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A Group Decision Making Method for Determining the Importance of Customer Needs Based on Customer- Oriented Approach

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Abstract

Nowadays one of the effective techniques for total quality management is Quality Function Deployment that pays attention to recognition of customer's needs and analysis process in all the planning and production stages. This paper presents a Group Decision Model to determine importance amount of customers' needs for product of one organization. In this model, all assessments are stated using linguistic variables. Firstly, on the basis of presented approach and after collection of customers' needs, raw weight of each customer's need is accounted. In the next stage, implementation of each demand in organization product and its competitors is determined, and relative weight of each customer's need is calculated with respect to organization plan. Finally presented model is illustrated for an applied case and final findings are analyzed.

Keywords
Group Decision, Quality Function Deployment (QFD), Ranking, fuzzy TOPSIS

1. Introduction
Quality Function Deployment (QFD) is a useful tool for converting customer needs into current features of product and also it is for decision when we should take in to account collection of subjects accompanied by their requirements simultaneously during decision. The basis of QFD is House of Quality Matrix (HOQ) and its function is creation of requirements associated to customers. The matrix has two major sections: First section is allocated to customer data and second one to technical data that every one is placed in a separate table [1]. Therefore we should be careful in accounting and achieving final results of this matrix and should use suitable techniques to collect, register and process data. With regarding to this subject that customers' viewpoints about importance of their requirements generally are stated verbally, thus, using of linguistic variables containing fuzzy quantity related to them, in comparison with utilization of numerical scale in assessments, is more suitable and also will facilitate statement of viewpoints and will has important role in promoting final results. Lai et.al (2008) [2] have presented one decision model using fuzzy QFD to determine importance of customers needs in a competitive environment. Buyykozkan et.al (2007) [3] have presented a Group Decision Model with regarding to various approaches for explaining viewpoints of every one of customers (numerical, linguistic) about importance of their requirements. This article presents a new decision pattern to rank customer's needs. In this new method, calculation of raw weight of customers needs has been performed in group decision environment with respect to all assessments in the form of linguistic variables by using fuzzy TOPSIS method. This method is easy and interesting for decision makers whereas it has high accuracy and in this method, number of necessary assessments will increase uniformly by increasing the number of customers' needs. Research method has been explained in second section of this article. In this section, firstly, raw weight of each one of the customers' needs is determined by virtue of assessment of

customers' needs by their representatives and regarding to determined attributes for decision. And in turn, assessment of organization's product and its competitors is determined by using viewpoints of assessor customers. Presentation of customer's viewpoints in this section also is performed by using linguistic variables and regarding to customer's needs attribute. at the end of this section, QFD team determine organization's program with regarding to product position in competitive market from view of implementation of every one of customers needs and then, with respect to this program, relative weight of each customers needs are calculated. In third section, an applied example has been presented to illustrate the model calculations and then results of this model have been compared with other methods. Finally in fourth section, results obtained from research and also recommendations for future researches are explained

2. Research Method

Presented method in this research consists of four stages that they as follows: collection of customer's needs, calculation of raw weight of customer's needs, assessment of organization and its competitors from customers point of view, and finally calculation of relative weight of customers needs that is attribute for final rank of customer's needs. Now we will explain each one of the stages:

2.2 Calculation of raw weight of customers needs

After distinguishing customers' needs, major decision attributes to measure importance of every one of customer's needs and also technical weight of each one of attribute are determined by QFD team. Then by supply forms for taking opinions, assessor customers are asked to determine importance amount of every one of current requirements with regarding to major decision attribute and to enter them in current decision matrix in forms. Assessor customers explain requested data by using of defined linguistic variables. Figure 1 shows an example of mentioned matrix. In this matrix, Aj represent decision attribute and Cn_m indicate every each customers' needs. Data Obtained from opinions of every one of customers present one decision matrix, thus decision matrixes will present as number as assessor customers exist.

Attribute / need	A_1	.	.	A_j
Cn_1				
. . .				
Cn_m				

Figure 1: Assessment of customers' needs with regarding to major decision attributes

In this stage, to achieve final matrix of decision, average weight of all input matrixes (that is as number as assessor customers) should be calculated regarding to principles of Group Decision. To do this, firstly linguistic variables should be converted into relevant fuzzy numbers, because components of all matrices have been explained as linguistic variables. To achieve final matrix of decision, average of all matrices should be calculated regarding to importance amount of opinions of each customers and consequently final matrix of decision would achieve.
Note: whenever, in an assessment process, one alternative has the highest value (definite or fuzzy) of profit attribute and the lowest value of cost attribute, we would call it as excellence alternative. To assess and compare all needs with excellence alternative (that is allocated the highest score by all the customers), one figurative row with defined components of excellence alternative should be created in end side of matrix. After calculation of final decision matrix, weight of each alternative (customers' needs) is calculated by using fuzzy TOPSIS [6]. To resolve such problems by taking into account m as alternative and n as decision attribute, following steps are recommended:

- calculation of weighted normalized matrix:

$$\vec{\vec{V}} = \tilde{R}_D \otimes \tilde{w}_{n*n} \quad (1)$$

Which $\tilde{V}$ is weighted normalized fuzzy decision matrix, $(\tilde{R}_D)$ is normalized matrix and $\tilde{w}$ is one diagonal matrix from obtained weights for attributes.

- Specification of ideal negative and positive solution:
- Calculation of distance size based on Euclidean in lieu of ideal positive and negative solution and in question alternative (d_i^+) and (d_i^-) as follow:

$$d_i^+ = \sqrt{\sum_{j=1}^{k} \frac{(1-\sigma_{ij})^2 + 2(1-\varsigma_{ij})^2 + 2(1-\tau_{ij})^2 + (1-\upsilon_{ij})^2}{6}} + \sqrt{\sum_{j=k+1}^{n} \frac{(\sigma_{ij})^2 + 2(\varsigma_{ij})^2 + 2(\tau_{ij})^2 + (\upsilon_{ij})^2}{6}} \quad ,(i = 1,2,...,m) \tag{2}$$

$$d_i^- = \sqrt{\sum_{j=1}^{k} \frac{(\sigma_{ij})^2 + 2(\varsigma_{ij})^2 + 2(\tau_{ij})^2 + (\upsilon_{ij})^2}{6}} + \sqrt{\sum_{j=k+1}^{n} \frac{(1-\sigma_{ij})^2 + 2(1-\varsigma_{ij})^2 + 2(1-\tau_{ij})^2 + (1-\upsilon_{ij})^2}{6}} \quad ,(i = 1,2,...,m) \tag{3}$$

Which attribute from 1 to K are profit (positive) types and attribute from K+1 to m are cost (negative) ones.

- Calculation of relative closeness of alternatives to ideal solution (C_i):

$$c_i = \frac{d_i^-}{(d_i^- + d_i^+)} \tag{4}$$

- Calculation of importance amount of every one of alternative with regarding to excellence alternative (That was defined figuratively or it exists between alternatives), we could obtain importance of each alternative (Customers needs) relative to authorized score limit:

$$W_i = (C_i / C_f) * M \tag{5}$$

Which w_i is importance amount (raw weight) of each alternative, C_i relative closeness of every one of the alternatives to ideal solution, C_f closeness of excellence alternative to ideal solution and M is authorized score limit for importance of alternative .

2.3 Assessment of organization and its competitors from customers point of view

Major objective in this stage is to obtain implementation of customers' needs in current product of organization and its competitors from customer's point of view. In this stage, assessor customers evaluate organization's product and its competitors by completing decision matrices which its example has been presented in figure 2. In this matrix, Cn_m(s) indicate needs of customers, and matrix alternatives are as following: organization (Org) and organization's competitors (R_k).

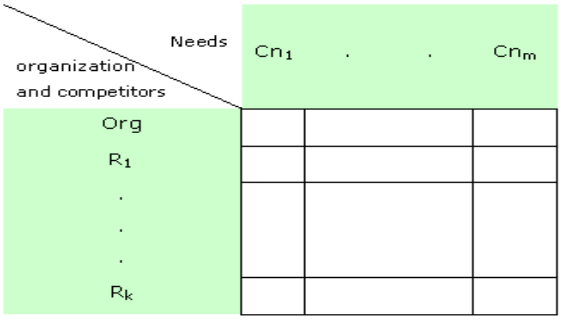

Figure 2: Assessment of organization and competitors

Calculation algorithm for assessment of customers from organization's product and its competitors is as follows:

1. Add one row with specifications of excellence alternative in end side of each input matrix.
2. Convert all matrices data which have been explained as linguistic variables into related fuzzy quantities.
3. Calculate average of all matrices and compute the defuzzified value is by using following formula:

$$\tilde{N} = (\sigma, \varsigma, \tau, \upsilon) \Rightarrow N = \frac{\sigma + 2\varsigma + 2\tau + \upsilon}{6} \tag{6}$$

4. Calculate score related to product of each organization by using Eq. (5) in order to assess organization's product and every one of its competitors relative to score limit.

2.4 Calculation of relative weight of costumers needs

With looking to the House of Quality Matrix, we find out that, requirements of customers have been identified and categorized, also values related to columns of importance of customers needs, assessment of organization and all its competitors have been calculated. Now, organization plan should be determined to implement each customers' needs. The QFD team will determine the program with respect to position of organization and competitors. For example, following accountings method can be used as one rule to obtain organization program.

If we call organization program as P_o, value for assessment of organization as w_{org}, and value for assessment of competitors as w_{Ri}, then accounting rule for organization plan will be as follows:

$$P_o = Max(W_{Org}, W_{R_i}) \tag{7}$$

By obtaining organization program; recovery ratio, definite weight and relative weight of every one of customers' needs are calculated by following formulas:

$$IR_i = \frac{P_o}{W_{org}} \quad , \quad AW_i = IR_i \times W_{cni} \quad \Rightarrow RW_i = (\frac{AW_i}{Max * AW_i}) \times M \tag{8}$$

Which IR_i is recovery ratio, AW_i is definite weight, W_{cni} is raw weight, and RW_i is relative weight of $i_{(n)}$ requirement. By calculation relative weight of all customers' needs, calculations for first section of HOQ Matrix (customer data) will be completed.

3. Numerical Example

Suppose, we have 4 requirements cn_1, cn_2, cn_3 and cn_4 for an organization product. Selected assessor customers are 3 persons (DM_1, DM_2 and DM3) that importance amount of their opinions the equal to 40%, 35% and 25% respectively. Criteria for assessment of customers' needs are Quality (QU), Efficiency (EF) and Cost (CO) that their importance respectively has been determined as 35%, 35% and 30%. Output for taking opinions of assessor customers as compared with importance of every one of requirements correspond to Table 2. Organization also has one competitor that assessment of organization's product and its competitor from assessor customers' point of view correspond to Table 3. Used linguistic variables of customers are corresponding to Table 1.

Table 1: specifications of used linguistic variables of customers

Title	Symbol	fuzzy quantity (trapezoid)
Very low importance (operation)	VL	(0,1,1,2)
Low importance (operation)	L	(1,2,3,4)
Medium importance (operation)	M	(4,5,5,6)
High importance (operation)	H	(6,7,8,9)
Very high importance (operation)	VH	(8,9,9,10)

Table 2: Assessment of importance of each one of requirements

Decision-makers	Requirements	Attributes		
		QU	EF	CO
DM1	Cn1	H	M	L
	Cn2	H	H	VH
	Cn3	L	H	H
	Cn4	M	L	M
DM2	Cn1	H	M	M
	Cn2	M	H	H
	Cn3	H	M	M
	Cn4	L	L	L
DM3	Cn1	M	H	M
	Cn2	VH	H	VH
	Cn3	M	H	M
	Cn4	L	M	L
F		VH	VH	VL

Table 3: Assessment of organization's product and its competitor

Decision-makers	Alternative	Attributes			
		Cn1	Cn2	Cn3	Cn4
DM1	Org	M	M	M	M
	R1	H	L	M	H
DM2	Org	M	H	H	H
	R1	M	L	M	H
DM3	Org	M	M	M	L
	R1	H	M	M	M
F		VH	VH	VH	VH

3.1 Obtained results by using of proposed model

In order to calculate raw and relative weight of every one of customers' needs, firstly we convert input linguistic variables into related fuzzy quantities and then with regarding to importance of customers opinions, final matrix of decision could be obtained. Finally, with respect to positive (Quality and Efficiency) and negative (cost) decision criteria, and ideal solution related to them, relative closeness of every one of requirements to ideal solutions could be calculated corresponding to Table 4, and in final raw weight of every one of customers needs could be calculated with regarding to score limit considered for customers needs (M) which in this example is supposed as 5. Regarding to results of Table 4, we find out that raw weight of first demand is higher than others.

Table 4: Relative closeness and raw weight of each one of needs

	d_i^-	d_i^+	C_i	rank	W_i
Cn_1	0.99	1.07	0.481	1	4.38
Cn_2	0.93	1.02	0.4763	2	4.33
Cn_3	0.94	1.1	0.4615	3	4.2
Cn_4	0.95	1.23	0.4358	4	3.97
F	1.1	0.91	0.5495		5

In next stage, in order to assess organization's product and its competitor, average weight of three input matrixes are obtained regarding to importance of opinions of every one of 3 assessor customers, after when we converted linguistic variables in Table 3 into related fuzzy quantities (Table 5). Then the defuzzified value is computed and calculate implementation of each one of needs in organization's product and its competitor and with regarding to supposed score limit (number 5) like as Table 6. Insert values related to raw weight of requirements and also assessment of organization's product and its competitor in relevant sections in HOQ Matrix with regarding to performed calculations, and calculate values related to organization program, recovery ratio, definite weight and finally relative weight of each one of requirements by using stated formulae. All mentioned calculations have been performed corresponding to Table 7 in section of customers' data in HOQ Matrix. With regarding to obtain final results, relative weight of first demand is higher than others which its reason is 1.33 recovery ratios for this demand. Raw weight of this demand is also higher than other ones.

Table 5: final decision matrix to assess organization's product and its competitor

	Cn_1	Cn_2	Cn_3	Cn_4
Org	(4,5,5,6)	(4.7,5.7,6,7)	(4.7,5.7,6,7)	(3.9,4.9,5.5,6.5)
R1	(5.3,6.3,6.9,7.9)	(1.7,2.7,3.5,4.5)	(4,5,5,6)	(5.5,6.5,7.2,8.2)
F	(8,9,9,10)	(8,9,9,10)	(8,9,9,10)	(8,9,9,10)

Table 6: Score of organization's product and its competitor

	Attribute			
	Cn_1	Cn_2	Cn_3	Cn_4
Org	2.778	3.264	3.264	2.92
R_1	3.681	1.736	2.778	3.82

.Table 7: The relative weight of every one of customers needs.

Row	Requirements	Importance amount	Assessment of competitor	Assessment of competitor	Organization program	Recovery ratio	Definite weight	Relative weight
1	Cn_1	4.38	2.78	3.68	3.68	1.33	5.80	5.00
2	Cn_2	4.33	3.26	1.74	3.26	1.00	4.33	3.74
3	Cn_3	4.20	3.26	2.78	3.26	1.00	4.20	3.62
4	Cn_4	3.97	5.25	6.88	6.88	1.31	5.19	4.48

3.2. Comparison of results

To compare results of presented model in this article with other presented models, results of 3 other models have been considered. First model is a traditional method in which only raw weight of customers' needs is considerable. Thus, obtained raw weight in this research, which has been calculated by fuzzy TOPSIS method, is taken into account. Second model is Buyykozkan et.al (2007) method. In this model with regarding to mentioned example, all assessments are taken into account linguistic and weighted normalized matrix is taken as input for this decision model. Third model is Lai et.al (2008) method. In this model, used raw weight is the same as raw weight which has been calculated by fuzzy TOPSIS method. Final rank of importance of customers' needs has come in Table 8, with regarding to final results of 3 mentioned models and presented model in this research.

Table 8: Comparison of final rank of importance of customers' needs by using of various methods

Rank / Title	1	2	3	4
Traditional method (raw weight)	Cn_1	Cn_2	Cn_3	Cn_4
Buyykozkan et. al	Cn_1,Cn_2	----	Cn_3,Cn_4	----
Lai et. al	Cn_2	Cn_1	Cn_4	Cn_3
Proposed method	Cn_1	Cn_4	Cn_2	Cn_3

For assessment of final results of all mentioned methods, measurement attribute (regardless of organization program) could be taken into account as composed form from two viewpoints as raw weight and market position. In first viewpoint, only importance of requirements is considerable from customers' point of view. Outcome of this assessment is raw weight obtained in section 3-1. In second viewpoint, only implementation of every one of customers' needs in organization's product and in current market is assessed. To perform this assessment Presented results in Table 5 are input for decision question, with this change in which requirements of customers, decision alternative and organization's product and its competitor are attributes for decision. To resolve the question, we also use fuzzy TOPSIS method (by taking into account same importance for decision attribute). Assessment attribute of methods could be obtained by having results two above viewpoints. Diagram1 show comparison of results of other methods with attribute of decision measurement.

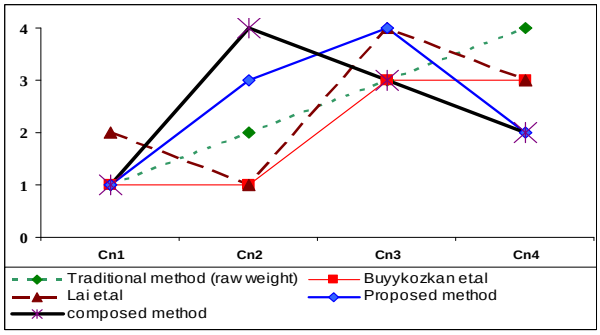

Figure 1: Ranking of importance of customers needs by using various methods

On this basis, proposed method has the lowest difference with measurement attribute in rank of customers' needs, and first and second priorities in rank for proposed and composed methods are same. Therefore, final results of proposed model have acceptable reliability as compared with other methods.

4. Conclusion

This research presents a decision model to determine importance of customers needs from organization's product or service by using of linguistic variables in a fuzzy environment. By using of proposed method of this model, raw weight of each customer's needs could be obtained by taking into account performed linguistic assessments. Also by using of this model, relative weight of each customer's needs could be calculated with respect to assessment amount of customers from organization's product and its competitors that has been explained by customers as linguistic variables and regarding to organization's program which presented product or service. In decision model of research,

convenience of explanation of assessments by customers is considerable, so that assessments could be explained by using of linguistic terms, and this capability would cause that more exact assessments are preformed by decision-makers, and regarding to more correct inputs, final results of decisions would have higher reality. Application of the proposed method has other advantages which among them, we refer to following cases: Application of the method in group decision, assessment of product in competitive environment, rank of organization's product in current market and final acceptable results in connection of ranking customers needs. Final results of proposed model (importance amount of customers' needs) are a basis to determine rank of technical requirements of product that will use in the next stage of HOQ Matrix (Technical data). To continue investigations about topic of research, we could pay attention to effect of correlation between customers' needs on calculations related to importance amount of each customer’s needs.

References

1. Ronald, G.D., 2006, "Quality Function Deployment", Godarzi Arezo, Kazemnejad Hajar, Dabiri Gholamreza, Green Frazandish Publication Institute (in persian).
2. Xin, L., Min, X., Kay-Chuan, T., and Bo, Y., 2008, Ranking of customer needs in a competitive environment, Computers and Industrial Engineering, 54, 202–214.
3. B., Gulcin, F., Orhan, and R., Da, 2007, Fuzzy group decision-making to multiple preference formats in quality function deployment, Computers in Industry, 58, 392-402.
4. Zimmermann, H.-J., 1991, Fuzzy Set Theory and its Applications, 2nd ed., Kluwer Academic Publishers, Dordrecht.
5. Lockett, A.G., Hetherington, B., Yallup, P., Stratford, M., and Cox, B. 1986, Modelling a research portfolio using AHP: A group decision process. R&D Management, 16(2), 151-160.
6. Li, D.-F., 2007, Compromise ratio method for fuzzy multi-attribute group decision making, Applied Soft Computing, 7, 807–817.