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The passenger service improvement using fuzzy QFD based on evidence reasoning approach; case study

Prof. A. Mirzazadeh
Department of Industrial Engineering,University of Kharazmi

Abstract

The airline service quality is an important issue in the international air travel transportation industry. The first passengers' encounter with airline staff is at the airport and therefore, improving the quality of passenger services is one of the main objectives of airlines. The study applies an extension of the Quality Function Deployment to examine the performance of Iran Air in passenger service and propose suggestions for improvement. Human judgments are often vague, and it is not easy for passengers to express the weights of evaluation criteria and the satisfaction of airline service quality using an exact numerical value. Fuzzy logic is a methodology to deal with ill-defined nature of the customer's linguistic judgments required in the QFD. Also, the evidential reasoning based QFD is a methodology for synthesizing various types of assessment information provided by QFD team members. The presented model can be considers vagueness of human thinking style. The Intelligent Decision System (IDS) software has been used to solve the problem. The results have been demonstrated that the staff training and the appropriate delayed flight handling are the most important elements of customer satisfaction and the highlighted areas for service improvement.

Key words: Passenger service; Service quality; Quality function deployment (QFD); Fuzzy sets; Evidential reasoning.

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Introduction

The high quality service is always important for service firms. Passenger satisfaction is a key performance index in the airline operation. We can provide desired service quality with understanding the passenger's expectations, in the other words, only the customer can truly define service quality. Higher service quality will lead to higher customer satisfaction and then, higher passenger demand, which will be affecting in increasing in the higher revenue.

Obviously, the tourists' impressions of a particular country are frequently affected by their first and last encounters at the gateway airport. Therefore, the overall airport experience of international travelers may have a significant impact in promoting or discouraging future international tourism and business activities in Iran. Thus, the evaluation of passenger satisfaction is an important issue for Iran air, the national airline of Iran. The Quality Function Deployment is a planning methodology for product and service development. It can be used to help businesses for understanding the customers' needs and meet these within their abilities and resources (Liang, et al., 2006). QFD is customer driven and translate customer needs into the appropriate technical requirements in products and services (Wang, 2007). However, most of the involved information in the QFD process is generated from human beings' perceptions and linguistic assessments that are quite subjective and vague. Both “voice of the customer” and the “voice of the technician” contains ambiguity and multiplicity of meaning (Chan, et al., 2005).

In this paper, a prioritization model is proposed in order to rank service attributes of airport passenger services. It dispels vagueness of the human statements. Fuzzy logic is used in this model in order to convert linguistic statements of passengers to the fuzzy numbers. Also, evidential reasoning approach helps QFD team members to express their judgments by complete and incomplete, precise and imprecise, known and unknown data. The reminder of the paper is organized as follows: In the next Section, a literature review of Service quality in airline industry, QFD, Fuzzy logic and Evidential Reasoning is presented. Then, the proposed methodology has been explained and the Iran Air case study, with data collection procedure, calculations and results are described. The last Section is devoted as the concluding remarks.

1. Background

In this section, we explain the theoretical essentials and review of the literature in the research area. The section includes: Service Quality in the airline industry, Quality Function Deployment (QFD), Fuzzy Logic and Evidential Reasoning.

1.1 Service Quality in the airline industry

There is no globally accepted definition of air service quality. In general, air service quality can be defined as a consumer's overall impression of relative efficiency of a supplier's organization and service (Park, et al., 2004) and involves various interactions between a passenger and airline employees, as well as anything that is likely to influence passengers' perceptions, of a carrier's image (Gursov, et al., 2005).

Understanding what customers expect to be a crucial step in delivering high-quality service, but only customers, can truly define service quality (Parasuramen, et al., 1985). However, a framework can be developed to define service quality as the degree and the direction of discrepancy between customers' expectations and perceptions. The most widely used model of customer-perceived service quality is SERVQUAL. We seek to develop a new model based on QFD to increase customer satisfaction and improve service quality.

1.2 Quality Function Deployment (QFD)

In the 1970s Quality Function Deployment (QFD) started in Japan and soon was used widely as a decision making tool all over the world. The aim of QFD is translating customer requirements into the appropriate technical requirements and determining the most important factors in their satisfaction. The main benefit of applying QFD is increasing customer satisfaction; because it is taking customers' requirements into consideration, including customers' voices in the product planning and design stages.

The original applications of Quality Function Deployment were mostly in industries such as automobiles, electronics and software. It quickly spread to other industries such as government, banking, healthcare, education and research. Now, it covers almost all types of industry worldwide.(Zare, 2009) QFD is probably the most important management tool developed to assure quality in new or improved products and services (Han, et al., 2001)

QFD is composed of four successive matrices. The first one is customer requirement planning matrix, also called the "House of Quality" for its typical shape. Most studies just focus on this matrix to develop the model for strategic customer service management.

The HOQ matrix is composed of two main parts, related to customer's requirements ("what" customer needs - CRs) and technical requirements which can be design requirements or service factors ("how" the product has to be made, design requirements - DRs or service factors - SFs). A group of organization experts form a QFD team. The HOQ is thus adopted by the QFD team members to transform the customer's requirements and needs into product or service's characteristics.

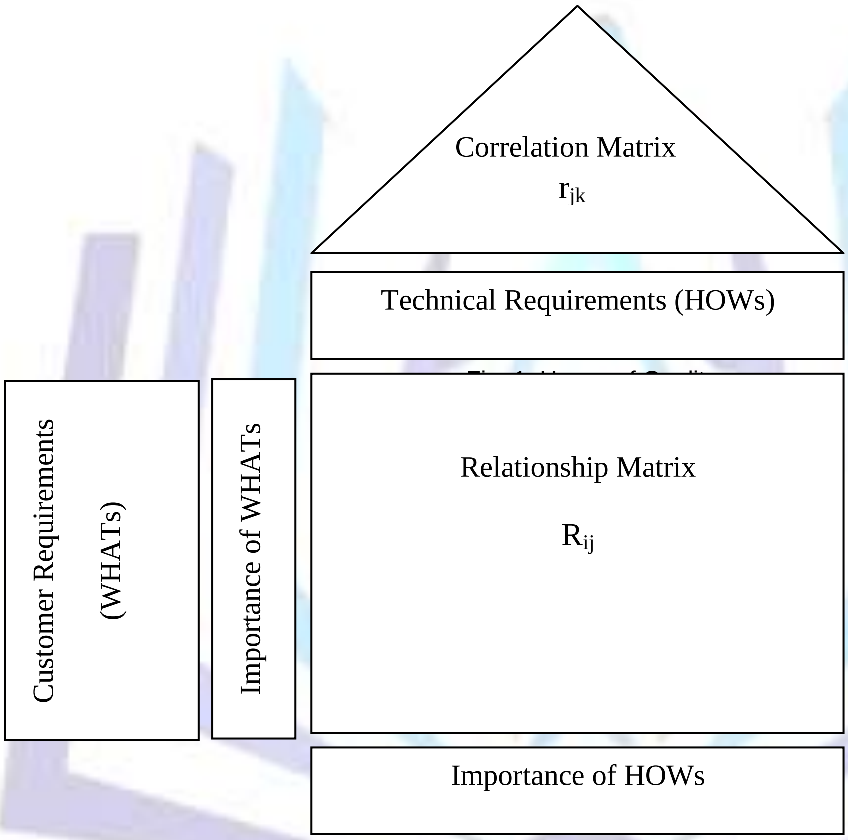
At the beginning of the process, customer's needs and requirements have to be identified. CRs are listed in row in the HOQ and are weighted in order to express their relative importance. The weight of each CR is inserted in a column in the matrix. CRs must be translated into technical requirements, Design requirements (DRs) or service factors (SFs) that probably affect one or more CRs. They are measurable attributes concerning a firm's product or service and are listed in columns in the HOQ.

The core element of the matrix is the "relationship matrix". In order to complete this part of the HOQ, the relationship between customer's needs and firm's ability to meet those needs have to be determined. The relationships are expressed with graphic symbols that indicate how and to what extent each technical requirement meets each CR. Usually, symbols express three degrees of strength (weak, medium, strong), which are translated in an appropriate rating scale. Absence of symbols means absence of relationships.

In a similar manner, the top side of the HOQ, called the "correlation matrix" is then filled in, expressing how technical requirements affect each other. A positive relationship indicates that two technical requirements can complement or improve each other, while a negative one suggests that tradeoffs are required. Correlations are indicated with graphic symbols that express the degree of relation between technical requirements. Symbols are then translated into a four-value rating scale (strong negative, negative, positive, strong positive). Again, it is possible to have no correlations between technical requirements.

The result of the matrix is the ranking of technical requirements in descending order of importance. The more important technical requirements, the more effective they are in improving customer satisfaction. (Bottani, et al., 2006)

The Fig1 illustrates House of Quality. CR1 ~ CRm are the m identified customer wants (WHATs), SF1 ~ SFn are the n relevant service factors (HOWs), W1 ~ Wm are the relative weights (also called the degrees of importance) of the customer wants, R= (Rij) m × n is the relationship matrix between WHATs and HOWs, and r = (rjk) n × n is the interrelationship matrix (also called correlation matrix) between HOWs, satisfying rjk ≡ rkj for j, k = 1,….n



As mentioned before, QFD is based on judgments of customers and QFD team members which are expressed as linguistic and vague ideas. In the traditional QFD most of the input variables are assumed to be precise and are treated as crisp numerical data (Lin, et al., 2011). But crisp values are inadequate to model vagueness of decision data and it presents a special challenge to the effective calculation of the importance of technical requirements. Fuzzy logic and evidential reasoning are two techniques which can be combined with QFD and take vagueness and uncertainty of linguistic statements into account.

1.3 Fuzzy Logic

Conventional QFD is a deterministic method. The input variables in construction applications are assigned deterministic values which do not reflect uncertain and noisy nature of data in a multi-attribute and multi-participant decision making processes. The output is computed as a deterministic value which does not reflect the variability in the data. To overcome this lack of precision and reliability, Fuzzy Logic was integrated by some researchers into conventional QFD, both to define input data and to analyze the output (Lee, et al., 2009)

Fuzzy logic can handle inexact information and linguistic variables in a mathematically well-defined way which simulates the processing of information in natural language communication. For example, expressions such as: "high competition", "low interference", "low impact" and "high collaboration" are imprecise. These sentences in a natural or synthetic language are the values of linguistic variables which represent linguistic concepts such as: Very Low, Low, Medium and so on. Thus, a systematic use of words to characterize values of variables, the values of probabilities, the relationship between variables and so on, constitute a linguistic approach usually described as Fuzzy Logic. (Temponi, et al., 1999)

In our approach we use Fuzzy Logic to capture inherent imprecise and vague nature of input data involved in the prioritization and weighting of customer requirements.

1.3.1 Triangular Fuzzy Number (TFN)

If a, b and c denotes the smallest possible value, the most promising value and the largest possible value, respectively, that describes a fuzzy event, then the triangular fuzzy number (TFN), as shown in Fig. 2, can be denoted as a triplet (a, b, c) where, a ≤ b ≤ c. when a=b=c, it is a none fuzzy number by convention. The membership function can be defined as

$$\mu N(x): \begin{cases} (x-a)/(b-a) & x \in [a, b] \\ (c-x)/(c-b) & x \in [b,c] \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

If M= (a1, b1, c1) and N= (a2 ,b2 ,c2) represents two TFNs, then required fuzzy calculations are performed as below (Chien, et al., 2000)

Fuzzy addition

$$M \oplus N = (a1 + a2, b1 + b2, c1 + c2) \quad (2)$$

Fuzzy multiplication

$$M \otimes N = (a1 \times a2, b1 \times b2, c1 \times c2) \quad (3)$$

Fuzzy multiplication

$$M \otimes 1/N = (a1/c2, b1/b2, c1/a2) \quad (4)$$

Fuzzy and a natural number multiplication

$$r \otimes M = (r.a , r.b, r.c) \quad (5)$$

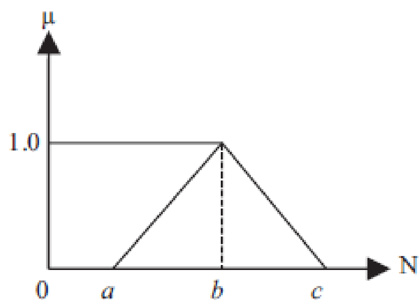


Fig. 2. Triangular fuzzy number (TFN)

1.4 Evidential Reasoning

Many complex multi attribute decision analysis (MADA) problems involve both quantitative and qualitative attributes as well as various types of uncertainties such as incomplete information, complete ignorance and fuzziness. Such complex MADA problems can always be modeled using evidential reasoning (ER) approach. The ER approach models both quantitative and qualitative attributes using a distributed modeling framework, in which each attribute is characterized by a set of collectively exhaustive assessment grades, probabilistic uncertainty including incomplete information and complete ignorance by a belief structure, and fuzzy uncertainty by fuzzy linguistic variables.

In certain decision situation such as group decision making, however, a new type of interval uncertainty is likely encountered. For example, quantitative data may not be known precisely but may be estimated to belong to intervals with certain confidence level. A decision maker (DM) may be unable to give precise judgment. In group decision analysis, different DMs may assign different degrees of belief to the same judgment. It will be very difficult to synthesize different degrees of belief to generate a precise point estimate. If DMS cannot reach a consensus, using interval belief degree may be a sensible option in such circumstances.

A type of interval uncertainty is caused by interval assessment grades. For instance, in real decision analysis, some alternatives may not be assigned to some definite assessment grade, say, Excellent or very good or good. In this situation, DM may prefer to assign them to an interval assessment grade, say between Excellent and Good. It can be either Excellent or Very good or Good. But, DM may not be sure which one (Wang, et al., 2006)

In this approach, evidential reasoning is used to facilitate assessing the relationship between CRs and SFs and the interrelationship between SFs. It will allow QFD team members to express their judgments by complete and incomplete, precise and imprecise, known and unknown data.

2. The Proposed Methodology and Case study

This section describes two approaches to QFD which are developed to make it more representative and workable. Phases 1 highlights incorporating Fuzzy set theory into QFD and phases 2 explains embedding evidential reasoning theory into it.

2.1 Phases 1- Fuzzy Logic and QFD

In this section, Fuzzy approach is applied to determine weighted importance of service factors (SFs). The section include: Determining CRs, Questionnaire design and survey, converting linguistic variables to fuzzy numbers, Determining SFs, Weighted importance of SFs and Crisp weighted importance of SFs.

2.1.1 Determining CRs

First step in applying QFD is determining Customers' requirements. With a literature review, interviews with experienced staff and passenger service forwarders and considering passengers' complaints, 7 main passengers' demand where determined which are shown in table 1.

Table 1
Customer Attributes in passenger service

Customer requirements	abbreviation
1 Courtesy of staff	CR1
2 Neat appearance of staff	CR2
3 knowledgeable and accurate staff	CR3
4 staff willingness to help and solve passengers' problems	CR4
5 Quick and efficient check-in and boarding	CR5
6 Presenting passengers with up-to-date information about baggage allowance, the amount imposed for overweight baggage, size and weight of handbag, forbidden goods in baggage, procedure of check-in and boarding, suitable time for attendance at counter and gate)	CR6
7 Proper handling of delayed flights(staff behavior to delayed passengers, understanding passengers' specific needs, presenting passengers with high quality food and beverage, informing passengers of departure time.	CR7

2.1.2 Questionnaire design and survey

The 7 customer requirements seen in table 1 are used in questionnaire with attitude to assess the importance and perceived quality of each one using a five point linguistic rating, ranging from very low or very unimportant to very high or very important. The sample was taken from the passengers of Iran Air that flies from Imam Khomeini International Airport, between November and December of 2010, with 200 questionnaires issued. When respondents denied to be interviewed or were unable to complete the questionnaire, the survey was considered invalid. At last, 153 useful responses were obtained. Table 3 shows the average importance of CRs and level of satisfaction based on passengers' judgments.

2.1.3 Converting linguistic variables to fuzzy numbers

Expressing linguistic variables in fuzzy numbers is an appropriate way for describing inputs in QFD. Table 2 Shows linguistic terms used in questionnaire and corresponding fuzzy numbers. Wi is the fuzzy triangular number which is adopted to translate the linguistic judgment of importance level given to the ith CR by passengers. Fig.3. illustrates membership functions for linguistic values.

Table 2
Linguistic judgments and corresponding fuzzy numbers

Linguistic expressions	Triangular fuzzy number
Very high (VH)	(0.8,1,1)
High (H)	(0.6,0.8,1)
Medium (M)	(0.3,0.5,0.7)
Low (L)	(0,0.2,0.4)
Very low (VL)	(0,0,0.2)

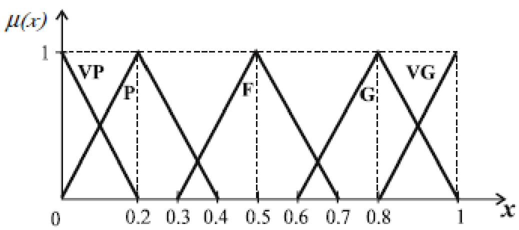


Fig. 3. Membership functions for linguistic values

Table 3
Level of importance and satisfaction of CRs

Customer requirements	Importance	Importance in fuzzy form (Wi)	Satisfaction	Satisfaction in fuzzy form
CR1	VH	(0.8,1,1)	H	(0.6,0.8,1)
CR2	VH	(0.8,1,1)	M	(0.3,0.5,0.7)
CR3	VH	(0.8,1,1)	H	(0.6,0.8,1)
CR4	VH	(0.8,1,1)	H	(0.6,0.8,1)
CR5	VH	(0.8,1,1)	M	(0.3,0.5,0.7)
CR6	H	(0.6,0.8,1)	M	(0.3,0.5,0.7)
CR7	VH	(0.8,1,1)	M	(0.3,0.5,0.7)

2.1.4 Determining SFs

QFD team members should determine strategic actions the firm can undertake to improve service performances. Each of them should have impact on at least one customer requirement. These actions correspond to "HOWs" in the proposed customer service HOQ. In this paper, strategic actions are called SFs (service factors). According to CRs which were identified before, QFD team members determined a list of possible "HOWs" when customer service performance related to passenger service has to be improved. Table 4 shows the list of SFs.

Table 4
List of strategic actions

Service factors	Abbreviation
1 Training the necessary skills to staff	SF1
2 Delivering catalogues containing the required information for passengers in sales offices	SF2
3 Assigning enough staff to check-in counters and gates of flights	SF3
4 Increasing the quota for staff uniforms	SF4
5 Using useful information in Iran Air website	SF5
6 Attendance and accountability of supervisors and top ranking staff in the gate, in case of delayed flights	SF6
7 Designing a "Performance monitoring and evaluation system", "Disciplinary system" and "Reward system" for staff	SF7
8 Availability of all airline circulars and procedures for staff	SF8
9 Supplying the special needs of passengers such as blanket, medicine, baby's food,… in case of delayed flights	SF9
10 Efficient management, in order to increase productivity and reduce unnecessary overtime work	SF10
11 repairing devices and replacing old devices with new ones	SF11
12 Preparing high quality food and beverage (refreshment) for passengers in case of delayed flights.(contract with airport restaurants, if needed)	SF12
13 announcing the gate number and time for boarding to passengers in check-in counters	SF13

2.1.5 Weighted importance of SFs (Wi*)

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If there are n CRs, Wi* is a [n ×1] vector that indicates the rank of real importance for each CR. The introduction of Wi* is required to weight each service factor considering not only the importance customer gives it, which is expressed by the value Wi, but also

The performance delivered by the firm for that factor. To gain competitive advantage, the firm must provide superior service to the customers on critical service factors, that is either those that are perceived as the most important ones or where service perceived is inferior. Conversely, improving service either for a factor whose importance is trivial or where the firm already delivers a superior service is useless.

Weighted importance of SFs is calculated as below:

$Wi^* = di \otimes Wi$, i= 1,…, n (6)

And di is:

. $di = di+ / (di+ + di-)$ (7)

di+ is the gap between the perceived quality service which customers receive now, and what they can receive in the positive ideal state; di- is the gap between the perceived quality of service which customers receive now, and what they can receive in the negative ideal state; di is the distance between the positive ideal state and the total. In this paper, the performance delivered was retrieved from questionnaire which was answered by passengers. Positive ideal state and negative ideal state for each CR where determined by QFD team members.

Since all performance values are fuzzy, a distance between fuzzy numbers has to be assessed. To this extent, the Hamming procedure is suggested to be adopted. This procedure identifies the distance between fuzzy numbers as the distance of the center of gravity of the respective membership functions.

. di+ and di- are crisp values calculated by hamming distance:

$d(\mu A(x), \mu B(x)) = \int_x |\mu A(x) - \mu B(x)|\, dx$ (8)

Where x is the universe of discourse. A and B are two fuzzy sets, and the hamming distance between two fuzzy numbers belonging to A and B, respectively, is calculated by Eq. (8)

Here, the hamming distance is employed for contiguous functions. μA(x) indicates the membership degree of x in A. membership degree does not state absolute importance, but it is subjective and dependent on the set content. Table 5 contains di+ , di-, di and fuzzy weighted importance Wi* for all customer requirements.(Khademi-Zare, et al., 2010)

Table 5

Distance and fuzzy weighted importance of CRs

CR	Satisfaction (Present state)	Positive ideal state performance	Negative ideal state performance	. di+	di-	di	Wi	Wi*
CR1	H	VH	VL	0.1	0.525	0.16	(0.8,1,1)	(0.128,0.16,0.16)
CR2	M	VH	VL	0.375	0.375	0.5	(0.8,1,1)	(0.4,0.5,0.5)
CR3	H	VH	VL	0.1	0.525	0.16	(0.8,1,1)	(0.128,0.16,0.16)
CR4	H	VH	VL	0.1	0.525	0.16	(0.8,1,1)	(0.128,0.16,0.16)
CR5	M	H	VL	0.35	0.375	0.483	(0.8,1,1)	(0.386,0.483,0.483)
CR6	M	H	VL	0.35	0.375	0.483	(0.6,0.8,1)	(0.29,0.386,0.483)
CR7	M	H	VL	0.35	0.375	0.483	(0.8,1,1)	(0.4,0.5,0.5)

2.1.6 Crisp weighted importance of SFs

In order to calculate crisp weighted importance of SFs, Wi* should be defuzzified.

If A (a, b, c) is a triangular fuzzy number, defuzzified value will be computed as below:

$(a+4b+c)/6$ (9)

Table 6 contains defuzzified values of Wi*

Table 6

Defuzzified Wi*

CR	Fuzzy Wi*	Defuzzified Wi*
CR1	(0.128,0.16,0.16)	0.155
CR2	(0.4,0.5,0.5)	0.483
CR3	(0.128,0.16,0.16)	0.155
CR4	(0.128,0.16,0.16)	0.155
CR5	(0.386,0.483,0.483)	0.467
CR6	(0.29,0.386,0.483)	0.386
CR7	(0.4,0.5,0.5)	0.483

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2.2 Phases 2- Evidential Reasoning and QFD

In this section, Evidential Reasoning Theory is applied to formulate the relationships between customers' requirements (CRs) and service factors (SFs) and among SFs. The section include: Belief structure, Modeling the relationship matrix between CRs and SFs, Modeling the interrelationship matrix between SFs, IDS software, Incorporating the interrelationship matrix into the final ratings of technical importance and Normalizing and ranking technical importance ratings.

2.2.1 Belief structure

In terms of the previously defined rating scales, QFD team members can express their opinions using belief structures. A belief structure is a distribution of probabilistic assessment. For example if a QFD team member may determine the relationship of SF1 and CR1 to be strong to the belief degree of 60% and medium to the degree of 40%. Such an assessment can be modeled as {(9, 60%), (3, 40%)}, with the belief degrees added to 100%. It is a complete assessment. If another QFD team member rates the relationship of SF1 and CR1 between strong and medium with a belief degree of 20% and low to a belief degree of 70%, such an assessment can be modeled as {(3-9,20%),(1,70%)}, leading to a total belief degree of 90%. It is an incomplete and imprecise assessment. If the total belief degree of an assessment is less than 100%, the assessment is said to be incomplete; otherwise it is said to be complete. Note that the total belief degree cannot be larger than 100%; otherwise, the assessment makes no sense. For an incomplete assessment, the remaining belief degree represents the probability that has not been assigned to any rating, but it could be assigned to anyone of the ratings or their combinations.

Therefore, the remaining belief degree could be assigned to any of the rating scale 0-9. If a QFD team member has no idea about the relationship of SF1 and CR1 or cannot provide any information about the assessment, such an assessment is called total ignorance and can be characterized by the belief structure {(0-9,100%)}.

For a given belief structure, it can be characterized by an expected score no matter whether it is complete or not. For example, the above three belief structures can be characterized by expected scores in the following way:

{(9, 60%), (3, 40%)} → 9 × 60% + 3 × 40% = 6.6

{(3-9, 20%), (1, 70%)} → [3-9] × 20% + 1 × 70% + [0-9] × 10% = 1.3-3.4

{(0-9,100%)} → [0-9] × 100% = 0-9

Where the 10% in the second belief structure, is the remaining belief degree, which could be assigned to any rating of 0-9. To sum up, evidential reasoning helps QFD team members to express their opinions freely, truly and independently.

2.2.2 Modeling the relationship matrix between CRs and SFs

The relationship matrix between WHATs and HOWs reflects the impact of the fulfillment of HOWs on the satisfaction of WHATs. The matrix should be developed by QFD team members. To help the team members assess the relationships and express their opinions, rating 0-1-3-9 is used to denote no relationship, weak, medium and strong relationship between WHATs and HOWs. Different from the traditional QFD, which requires the team members to provide a consensus assessment for each relationship, the ER-based QFD methodology allows the team members to express their opinions using belief structures individually and independently. (Chin, et al., 2009)

Two supervisors of Iran Air were appointed to determine the relationships of CRs and SFs and also the interrelationship of SFs. The two decision makers (DMs) are of different importance. DM1: 60% - DM2: 40%. The assessments provided by DMs are belief structures which are listed in table 7.

Table 7

Assessments on the relationship between 7 CRs and 13 SFs.

		SF1	SF2	SF3	SF4	SF5	SF6	SF7
CR1	DM1 60%	9	0	1-3	0	0	9	9 : 70% 3 : 20%
	DM2 40%	9 : 70% 3 : 20%	0	1 : 80% 3 : 290%	0	0	9 : 80%	3-9 : 80% 9 : 20%
CR2	DM1 60%	1-3 : 70%	0	0	9	0	0	3 : 80% 9 : 20%
	DM2 40%	1	0	0	3-9 : 80%	0	0	1 : 10% 3 : 90%
CR3	DM1 60%	9 : 90% 3 : 10%	0	1	0	0	0	3
	DM2 40%	3-9 : 80%	0	1-3 : 90%	0	0	0	3-9 : 80%
CR4	DM1 60%	3 : 80%	0	3-9 : 90%	0	0	9 : 90% 3 : 10%	1-3 : 20% 3 : 80%
	DM2 40%	3 : 70% 3-9 : 20%	0	3 : 80% 1 : 20%	0	0	9 : 70% 3 : 10%	3
CR5	DM1 60%	3-9 : 80%	3-9 : 60% 3 : 20%	9 : 70% 3-9 : 30%	0	3-9	0	3-9
	DM2 40%	9 : 80%	3 : 80%	9	0	3 : 80% 9 : 20%	0	3 : 70% 3-9 : 10%
CR6	DM1 60%	0	9 : 80%	0	0	9 : 90%	0	0

			3 : 10%			3 : 10%		
	DM2 40%	0	3-9	0	0	3-9	0	0
CR7	DM1 60%	3-9 : 90%	0	0	0	0	3-9	3-9 : 20% 3 : 80%
	DM2 40%	9	0	0	0	0	9	3 : 70%

		SF8	SF9	SF10	SF11	SF12	SF13
CR1	DM1 60%	0	9	3 : 80% 3-9 : 20%	0	0	0
	DM2 40%	0	3-9 : 60% 9 : 30%	3	0	0	0
CR2	DM1 60%	0	0	0	0	0	0
	DM2 40%	0	0	0	0	0	0
CR3	DM1 60%	1-3 :20% 3-9 : 80%	0	3-9 : 20% 3 : 80%	0	0	0
	DM2 40%	3 : 70% 1 : 10%	0	3 : 90% 9 : 10%	0	0	0
CR4	DM1 60%	3 : 70% 9 : 10%	3-9 : 40% 9 : 60%	1-3 : 70% 1 : 20%	0	0	3-9 : 70% 3 : 30%
	DM2 40%	3-9 : 20% 3: 80%	9	1	0	0	3
CR5	DM1 60%	1	0	1 : 80% 3 : 20%	3	0	1-3
	DM2 40%	1 : 80% 3 : 20%	0	1-3 : 60% 1 : 40%	3-9 : 60% 3 : 40%	0	3-9
CR6	DM1 60%	3-9 : 80 % 9 : 20%	0	0	0	0	0
	DM2 40%	3	0	0	0	0	0
CR7	DM1 60%	0	9 : 80% 3 : 20%	0	0	9	0
	DM2 40%	0	3-9 : 60% 9 : 40%	0	0	3-9 : 30% 9 : 60%	

The assessments in table 7 need to be weighted and averaged to generate a collective assessment for each relationship. If there are M decision makers (DMs) and each of them is assigned a weight θl > 0 (l= 1,….,M) with $\sum_{l=1}^{M}\theta_l = 1$. Let {(Hpq, β pq(l)), p= 0,…,N ; q= p,…,N} be the belief structure provided by DM l on the assessment of relationship Rij, where Hpp for p=0 to N are the crisp ratings defined for relationship assessment, Hpq for p=0 to N and q= p+1 to N are intervals between Hpp and Hqq, and β pq(l) are the belief degrees to which the relationship Rij is assessed to interval rating Hpq. For the rating scale 0-9 defined before, we have four crisp ratings inclusive zero, which are 0,1,3,9 and six possible intervals that are: 0-1, 0-3, 0-9, 1-3, 1-9, 3-9. Therefore, we have N= 3 and

$$\mathrm{H} = \begin{Bmatrix} H_{00} & H_{01} & H_{02} & H_{03} \\ & H_{11} & H_{12} & H_{13} \\ & & H_{22} & H_{23} \\ & & & H_{33} \end{Bmatrix} = \begin{Bmatrix} 0 & 0-1 & 0-3 & 0-9 \\ & 1 & 1-3 & 1-9 \\ & & 3 & 3-9 \\ & & & 9 \end{Bmatrix} \qquad (10)$$

, which constitutes a frame of discernment in the terminology of the theory of evidence. The collective assessments of the M team members for each relationship is also a belief structure, which is denoted as {(Hpq, βpq), p = 0,…,N ; q= p,…,N) and determined by

$$\mathrm{Bpq} = \sum_{l=1}^{M}\theta_l\beta_{pq}^{(l)} \quad , \text{p= 0,…,N ; q=p,…,N} \qquad (11)$$

All the assessments for the relationships between WHATs and HOWs form a belief relationship matrix R= (Rij) m × n , where Rij is characterized by a belief structure.

Table 8 shows the collective assessment results for the relationships which form a belief relationship matrix. Note that the belief degrees assigned to the rating interval 0-9 represents "ignorance" information. That is to say, they have not been assigned to any ratings by the two DMs. (Chin, et al., 2009)

Table 8
Belief relationship matrix between the 7 CRs and 13 SFs

	SF1	SF2	SF3	SF4	SF5	SF6	SF7
CR1	9 : 88% 3 : 8% 0-9 : 4%	0	1-3 : 60% 1 : 32% 3 : 8%	0	0	9 : 92% 0-9 : 8%	9 : 50% 3 : 12% 3-9: 32% 0-9 : 6%
CR2	1-3 : 42% 1 : 40% 0-9 : 18%	0	0	9 : 60% 3-9 : 32% 0-9 : 8%	0	0	3 : 84% 9 : 12% 1 : 4%
CR3	9 : 54% 3 : 6% 3-9 : 32% 0-9 : 8%	0	1 : 60% 1-3 : 36% 0-9 : 4%	0	0	0	3 : 60% 3-9 : 32% 0-9 : 8%
CR4	3 : 76% 3-9 : 8% 0-9 : 16%	0	3-9 : 54% 3 : 32% 1 : 8% 0-9 : 6%	0	0	9 : 82% 3 : 10% 0-9 : 8%	1-3 : 12% 3 : 88%
CR5	3-9 : 48% 9 : 32% 0-9 : 20%	3-9 : 36% 3 : 44% 0-9 : 20%	9 : 82% 3-9 : 18%	0	3-9 : 60% 3 : 32% 9 : 8%	0	3-9 : 64% 3 : 28% 0-9 : 8%
CR6	0	9 : 48% 3 : 6% 3-9 : 40% 0-9 : 6%	0	0	9 : 54% 3 : 6% 3-9 : 36% 0-9 : 4%	0	0
CR7	3-9 : 54% 9 : 40% 0-9 : 6%	0	0	0	0	3-9 : 60% 9 : 40%	3-9 : 12% 3 : 76% 0-9 : 12%

	SF8	SF9	SF10	SF11	SF12	SF13
CR1	0	9 : 72% 3-9 : 24% 0-9 : 4%	3 : 88% 3-9 : 12%	0	0	0
CR2	0	0	0	0	0	0
CR3	1-3 : 12% 3-9 : 48% 3 : 28% 1 : 4% 0-9 : 8%	0	3-9 : 12% 3 : 84% 9 : 4%	0	0	0
CR4	3 : 74% 9 : 6% 3-9 : 8% 0-9 : 12%	3-9 : 24% 9 : 76%	1-3 : 42% 1 : 52% 0-9 : 6%	0	0	3-9 : 42% 3 : 58%
CR5	1 : 92% 3 : 8%	0	1 : 64% 3 : 12% 1-3 : 24%	3 : 76% 3-9 : 24%	0	1-3 : 60% 3-9 : 40%
CR6	3-9 : 48% 9 : 12% 3 : 40%	0	0	0	0	0
CR7	0	9 : 64% 3 : 12%	0	0	9 : 84% 3-9 : 12%	0

ISSN:2321-1091

3-9 : 24%	0-9 : 4%

2.2.3 Modeling the interrelationship matrix between SFs

The interrelationship matrix measures the interrelationships or called correlation relationships between HOWs and is also assessed by the QFD team members. To distinguish between positive and negative interrelationships between HOWs, positive and negative ratings are both adopted. Table 9 shows rating scale definition used in this paper for assessments of the interrelationships.

Table 9
Rating scales for interrelationship matrix

Rating	Definition
7	Strong positive correlation
3	Positive correlation
0	No correlation
-3	Negative correlation
-7	Strong negative correlation

Note that the rating scales for interrelationship matrix can be different from the rating scales for the relationship matrix. Each QFD team member can assess the interrelationship matrix using belief structures independently and the collective assessment of the interrelationship matrix by the M DMs is also a belief interrelationship matrix r= (rjk) n×n, where rjk are belief structures determined by

. rjk = $\sum_{l=1}^{M}\theta_l r_{jk}^{(l)}$ = $\sum_{l=1}^{M}\theta_l$ {(Hpq , $\alpha_{pq}^{(l)}$) , p= -N,…,N; q= p,…,N}

= {(Hpq , $\sum_{l=1}^{M}\theta_l\alpha_{pq}^{(l)}$), p= -N,…,N; q= p,…,N} , j,k = 1,…,n (12)

In which $r_{jk}^{(l)}$ = {(Hpq, $\alpha_{pq}^{(l)}$), p= -N,…, N; q= p,…, N} is the belief structure on rjk provided by team member l and $\alpha_{pq}^{(l)}$ is the belief degree to which rjk is assessed to the interval Hpq. Due to the fact that each service factor is always very strongly positively correlated to itself, rjj is thus always identical to {(9,100%)} for any j= 1,…, n

The above belief interrelationship matrix is then converted into an expected score matrix E(r) = (E (rjk)) n×n, where E (rjk) = $\sum_{p=-N}^{N}\sum_{q=p}^{N}\sum_{l=1}^{M}\theta_l\alpha_{pq}^{(l)}H_{pq}$ is the expected score of belief structure rjk and can be computed using interval arithmetic.

Note that the expected score matrix can also be generated by first transforming the belief structures provided by the DMs into the expected scores and then weighting them together. The result will be the same. (Chin, et al., 2009)

As mentioned before, two supervisors of Iran Air were appointed to act as decision makers and they determined the interrelationships between SFs by belief structures. Their assessments are listed in table 10. Table 11 shows collective assessment results for the interrelationships.

Table 10
Assessments on the interrelationships between 13 SFs

		SF1	SF2	SF3	SF4	SF5	SF6	SF7
SF1	DM1 60%	9	0	3:80%	0	0	0	0
	DM2 40%	9	0	3-7	0	0	0	0
SF2	DM1 60%	0	9	0	0	0	0	0
	DM2 40%	0	9	0	0	0	0	0
SF3	DM1 60%	3:80%	0	9	0	0	3	0
	DM2 40%	3-7	0	9	0	0	3:90% 7:10%	0
SF4	DM1 60%	0	0	0	9	0	0	0
	DM2 40%	0	0	0	9	0	0	0
SF5	DM1 60%	0	0	0	0	9	0	0
	DM2 40%	0	0	0	0	9	0	0
SF6	DM1 60%	0	0	3	0	0	9	0
	DM2 40%	0	0	3:90% 7:10%	0	0	9	0
SF7	DM1 60%	0	0	0	0	0	0	9
	DM2 40%	0	0	0	0	0	0	9
SF8	DM1 60%	0	0	0	0	0	0	0
	DM2 40%	0	0	0	0	0	0	0
SF9	DM1 60%	0	0	7:10% 3:90%	0	0	7:80% 3:20%	3-7: 10% 3:90%
	DM2 40%	0	0	3	0	0	7	0
SF10	DM1 60%	7	0	-3	0	0	0	3
	DM2 40%	3:20% 7:80%	0	-3:90% -7:10%	0	0	0	3:80% 3-7:20%
SF11	DM1 60%	0	0	0	0	0	0	0
	DM2 40%	0	0	0	0	0	0	0

ISSN:2321-1091

SF12	DM1 60%	0	0	0	0	0	0	0
	DM2 40%	0	0	0	0	0	0	0
SF13	DM1 60%	0	0	0	0	0	0	0
	DM2 40%	0	0	0	0	0	0	0

		SF8	SF9	SF10	SF11	SF12	SF13
SF1	DM1 60%	0	0	7	0	0	0
	DM2 40%	0	0	3:20% 7:80%	0	0	0
SF2	DM1 60%	0	0	0	0	0	0
	DM2 40%	0	0	0	0	0	0
SF3	DM1 60%	0	7:10% 3:90%	-3	0	0	0
	DM2 40%	0	3	-3:90% -7:10%	0	0	0
SF4	DM1 60%	0	0	0	0	0	0
	DM2 40%	0	0	0	0	0	0
SF5	DM1 60%	0	0	0	0	0	0
	DM2 40%	0	0	0	0	0	0
SF6	DM1 60%	0	7:80% 3:20%	0	0	0	0
	DM2 40%	0	7	0	0	0	0
SF7	DM1 60%	0	3-7:10% 3:90%	3	0	0	0
	DM2 40%	0	3:80% 7:20%	3:80% 3-7:20%	0	0	0
SF8	DM1 60%	9	0	0	0	0	0
	DM2 40%	9	0	0	0	0	0
SF9	DM1 60%	0	9	0	0	0	0
	DM2 40%	0	9	0	0	0	0
SF10	DM1 60%	0	0	9	0	0	0
	DM2 40%	0	0	9	0	0	0
SF11	DM1 60%	0	0	0	9	0	0
	DM2 40%	0	0	0	9	0	0
SF12	DM1 60%	0	0	0	0	9	0
	DM2 40%	0	0	0	0	9	0
SF13	DM1 60%	0	0	0	0	0	9
	DM2 40%	0	0	0	0	0	9

Table 11
Belief interrelationship matrix between 13 SFs

	SF1	SF2	SF3	SF4	SF5	SF6	SF7
SF1	9	0	3 : 48% 3-7: 40% 0-9: 12%	0	0	0	0
SF2	0	9	0	0	0	0	0
SF3	3 : 48% 3-7: 40% 0-9: 12%	0	9	0	0	3: 96% 7: 4%	0
SF4	0	0	0	9	0	0	0
SF5	0	0	0	0	9	0	0
SF6	0	0	3: 96% 7: 4%	0	0	9	0
SF7	0	0	0	0	0	0	9
SF8	0	0	0	0	0	0	0
SF9	0	0	7: 6% 3:94%	0	0	7: 88% 3: 12%	3-7: 6% 3: 86% 7: 8%
SF10	7: 92% 3: 8%	0	-3: 96% -7: 4%	0	0	0	3: 92% 3-7: 8%

ISSN:2321-1091

SF11	0	0	0	0	0	0	0
SF12	0	0	0	0	0	0	0
SF13	0	0	0	0	0	0	0

	SF8	SF9	SF10	SF11	SF12	SF13
SF1	0	0	7: 92% 3: 8%	0	0	0
SF2	0	0	0	0	0	0
SF3	0	7: 6% 3:94%	-3: 96% -7: 4%	0	0	0
SF4	0	0	0	0	0	0
SF5	0	0	0	0	0	0
SF6	0	7: 88% 3: 12%	0	0	0	0
SF7	0	3-7: 6% 3: 86% 7: 8%	3: 92% 3-7: 8%	0	0	0
SF8	9	0	0	0	0	0
SF9	0	9	0	0	0	0
SF10	0	0	9	0	0	0
SF11	0	0	0	9	0	0
SF12	0	0	0	0	9	0
SF13	0	0	0	0	0	9

3.2.4 IDS software

Interval ER algorithm can be used to aggregate the belief relationship matrix and obtain the initial technical importance ratings of SFs. But, inevitably the calculations involved in the aggregation process could be relatively complicated. Without a user friendly computer interface to facilitate information collection, processing and display, the task could be rather difficult to accomplish by hands, even for a relatively small scale problem. In this paper we take the advantage of Intelligent Decision System (IDS) software which is a software package designed to assist multi attribute decision analysis (MADA) or multi criteria decision making (MCDM). (Xu, et al., 2003)

CRs will be inserted as attributes and SFs as alternatives. CRs should be weighted with values of defuzzified Wi* in table 6. And all assessments of belief relationship matrix in table 8 should be inserted in the software. But, IDS cannot handle interval values. So instead of 13 SFs, 26 SFs will be inserted in the software. For example, instead of SF1, there will be SF1b and SF1w. SF1b is based on assessments of best possible performance and SF1w is based on assessments of worst possible performance.

To identify the best possible performance for an assessment, it is assumed that the unknown information turns out to be favorable. (Chin, et al.,2008) For example, if the relationship between CR1 and SF1 is determined to be {(1-3,70%); (unknown, 30%)}, the best case scenario is that the 30% of unknown turns out to be in grade 9 and the 70% of grade 1-3 performance turns out to be all in grade 3. Therefore, the assessment in best case scenario will be {(3, 70%), (9, 30%)}. In the software, this amount could be inserted as assessment between CR1 and SF1b.

Similarly, the worst case scenario would be that all unknown information turns out to be unfavorable.(Chin, et al., 2008) For example, the assessment {(1-3,70%); (unknown, 30%)} will be {(1,70%) , (1,30%)} or {(1,100%)}. This amount would be inserted in software as assessment between CR1 and SF1w. By modeling the problem in IDS software, we obtain the initial technical importance ratings of 13 SFs, which are shown in table 12, where Inf and Suf represents the lower and upper bounds, respectively

Table 12
Technical importance ratings without considering the correlations between SFs

	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8	SF9	SF10	SF11	SF12	SF13
Inf	0.432	0.168	0.210	0.122	0.206	0.224	0.429	0.183	0.246	0.109	0.078	0.146	0.078
Suf	0.734	0.289	0.267	0.164	0.302	0.299	0.576	0.249	0.290	0.140	0.097	0.164	0.152

3.2.5 Incorporating the interrelationship matrix into the final ratings of technical importance

Existing QFD methodologies either take no account of the interrelationships between HOWs or consider them at very beginning. The most commonly used approach is to incorporate the impact of interrelationships into the relationship matrix between WHATs and HOWs and modify its elements by the equation below:

$R^{`}_{ij} = \sum_{k=1}^{n} R_{ik} \; r_{kj}$, i= 1, m; j=1,…, n (13)

Where $R^{`}_{ij}$ is the adjusted relationship strength between CRi and SFj and rkj is the interrelationships between SFk and SFj. Based upon Eq. 13, the technical importance ratings of SFj can be obtained as

$TR_j^{`} = \sum_{i=1}^{m} w_i \;\; R_{ij}^{`} = \sum_{i=1}^{m} w_i \left(\sum_{k=1}^{n} R_{ik} \;\; r_{kj}\right) = \sum_{k=1}^{n} (\sum_{i=1}^{m} w_i \; R_{ik}\,) \, r_{kj} = \sum_{k=1}^{n} TR_k \, r_{kj}$ j= 1,…,n (14)

Where $TR_j^{`}$ and TR_j are respectively the technical importance ratings with and without the consideration of the interrelationships between HOWs. As can be seen from Eq. 14, the interrelationships can also be considered at the end of computational process after the initial technical importance ratings TRk (k= 1,…,n) are all obtained. The ER- based QFD methodology considers the influence of the interrelationships matrix on the final technical importance ratings along the guideline.

Let E(SFj) = [E_j^L , E_j^U] (j= 1,…,n) be the initial technical importance ratings obtained by IDS software and E(r) = (E(rij))n×n be the expected score matrix. Obviously, the initial ratings E(SFj) for j=1 to n have not considered the interrelationships between HOWs. After considering the interrelationship matrix characterized by the expected score matrix E(r) = (E (rij)) n×n, the final technical importance ratings can be computed by Eq.14 as

$TR_j^{`} = \sum_{k=1}^{n} E(DR_k) \, E(r_{kj})$, j= 1,…,n (15)

So, we first transform the belief interrelationship matrix in Table 11 into the expected score matrix by the method described before, as shown in Table 13, then calculate the final technical importance ratings by Eq. 15 as shown in Table 14

Table 13
Expected score correlation matrix transformed from Table 11

	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8	SF9	SF10	SF11	SF12	SF13
SF1	9	0	1.8-5.08	0	0	0	0	0	0	6.68	0	0	0
SF2	0	9	0	0	0	0	0	0	0	0	0	0	0
SF3	1.8-5.08	0	9	0	0	3.16	0	0	3.24	-3.16	0	0	0
SF4	0	0	0	9	0	0	0	0	0	0	0	0	0
SF5	0	0	0	0	9	0	0	0	0	0	0	0	0
SF6	0	0	3.16	0	0	9	0	0	6.52	0	0	0	0
SF7	0	0	0	0	0	0	9	0	3.32-3.56	3-3.32	0	0	0
SF8	0	0	0	0	0	0	0	9	0	0	0	0	0
SF9	0	0	3.24	0	0	6.53	3.56	0	9	0	0	0	0
SF10	6.68	0	-3.16	0	0	0	3-3.32	0	0	9	0	0	0
SF11	0	0	0	0	0	0	0	0	0	0	9	0	0
SF12	0	0	0	0	0	0	0	0	0	0	0	9	0
SF13	0	0	0	0	0	0	0	0	0	0	0	0	9

Table 14
The final technical importance ratings considering the interrelationships between service factors

	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8	SF9	SF10	SF11	SF12	SF13
Inf	4.994	1.512	3.828	1.098	1.854	4.286	5.064	1.647	5.779	3.875	0.702	1.314	0.702
Suf	8.897	2.601	7.574	1.476	2.718	5.428	6.681	2.241	7.475	6.312	0.873	1.476	1.368

3.2.6 Normalizing and ranking technical importance ratings

The technical importance ratings determined by Eq. 15 are usually intervals due to the presence of uncertainty in subjective judgments, which are non-normalized and can be normalized by the following equation:

$TR_J = \frac{TR_j^{`}}{\sum_{i=1}^{n} TR_i^{`}} = [\frac{(TR_j^{`})^L}{(TR_j^{`})^L + \sum_{i\neq j} (TR_i^{`})^U} , \frac{(TR_j^{`})^U}{(TR_j^{`})^U + \sum_{i\neq j} (TR_i^{`})^L}]$, j= 1,…,n (16)

Where $(TR_j^{`})^L$ and $(TR_j^{`})^U$ are the lower and upper bounds of $TR_j^{`}$, respectively. The normalized technical importance ratings are also shown in Table 15 and visualized in Figure 4, from which the ranking order of the thirteen service factors can be generated as

SF1> SF9 > SF7 > SF3 > SF10> SF6 > SF5 > SF2 > SF8 > SF12 > SF4> SF13>SF11

Table 15
Normalized technical importance rating and their ranking order

	SF1	SF2	SF3	SF4	SF5	SF6	SF7	SF8	SF9	SF10	SF11	SF12	SF13
Inf	0.097	0.028	0.074	0.02	0.034	0.079	0.095	0.03	0.108	0.073	0.013	0.024	0.013
Suf	0.219	0.069	0.187	0.04	0.072	0.144	0.174	0.06	0.195	0.161	0.024	0.04	0.037
Average	0.158	0.048	0.130	0.03	0.053	0.111	0.134	0.045	0.151	0.117	0.018	0.032	0.025
Ranking order	1	8	4	11	7	6	3	9	2	5	13	10	12

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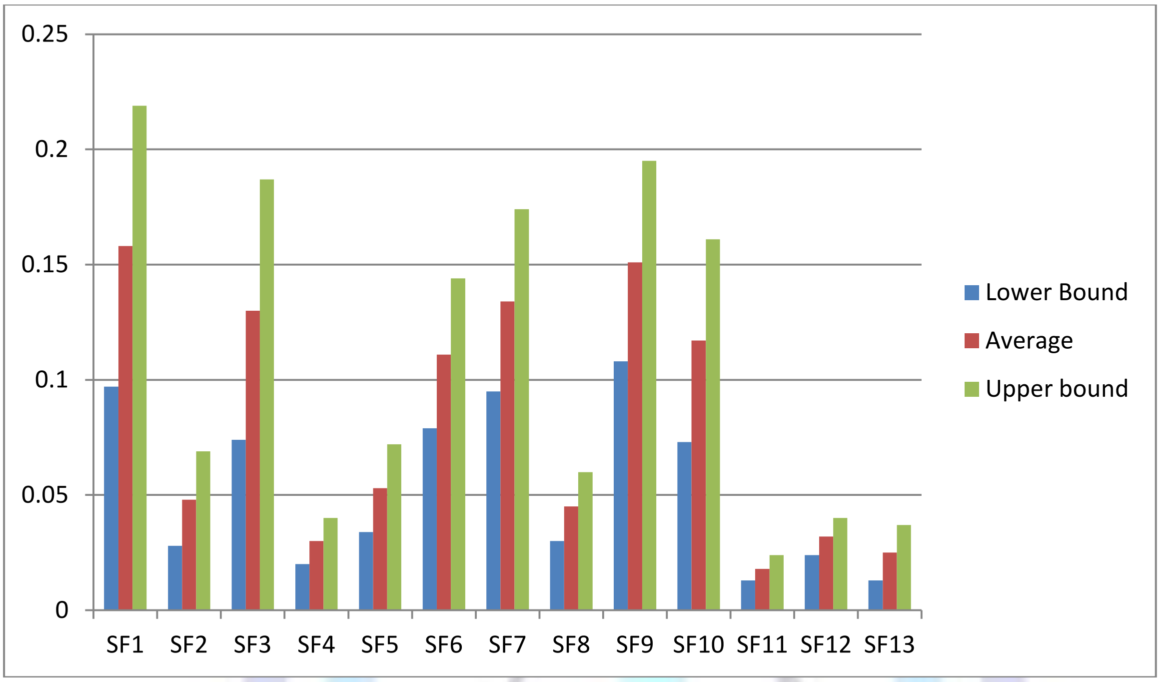

Fig.4. Normalized technical importance ratings of thirteen service factors (SFs)

3. Conclusions

This study has addressed the applicability of QFD in improving passenger service quality at the airport. A case study was done on Iran Air passengers traveling from Imam Khomeini international airport based on this methodology.

The developed methodology could be rightly considered as a useful tool for improving service quality. It causes the identification of service factors that are perceived to affect service quality from the customer's point of view, enabling the assessment of possible gaps between perceived service quality and positive and negative ideal state used in weighting the customer requirements, determining key service factors and ranking those factors based on their effect on customers' satisfaction and improving customer service.

Since personal judgments are required fuzzy logic and evidential reasoning theory has been adopted as a useful tool to build the customer service HOQ. It is well recognized that human assessments of service quality are always subjective and thus imprecise; also, the linguistic terms people use to express their judgments are vague in nature. Through fuzzy logic, linguistic judgments of passengers (about importance of customer requirements and perceived quality of each one of them) have been appropriately translated into a triangular fuzzy number.

Evidential reasoning can be used for dealing with various types of uncertainties such as incomplete, imprecise and missing information that may occur while using QFD. The proposed methodology allows QFD team members to independently express their opinions using a unified belief structure, so it can accommodate judgments that may be complete or incomplete, precise or imprecise such as intervals. It can also handle the situations where QFD team members do not provide any assessment information either because they feel difficult to make proper judgment or simply because they do not want to make any judgment due to whatever reason they may have.

In comparison with fuzzy logic, evidential reasoning provides more flexibility to people to make true judgments and allows them express their opinions freely still within a rigorous and systematic frame-work. However, understanding the questionnaires designed based on belief structure is somehow complicated. So, it is better to design questionnaire based on linguistic variables and then transform them into fuzzy numbers, when a large number of people are surveyed. But, when a few people are surveyed, it is possible to allocate enough time to explain belief structures and the way the questionnaires are answered. In this paper, two supervisors of Iran Air assigned as decision makers and determined the relationships between HOWs and WHATs by belief structures.

The methodology has been found to be an effective and easy tool to adopt. It has been successfully implemented on Iran Air passengers. The analysis shows that the most important factor in passengers' satisfaction is staff training. Training courses are useful for both newly employed and other staffs because of learning and updating information. Because the staff is directly in contact with passengers, courses in effective communication skills can be so applicable.

Additionally, the factor in the greatest need of improvement is "Supplying the special needs of passengers such as blanket, medicine, baby's food,… in case of delayed flights". Flight delays are inevitable, but paying special attention to passengers and meeting their requirements will help them to tolerate unpleasant situation until the flight departure.

However, SF11, which is "repairing devices and replacing old devices with new ones", has a minimal impact on improving passenger satisfaction. As shown in Table 15, it is the last service factor in the ranking order.

4. References

Bottani, E., Rizzi, A., 2006. Strategic management of logistics service: A fuzzy QFD approach. International Journal of Production Economics 103, 585-599

Chan, L.K., Ming-Lu, W., 2005. A systematic approach to quality function deployment with a full illustrative example. Omega 33, 119-139.

Chien, C. J., Tsai, H.H., 2000. Using fuzzy numbers to evaluate perceived service and quality. Fuzzy Sets and Systems 116, 289-300

Chin, K.S., Wang, Y.M., Yang, J.B., Poon, K.K.G, 2009. An evidential reasoning based approach for quality function deployment under uncertainty. Expert Systems with Applications 36, 5684-5694

Chin, K.S., Xu, D.L., Yang, J.B., Lam, J.P.K., 2008. Group-based ER-AHP system for product project screening. Expert Systems with Applications 35, 1909-1929

Gursov, D., Chen, M.H., Kim, H.Y., 2005. The US airlines relative positioning based on attributes of service quality. Tourism management 26, 57-67.

Han, S.B., Chen, S.K., Ebrahimpour, M., Sodhi, M.S., 2001. A conceptual QFD planning model. International Journal of Quality & Reliability Management 18, 796-812.

Khademi-Zare, H., Zarei, M., Sadeghieh, A., Owlia, M.S., 2010. Ranking the strategic actions of Iran mobile cellular telecommunication using two models of fuzzy QFD. Telecommunication Policy 34, 747-759.

Lee, D.E., Lim, T.K., Arditi, D., 2009.Automated stochastic quality function deployment system for measuring the quality performance of design/build contractors. Automation in Construction 18, 348-356

Liang, G.S., Chou, T.Y., Kan, S.F., 2006. Applying fuzzy quality function deployment to identify service management requirements for an ocean freight forwarder. Total Quality Management 539-554.

Lin, L.Z, Chen, W.C., Chang, T.J., 2011. Using FQFD to analyze island accommodation management in fuzzy linguistic preferences. Expert Systems with Applications 38, 7738-7745.

Massahi, M., A. Mirzazadeh and A. Mirzadeh. P, 2012. The Evidential Reasoning Approach for Suppliers Prioritization with Group-AHP Weights. Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management, Istanbul, Turkey, July 3-6. 1945-1953.

Mirzazadeh, A. and M. Safari, 2008. Project Risks Assessment by using Mathematical Theory of Evidence under Uncertainty Conditions. Fourth International Conference of Project Management. Tehran, Iran.

Parasuraman, A., Zeithaml, V.A., Berry, L.L., 1985. A conceptual model of service quality and its implications for future research. Journal of Marketing 49, 41-50.

Park, J.W., Robertson, R., Wu, C.L., 2004. The effect of airline service quality on passengers' behavioral intentions: a Korean case study. Journal of Air Transport Management 10, 435-439.

Rahgan S. and A. Mirzazadeh, 2012. A new method in the location problem using Fuzzy evidential reasoning. Research Journal of Applied Science, Engineering and Technology 4, 4636-4645.

Temponi, C., Yen, J., Tiao, W.A., 1999. House of quality: A fuzzy logic-based requirements analysis. European Journal of Operational Research 117, 340-354

Wang, R.T., 2007. Improving service quality function deployment: The air cargo sector of China airlines. Journal of Air Transport Management 13, 221-228.

Wang, Y.M., Yang, J.B., Xu, D.L., Chin, K.S., 2006. The evidential reasoning approach for multiple attribute decision analysis using interval belief degrees. European Journal of Operational Research 175, 35-66

Xu, D.L., Yang, J.B., 2003. Intelligent Decision System for Self-Assessment. Journal of Multi-Criteria Decision Analysis 12, 43-60

Zare Mehrjerdi, Y., 2009. Quality function deployment and its extensions. International Journal of Quality & Reliability Management 27, 616-640.