for each pairwise matrices; hence for each matrix, a corresponding vector will be acquired.

4. Calculating final weight of choices. It will be acquired by merging proportional weight.

Fuzzy Analytical Hierarchical Process by Chang Analysis of Development Method

This method is simpler than other fuzzy analytical hierarchical process method, and meanwhile it's similar to classic analytical hierarchical process method. Van Laarhoven and his colleague introduced fuzzy analytical hierarchical process in 1983.

Schedule 4, Corresponding Fuzzy Numbers with Preferences in Pairwise Comparisons

Explanatory statement for determining the preference	Triangular fuzzy number
Complete and absolute preference or importance	(2.5, 3, 3.5)
Very stronger preference or importance	(2, 2.5, 3)
Stronger preference or importance	(1.5, 2, 2.5)
Low preference or importance	(1, 1.5, 2)
Almost equal preference or importance	(0.5, 1, 1.5)
Absolutely preference or importance	(1, 1, 1)

Chang Analysis of Development Method

Assume two sets, $X=\{x_1, x_2, \ldots, x_n\}$ be set of choices (purposes) and $U=\{u_1, u_2, \ldots, u_m\}$ be set of indexes (ideals). According to Chang analysis of development method by considering each purpose, analysis of development could have been done for each ideal. Steps of Chang analysis of development could have been explained as follows:

1. Obtaining combined fuzzy expansion for each purpose: If $M_{g_i}^1$, $M_{g_i}^2$, …, $M_{g_i}^m$ be size of i[th] purpose for m ideals, criterion combined fuzzy expansion for i[th] purpose will be defined as follows:

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

If $M_{g_i}^j = (l_{ij}, m_{ij}, u_{ij})$, $\sum_{j=1}^{m} M_{g_i}^j$ is defined by fuzzy operators above. The analysis of development surface of m can be defined as follows:

$$\sum_{j=1}^{m} M_{g_i}^j = (l_{i1}, m_{i1}, u_{i1}) \otimes (l_{i2}, m_{i2}, u_{i2}) \otimes \otimes (l_{im}, m_{im}, u_{im})$$
$$= (\sum_{j=1}^{m} l_{ij}, \sum_{j=1}^{m} m_{ij}, \sum_{j=1}^{m} u_{ij}) = (l_i', m_i', u_i')$$

Also for obtaining $\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j]^{-1}$ by fuzzy sum operator, we have:

$$\sum\sum M_{g_i}^j = \sum_{i=1}^{n}(\sum_{j=1}^{m} l_{ij}, \sum_{j=1}^{m} m_{ij}, \sum_{j=1}^{m} u_{ij}) = (\sum_{i=1}^{n} l_i', \sum_{i=1}^{n} m_i', \sum_{i=1}^{n} u_i')$$
$$(\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j)^{-1} = (\frac{1}{\sum_{i=1}^{n} u_i'}, \frac{1}{\sum_{i=1}^{n} m_i'}, \frac{1}{\sum_{i=1}^{n} l_i'})$$

Hence,

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes (\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^j)^{-1}$$
$$= (l_i', m_i', u_i') \otimes (\frac{1}{\sum_{i=1}^{n} u_i'}, \frac{1}{\sum_{i=1}^{n} m_i'}, \frac{1}{\sum_{i=1}^{n} l_i'}) =$$
$$(\frac{l_i'}{\sum_{i=1}^{n} u_i'}, \frac{m_i'}{\sum_{i=1}^{n} m_i'}, \frac{u_i'}{\sum_{i=1}^{n} l_i'})$$
$$= (l_i, m_i, u_i)$$

2. Calculating the grade of preference (possibility) of S_i to S_k. if $S_i = (l_i, m_i, u_i)$ and $S_k = (l_i, m_i, u_i)$, the grade of preference of S_i to S_k that has been shown by $V(S_i \geq S_k)$ is define as follows:

$$V(S_i \geq S_k) = \sup_{x \geq y} (\min\{\alpha_{s_i}(x), \alpha_{s_k}(y)\})$$

For triangular fuzzy numbers is equal to following relation:

$$V(S_i \geq S_k) = \alpha_{s_i}(d) = \begin{cases} 1 & m_i \geq m_k \\ 0 & l_k \geq u_i \\ \frac{l_k - u_i}{(m_i - u_i) - (m_k - l_k)} & o.w. \end{cases}$$

d is correspond with greatest point of intersection between α_{S_i} and α_{S_k}. Figure 1 is showing V ($S_i \geq S_k$):

3. Grade of preference of a convex fuzzy number S that is greater than K convex fuzzy numbers S_i ; i = 1, 2, …, k, is defining as follows:

V ($S \geq S_1, S_2, \ldots, S_k$) = V(($S \geq S_1$), ($S \geq S_2$), ,($S \geq S_k$))

= min(V($S \geq S_1$), V($S \geq S_2$), …, V($S \geq S_k$))

= min V($S \geq S_i$) i = 1,2,…,k

If assume $d'(A_i)$ = min V($S_i \geq S_k$) k = 1,2,…,n ; k ≠ I, then weight vector is obtaining as follows:

$w' = (d'(A_1), d'(A_1), \ldots, d'(A_1))$

It's noticeable that obtained weights are unfuzzy.

4. Normalizing the vector w′ and obtaining normalized weight vector W:

W = ($d(A_1), d(A_2), \ldots, d(A_n)$)

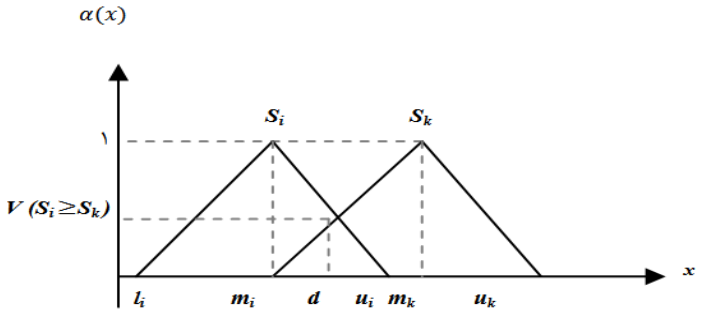

Figure 1: Grade of preference of S_i to S_k

PROMETHEE Method

The PROMETHEE method is one of prioritization methods that have been developed by Prof. Brans in 1982. This method is one of preference deciding methods and needs obvious extra information for deciding, these information are: between indexes information or weights vector and information of inside of each index or preference function. The between indexes information and weights vector are the same that it exist in most of the multi indexes deciding methods. However it's not necessary that weights vector be normalized, but for better understanding, it's noticed to be normalized and information of inside of index and choosing the choices on the basis of special index are the same. PROMETHEE does not alocate an absolute ideality value to each choice (not totally on all indexes, not on each index) the PROMETHEE preference structure is on the basis of pairwise comparisons. But contrary to most of the other methods, in PROMETHEE value of two choices difference on same index will be calculated. The decision maker may have no consideration on low difference between two choices on the same index or may adjust the value of preference according to sensibility. However in PROMETHEE method there is no ignorance for considering unreal preference in [0,1], but it's noticed that to define the preference function on this domain. Used preference functions in PROMETHEE method are in 6 classes that they have been presented in schedule 5.

Schedule 5, PROMETHEE Method's Preference Functions

Generalised criterion	Definition	Parameters to fix
Type 1: Usual Criterion	$P(d) = \begin{cases} 0 & d \leq 0 \\ 1 & d > 0 \end{cases}$	—
Type 2: U-shape Criterion	$P(d) = \begin{cases} 0 & d \leq q \\ 1 & d > q \end{cases}$	q
Type 3: V-shape Criterion	$P(d) = \begin{cases} 0 & d \leq 0 \\ \frac{d}{p} & 0 < d \leq p \\ 1 & d > p \end{cases}$	p
Type 4: Level Criterion	$P(d) = \begin{cases} 0 & d \leq q \\ \frac{1}{2} & q < d \leq p \\ 1 & d > p \end{cases}$	p, q
Type 5: V-shape with indifference Criterion	$P(d) = \begin{cases} 0 & d \leq q \\ \frac{d-q}{p-q} & q < d \leq p \\ 1 & d > p \end{cases}$	p, q
Type 6: Gaussian Criterion	$P(d) = \begin{cases} 0 & d \leq 0 \\ 1 - e^{-\frac{d^2}{2s^2}} & d > 0 \end{cases}$	s

Now, after pairwise comparisons, all relative choices and preference calculation will be calculated according to each index, the contracting preference value will be calculated, this index will be determined by relation 1.

$$\begin{cases}\pi(a,b) = \sum_{j=1}^{k} p_j(a,b)w_j \\ \pi(b,a) = \sum_{j=1}^{k} p_j(b,a)w_j \end{cases} \quad (1)$$

$P_j(a,b)$ is showing preference of a to b in j^{th} index and w_j is showing j^{th} index weight. Also the index $\pi(a,b)$ is showing that according to all indexes, with what grade a is better than b and $\pi(a,b)$ is showing the value of advantage of a to b according to all indexes. Thereof in most cases the conditions are in the way that a has preference to b and also the chose b in some other indexes has preference to a or it's possible that two choices in some indexes be the same, both above indexes are positive. It's trivial that if $\pi(a,b) \sim 0$ choice a has weaker general preference toward b and vice versa if $\pi(a,b) \sim 1$, it shows that choice a has stronger general preference toward b. after calculation of the contracting preference value, positive and negative preference currents for each assumed choice a will be calculated according to relations 2 and 3:

$$\phi^{+}(a) = \frac{1}{n-1}\sum_{x \in A}\pi(a,x) \quad (2)$$

$$\phi^{-}(a) = \frac{1}{n-1}\sum_{x \in A}\pi(x,a) \quad (3)$$

So that $\phi^{+}(a)$ is explaining the positive preference current of choice a and shows that how much choice a is dominating toward other choices on average.

$\phi^{-}(a)$ is negative preference current and it shows that how much other choices are dominating toward choice a on average.

Now by using following relation, general preference will be calculated and on the basis of this relation the final ranking will be done.

$$\phi(a) = \phi^{+}(a) - \phi^{-}(a) \quad (4)$$

Gradation by Using Fuzzy Membership Function

Now in this section, by using the results of merging of FAHP and PROMETHEE and by using fuzzy set theory which introduced by Professor Lotfizadeh in 1965, we'll define classes by the manner of trapezoidal fuzzy numbers and we'll grade dormitories.

A_r: r^{th} class (r = 1, 2, 3, 4)

S_{ij}: Grade of i^{th} dormitory in j^{th} dimension, i = 1,2,…,n , j = 1,2,…,7

w_j: Weight of j^{th} dimension

x_i: Score of i^{th} dormitory (if it have less score, it will be involved in better class):

$x_i = \sum_{j=1}^{7} S_{ij}\ (1 - w_j)$ Hence, set of classes will be as follows:

$$A_r = \frac{\mu_{A_r}(x_1)}{x_1} + \frac{\mu_{A_r}(x_2)}{x_2} + \ldots + \frac{\mu_{A_r}(x_n)}{x_n}$$

$\frac{\mu_{A_r}(x_j)}{x_j}$ Shows that j[th] dormitory with quantity of membership of $\mu_{A_r}(x_j)$ belongs to A_r. Hence, the class of j[th] dormitory will be determined as follows:

$Max_r = \{ \mu_{A_r}(x_j)\} = \mu_{A_R}(x_j)$

Result of this maximum determines that j[th] dormitory belongs to class A_R.

Numerical Example:

Here, 5 following student dormitories which had been chosen randomly, will be graded by presented methods:

A: Kosar dormitory of Razi University of Kermanshah

B: Fatemieh dormitory of Lorestan University

C: Ashrafi Esfahani's 3[rd] dormitory of Razi University of Kermanshah

D: Jamalzadeh dormitory of University of Tehran

E: Setaregan dormitory of Hamedan University

Considering schedule 1 and 3, results of weighing method for five mentioned dormitories are as follows: Results of using FAHP – PROMETHEE method for these five dormitories in each dimension are as follows:

By normalizing above dimensions (dividing to maximum dimension of each rank) we have:

Now by using presented method for gradation, and according to schedule 9 and following figure, the grade of dormitories will be determined as schedule 10:

Results of schedule 6 and 10 shows that results of the weighing method and classification by fuzzy numbers are not completely conforming; in the weighing method, Fatemieh dormitory of Lorestan is three stars and Setaregan dormitory of Hamedan is also three stars. It's happening while in the second method, these dormitories are one star and two stars respectively. This comparison shows the weakness of weighing method which is resulting from intense dependency to determining weights and also using accurate numbers in respect of state of being qualitative of dimensions. Therefore with high precision we can rely on the results of presented method.

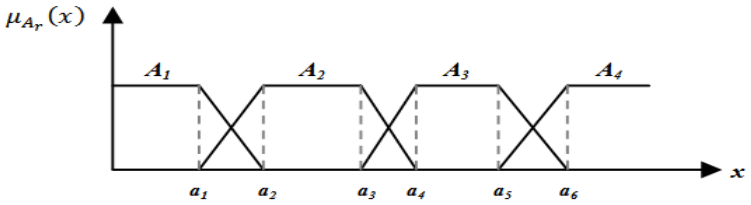

Figure 2: Membership Fuzzy Functions

Schedule 6: Results of weighing method

	Score of dimension 1	Score of dimension 2	Score of dimension 3	Score of dimension 4	Score of dimension 5	Score of dimension 6	Score of dimension 7	Total score	Grade
A	1314	550	630	14	306	3724	420	6958	***
B	666	330	435	6	450	4351	210	6448	***
C	1314	210	270	6	630	2166	420	5016	**
D	1314	380	1065	6	450	5396	930	9541	****
E	918	230	645	6	303	4541	0	6643	***

Schedule 7: Rank of dormitories in each dimension

	Score of dimension 1	Score of dimension 2	Score of dimension 3	Score of dimension 4	Score of dimension 5	Score of dimension 6	Score of dimension 7
A	1	1	3	1	5	4	2
B	3	4	4	3	3	3	3
C	1	5	5	3	1	5	2
D	1	3	1	2	2	1	1
E	2	2	2	3	4	2	3

Schedule 8: Normalized rank of dormitories in each dimension

S_{ij}	Score of dimension 1	Score of dimension 2	Score of dimension 3	Score of dimension 4	Score of dimension 5	Score of dimension 6	Score of dimension 7
A	0.333	0.2	0.6	0.333	1	0.8	0.667
B	1	0.8	0.8	1	0.6	0.6	1
C	0.333	1	1	1	0.2	1	0.667
D	0.333	0.6	0.2	0.667	0.4	0.2	0.333
E	0.667	0.4	0.4	1	0.8	0.4	1

And according to relation (5) we have:

Schedule 9: Score of ith dormitory

Dormitory	A	B	C	D	E
$x_i = \sum_{j=1}^{7} s_{ij}\,(1 - w_j) * 100$	326.674	504.474	457.680	239.358	405.260

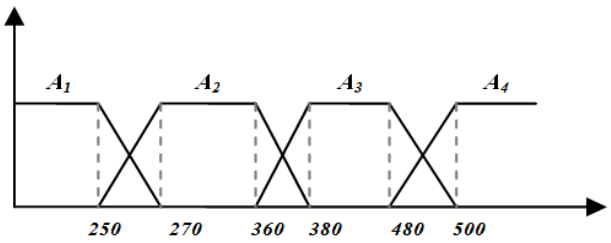

Figure 1-6: Gradation Classes

Schedule 10: Results of gradation by FAHP-PROMETHEE method and using fuzzy numbers

Dormitory	Grade
***	A
*	B
**	C
****	D
**	E

Conclusion

Although wide research, in relation to grading and ranking of higher education institutes and centers has been done, but no research for grading of student dormitories in international level has been reported.

Hence in this research by the manner of creating healthy competitive space and promoting the quality of dormitories and also equating the students paid tuition, we presented comfort and applicable approach for grading of dormitories.

In accordance with reaching this goal, the weighing method and also merging approach of FAHP and PROMETHEE and creative approach by using fuzzy numbers has been used.

Using weighing method in spite of simplicity and comfort speed, because of its intense dependency to weights which are determining for dimensions and indexes, also using accurate numbers for measuring qualitative dimensions, it has low precision. It's happening while FAHP and PROMETHEE method by leaning on pairwise comparisons and using preference functions has high precision and meanwhile their calculations are more complicated. Hence according to existed sensibility we chose one of two methods.

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