Strategic Public Management Journal: Evaluating Service Quality in the Aviation Industry

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Abstract

A hybrid fuzzy MADM method is proposed in this paper for evaluating airline service quality. Fuzzy set theory is used since it helps in measuring the ambiguity of concepts associated with human being's subjective judgment. After reviewing service quality evaluation models especially in the airline industry, SSQAI model was adopted as a construct for evaluating airline service quality in Iran. Fuzzy DEMATEL was applied to determine the degree of influence and impact of criteria on each other and extract cause and effect relations between them that helped in ranking criteria based on the degree of relationship. Then, ANP network map was constructed based on the relation map generated from Fuzzy DEMATEL analysis. Fuzzy ANP approach assisted in prioritizing criteria based on the need for improvement and enabled in a more accurate measurement in decision-making process taking the advantage of using linguistic variables. Fuzzy DEMATEL results demonstrate that expertise, Problemsolving, and conduct has the most influence on other factors and in opposite Valence, Waiting Time, Comfort are the factors which get the most impact from other factors and according to Fuzzy ANP analysis Valence, Convenience, Problem-solving, and Safety&Security are the factors with most priorities that need improvement.

Keywords: *Airline Service Quality, Fuzzy Theory, FMADM, Fuzzy DEMATEL, Fuzzy ANP*

INTRODUCTION

Nowadays, delivery of high-quality service has become an essential requirement for transport service providers especially airline companies (Ostrowski, O'Brien and Gordon, 1993) because of rapid technological developments in the transport sector. In recent years, competition between Iranian airlines has increased in domestic flights and these airlines try to gain more or at least not to lose their market share of passenger air transportation. The significant advances in communication and transportation technology has changed the world into a global village and let to the raise of air travel rates. Thus, the studies in airline service quality have obtained a major significance.

Kotler (1991) states that delivering high-quality service leads to satisfaction and loyalty of the airline passengers (Kotler, 1991) and enhances airlines to stay up in the competitive environment of passenger transportation (Nathanail, 2008). Airlines are required to keep the essential services and minimize efforts spent on the less important services while still maintaining passenger perceptions of airline service quality (Liou, Hsu, Yeh and Lin, 2011) in an acceptable level and they have to understand what passengers expect from their services in order to better serve their needs. Although a lot of researches has been conducted on airline service quality in different countries, there is still a little research concerning airline service quality in Iran. So, this paper is focused on evaluating airline service quality in Iran. This study gets the advantage of fuzzy decision-making theory, which considers the fuzzy subjective judgment of evaluators in the airline service quality evaluation process. The data are analyzed in the fuzzy environment, because it helps in better measuring different daily decision-making problems in many diverse aspects of the airline service quality.

1. LITERATURE REVIEW

In today's competitive environment, fulfilling desirable service quality is indispensable for the airlines' survival, competitiveness, profitability and sustained growth. High service quality, empower the airlines to retain their existing passengers and also attract customers from other airlines. Focusing on service quality leads to make a different image from competitors in the customers' mind. Promoting high-quality service plays a key role in generating profits (Zeithaml, Berry, Parasuraman, 1996). Offering high-quality services will increase customer satisfaction, leading to consumer retention and encouraging recommendations (Nadiri and Hussain, 2005). Quality is not a singular but a multi-dimensional phenomenon. Moreover, the utility value of “service quality” determinants are situation-dependent (Ghobadian, Speller, and Jones, 1996). Parasuraman, Zeithaml, and Berry (1985) defined the concept of service quality as a comparison between customers' expectations and actual service performance.

Park, Robertson, and Wu (2006) indicate that many airlines have difficulty in using a proper scale to evaluate service quality in order to appropriately assess and improve their service performance. Pakdil and Aydin (2007) modified SERVQUAL and proposed 34 criteria classified in eight dimensions to measure service quality in the airline industry. They used factor analysis to extract the eight dimensions that are: employees, tangibles, responsiveness, reliability and assurance, flight patterns, availability, image, and empathy. Liou and Tzeng (2007) suggested employees service, safety, and reliability, onboard service, schedule, on-time performance, frequent flyer program as airline service quality factors. Gilbert and Wong (2003) found incorporating measures of reliability, assurance, facilities, employees, flight patterns, customization and responsiveness as service quality factors. They used a 26-item questionnaire to compare passengers' expectations to their actual perceived airline service quality. Kuo and Liang (2011) used costs of processing time, convenience, comfort, information visibility, courtesy of staff, security, reaction capacity in airline service quality measurement.

MCDM methods have attracted many researchers to measure airlines integrated service quality level based on hierarchical concept and to make suggestions for improvement (Chang and Yeh, 2002; Liou and Tzeng, 2007; Tsaur, Chang and Yeh, 2002; Liou et al., 2011). Brady and Cronin (2001) believe that customers form their perceptions of service quality in a multilevel performance comparison. Then they combine these evaluations to arrive at an overall perception of service quality. Dabholkar, Thorpe, and Rentz (1996) and Brady & Cronin (2001) recommend that service quality should be based on a hierarchical concept. A review of some airline service quality measurements is shown in Table. 1.

Table 1. Review of airline service quality evaluation models

Research	Analysis method	Criteria
Chow (2014)	Tobit analysis, ANOVA	16 criteria; Flight delays, Baggage problems, Ticketing problems, In-flight services, Flight information, Check-in service, Cargo problems, Passenger service, Ticketing, Booking, Oversold tickets, Refunding, Animal death, Services for disabled, Ticket price, Flight cancellation, Weather conditions
Laming and Mason (2014)	Statistical analysis (Spearman)	9 criteria; Cabin features, in-flight food and drink, crew and pilots, seat features, IFE, Arrival, Boarding and departure, Website services, Check-in, flight delays
Tiernan, Rhoades, and Waguespack (2008)	Statistical analysis (F-test)	3 criteria; On-time arrivals, baggage reports, flight cancellations
Liou and Tzeng (2007)	AHP, Factor analysis (Rotated method, Varimax with Kaiser normalization), Fuzzy integral, Grey relation analysis	12 criteria in 6 dimensions; employees service (4), Safety and reliability (2), On-board service (3), Schedule (1), On-time performance (1), Frequent Flyer Program (1)
Pakdil and Aydin (2007)	Factor Analysis, Weighted SERVQUAL	34 criteria in 8 dimensions; Employees (4), Tangibles (5), Responsiveness (6), Reliability and assurance (4), flight patterns (3), Availability (3), Image (3), Empathy (6)
Tsaur, Chang and Yen (2002)	AHP, Fuzzy Theory, TOPSIS	15 criteria in 5dimentions; Tangibility (4), Reliability (3), Responsiveness (2), Assurance (3), Empathy (3)
Kuo and Jou (2014)	Structural Equation Modelling (SEM)	5criteria; Service quality gain, Service quality loss, Satisfaction, Behavioral intention, Perceived value
Liou, Hsu, Yeh, and Lin (2011)	Grey Relation Analysis (GRA), Weighted grey gap	28criteria; Booking service (3), Ticketing service (3), Check-in (4), Baggage handling (2), Boarding process (3), Cabin service (7), Baggage claim (2), Responsiveness (4)
Kuo and Liang (2011)	VIKOR, Grey Relation Analysis (GRA), Fuzzy Sets	7criteria, Costs of processing time, Convenience, Comfort, Information visibility, Courtesy of staff, Security, Reaction capacity

Wu and Cheng (2013) proposed a hierarchical conceptual framework for evaluating service quality in airline industry known as SSQAI model which is developed on the basis of Dabholkar et al. (1996) and Brady and Cronin's (2001) studies. The SSQAI model's construct used in this paper is shown in Fig. 1. Using this model in our study, the eleventh airline evaluation criteria of SSQAI and their symbol used in this research are: Conduct (C1), Expertise (C2), Problem-solving (C3), Cleanliness (C4), Comfort (C5), Tangibles (C6), Safety&Security (C7), Conduct (C8), Waiting Time (C9), Information (C10), and Convenience (C11). Some of the model's dimensions and criteria, based on Wu and Cheng (2013) are described to reduce ambiguity as follows: Interaction quality dimension; focuses on the interaction between customers and employees in the service industry Conduct; includes the meaning of attitude and behavior. Expertise; identifies the degree of interaction affected by the employees' task-oriented skills; outcome dimension; focuses on the outcome of the service act and indices what customers gain from service; Valence; focuses on the attributes like image that leads to satisfaction and acceptance the service by the customers. Physical environment quality dimension refers to the physical features of the service production process. Access quality; refers to the ease and speed with which people reach their desired information and locations. Information is referred to the feasibility of obtaining up-to-date information about service variety using phone and internet in an easy and comfortable way. The Convenience is based on things like (time, energy or frustration) that intends to save resources.

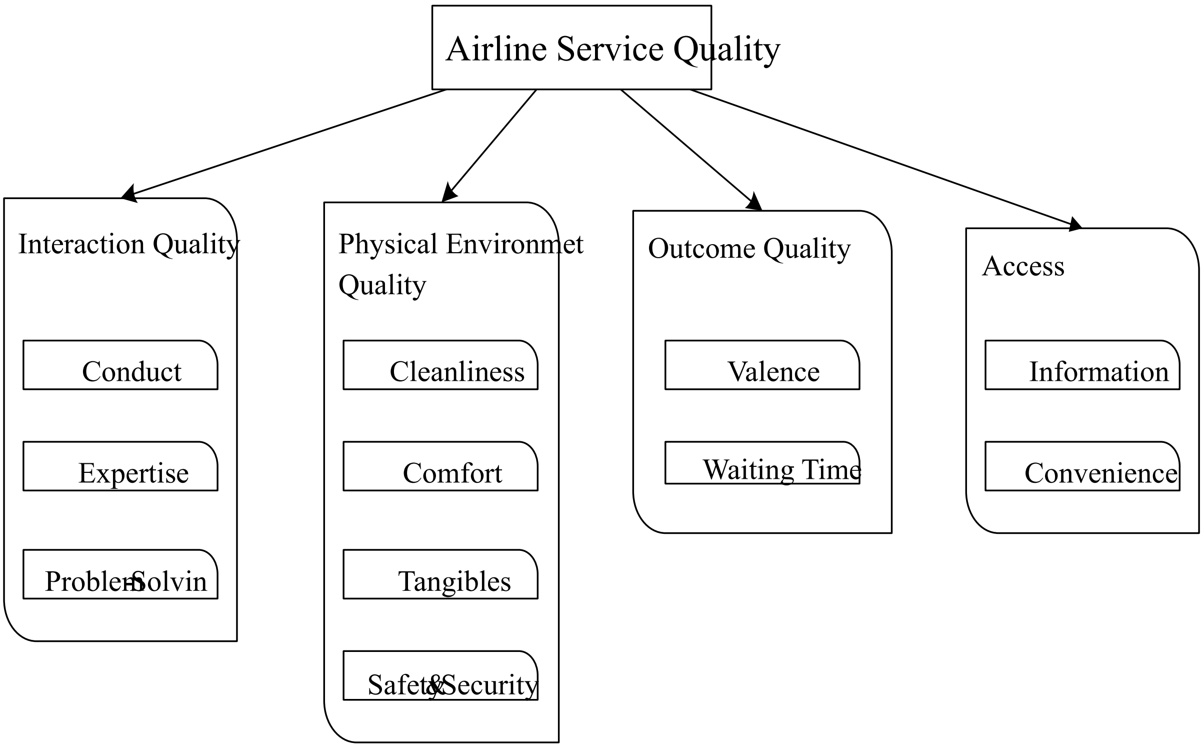

Figure 1. Airline measurement dimensions and criteria construct

2. METHODOLOGY

By consulting Iranian airline experts, it was found that the eleventh criteria in airline service quality proposed by Wu and Cheng (2013) as SSQAI model which is a performance-based measurement scale in a hierarchical structure specialized in measuring airline service quality.

First, Fuzzy DEMATEL was performed to find out the relation of criteria with each other. Direct relation matrix generated in Fuzzy DEMATEL is used as an input in Fuzzy ANP. Then, Fuzzy ANP technique was used to determine the need for improvement importance of each evaluation criteria, with calculating criteria rank due to experts' opinions. Sum of criteria in each cluster demonstrates the weight of that cluster. Our respondents involved 45 Iranian airline experts participated in evaluating criteria of airline service quality with filling fuzzy DEMATEL and ANP questionnaires.

3. FUZZY SET THEORY

The terms of expressions "Not very clear", "probably so", "very likely", usually can be heard in daily life, and their commonality is that they are more or less tainted with the uncertainty. It is very difficult for conventional quantification to express reasonably those situations that are overly complex or hard to define; so, the notion of a linguistic variable is essential for such situations (Zadeh, 1975). Fuzzy Theory firstly was introduced by Zadeh (1965). Fuzzy set theory is basically a theory of classes with non-sharp boundaries. This theory is a mathematical theory designed to model the vagueness or imprecision of human cognitive processes (Ayag and Ozdemir, 2012). Bellman and Zadeh (1970) described the decision-making method in fuzzy environments. Since then an increasing number of studies have dealt with uncertain fuzzy problems by applying fuzzy set theory. A triangular fuzzy number is shown in Fig. 2.

0 L M U

Figure 2. A triangular fuzzy number

4. FUZZY DEMATEL

All factors in a complex system directly or indirectly maybe either related to each other. Actually, it is difficult for a decision maker to evaluate a single effect from a single factor without considering interference from the rest of the system (Liou and Tzeng, 2007). DEMATEL technique is based on graph theory. It enables decision-makers to separate multiple measurement criteria into a cause and effect group to realize causal relationships more easily. In addition, directed graphs, called digraphs, represent a communication network or a domination relationship among entities and their groupings (Chen and Chen, 2010). This paper uses Fuzzy DEMATEL method in classifying and analyzing structural relationship of criteria in airline service quality. The steps of fuzzy DEMTEL are as follows:

4.1. Defining Fuzzy Linguistic Scale

For dealing with the vagueness of experts' opinions and expressions in decision making, linguistic ambiguities are represented through the conversion of linguistic variables into fuzzy numbers. The linguistic variable scale with triangular fuzzy numbers used here is seen in Table.2. This fuzzy linguistic scale formerly was applied in a fuzzy DEMATEL analysis by Wu and Lee (2007). **Table 2. The fuzzy linguistic scale**

Linguistic terms	Triangular fuzzy numbers
Very high influence(VH)	(0.75,1,1)
high influence(H)	(0.5,0.75,1)
Low influence(L)	(0.25,0.5,0.75)
Very low influence(VL)	(0,0.25,0.5)
No influence(No)	(0,0,0.25)

4.2. Calculating Initial Direct-Relation Average Matrix

Based on groups of direct matrices from experts, we can generate an average matrix Z in which each element is mean of the corresponding elements in the experts' direct matrices. Z_{ij} is presented as the degree to which the criterion i affects the criterion j. Each part of the triangular fuzzy number (l, m, u) is averaged. The average Matrix Z is calculated as follows:

$$l = \frac{\sum_{i=1}^{n} l}{N}$$

$$\sum^{n} m$$

$$m \; \frac{\;_{i\,1}}{N}$$

$$n$$

$$u \; \frac{\;_{i\,1} \;u}{N}$$

Now having l , m and u, Z is generated:

$$Z \; (l\ m\ u, \quad ,\ )$$

$$Z \; \frac{Z\ Z^{1} \quad ^{2} \ldots Z^{n}}{N}$$

4.3. Normalizing Initial Direct-Relation Matrix

To transform the various criteria scales into a comparable scale, the normalized direct-relation matrix X = $[X_{ij}]$ can be obtained as follows, in which all Z fuzzy numbers are divided by r,

$$r \; \max_{i} \; \sum_{j\,1}^{n} u_{ij}$$

$$x_{ij} \; \frac{z}{r_{ij}} \; \left(\frac{l}{r_{ij}}, \frac{m}{r_{ij}}, \frac{u}{r_{ij}}\right)$$

$$X \; \begin{bmatrix} x & \cdots & x_{n} \\ & \ddots & \vdots \\ x_{m} & \cdots & x_{mn} \end{bmatrix}$$

4.4. Acquiring Total Relation Matrix T

Each part of the total-relation matrix T can be acquired as follows, in which 'matrix I' is denoted as the identity matrix. The element t_{ij} indicates the indirect effects factor 'I' has on factor 'j', so the 'matrix T' can reflect the total relationship between each pair of system factors. Matrix T is acquired as follows:

For generating each item of matrix T these relations should be calculated:

$$T \; \lim_{k} (X \; X^{2} \ldots X^{k}) \; X (I \; X)^{1}$$

$$l_{ij} \; X_{l} (I \; X_{l})^{1}$$

$$m_{ij} \; X_{m} (I \; X_{m})^{1}$$

$$u_{ij} \; X_{u} (I \; X_{u})^{1}$$

With combining (l_{ij}''), (m_{ij}''), (u_{ij}'') matrices, total relation matrix is generated.

$$T = \lim_{k\to\infty}(X + X^2 + \dots + X^k)$$

$$\tilde{t}_{ij} = \left(l_{ij}'', m_{ij}'', u_{ij}''\right)$$

$$T = \begin{bmatrix} \tilde{t}_{11} & \cdots & \tilde{t}_{1n} \\ & \ddots & \\ \tilde{t}_{m1} & \cdots & \tilde{t}_{mn} \end{bmatrix}$$

4.5. Defuzzification Of Matrix T

"Defuzzification" is the selection of a specific crisp element based on the output fuzzy set and it also includes converting fuzzy numbers into crisp scores. The commonly used defuzzification method is centroid method commonly called as the Center of Area (COA) or center of gravity (COG) (Opricovic and Tzeng, 2003). The process of defuzzification has been proposed to locate the best non-fuzzy performance (BNP) value. Based on this method the following relation is formulated for converting a fuzzy number into crisp number X_{crisp}.

$$X_{crisp} = \frac{\int_l^u x\,\mu_{\tilde{N}}(x)\,dx}{\int_l^u \mu_{\tilde{N}}(x)\,dx}$$

For a triangular fuzzy number N= (l, m, u) best non-fuzzy performance (BNP) value for triangular fuzzy performance score of COA method, can be derived from the following relation:

$$BNP = l_{ij} + \frac{\left[(u_{ij} - l_{ij}) + (m_{ij} - l_{ij})\right]}{3}$$

This method is adopted in this paper since it has been widely used in the literature due to its simplicity and not requiring analyst's personal judgment. Deffuzified Total influence matrix T is shown in Table.3.

Table 3. Deffuzified Total influence matrix T

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1	0.056	0.114	0.164	0.054	0.151	0.077	0.081	0.198	0.129	0.117	0.134
C2	0.122	0.069	0.178	0.115	0.153	0.090	0.131	0.226	0.173	0.142	0.174
C3	0.130	0.150	0.106	0.139	0.197	0.138	0.171	0.250	0.187	0.145	0.168
C4	0.056	0.060	0.100	0.038	0.131	0.068	0.075	0.166	0.068	0.053	0.080
C5	0.069	0.081	0.139	0.060	0.068	0.100	0.094	0.180	0.081	0.063	0.078

C6	0.062	0.077	0.094	0.117	0.146	0.049	0.138	0.185	0.094	0.057	0.075
C7	0.058	0.083	0.095	0.051	0.153	0.115	0.053	0.178	0.070	0.055	0.067
C8	0.067	0.068	0.083	0.064	0.079	0.054	0.071	0.075	0.101	0.063	0.080
C9	0.059	0.060	0.088	0.053	0.092	0.049	0.060	0.168	0.051	0.053	0.134
C10	0.084	0.062	0.112	0.054	0.085	0.056	0.068	0.178	0.151	0.044	0.138
C11	0.068	0.072	0.120	0.065	0.090	0.056	0.069	0.174	0.091	0.066	0.055

4.6. Setting a Threshold Value and Filtering Data

It is necessary to set a threshold value to filter out negligible effects in matrix T because it helps explain the structural relation among factors while keeping the complexity of the whole system to a manageable level. After defining the threshold value as 'P', only the factors with greater effects than the threshold value in matrix T will be shown in an IRM. In setting threshold value, after defuzzifying matrix T, due to experts' opinions, the average of Deffuzified matrix T was adopted as the threshold value (P=0.1011). This filtered data (see Table. 4) will be used to construct ANP network relation map.

Table 4. Filtering data lower than threshold value in matrix T

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1		0.114	0.164		0.151			0.198	0.129	0.117	0.134
C2	0.122		0.178	0.115	0.153		0.131	0.226	0.173	0.142	0.174
C3	0.130	0.150	0.106	0.139	0.197	0.138	0.171	0.250	0.187	0.145	0.168
C4					0.131			0.166			
C5			0.139					0.180			
C6				0.117	0.146		0.138	0.185			
C7					0.153	0.115		0.178			
C8											
C9								0.168			0.134
C10			0.112					0.178	0.151		0.138
C11			0.120					0.174			

4.7. Calculating the Cause and Effect Relation of Criteria

To calculating the impact of criteria on each other and gain relation degree between criteria, we compute sum of each of the rows as R_i and sum of each column as C_j in matrix T through Eqs below. Respectively. R is generated as follows:

$$R_i = (L_i, M_i, U_i)$$

$$L_i = \sum_{j=1}^{n} l_{ij}; \quad M_i = \sum_{j=1}^{n} m_{ij}; \quad U_i = \sum_{j=1}^{n} u_{ij}$$

Similarly, C is generated as follows:

$$C_j \square (L\ M\ U_j ,_j ,\ _j)$$

$$L_j \square \square_{i \square 1}^{n} l_{ij} ;M_j \square \square_{i \square 1}^{n} m\ U_{ij} ;_j \square \square_{i \square 1}^{n} u_{ij}$$

The sum of row i, which is denoted as R_i, represents all direct and indirect influence given by factor i to all other factors. Similarly, the sum of column j, which is denoted as C_j summarizes both direct and indirect impact received by factor j from all other factors.

4.8. Calculating Impact-Relation Degree of Criteria

Naturally, when i = j, R_i+C_j shows all effects given and received by 'factor i'. That is, R_i+C_j indicates both, factor i's impact on the whole system and other system factor's impact on factor i. hence, the indicator R_i+C_j can represent the degree of interact that factor i has with other factors in the entire system.

$$R_i \square \ \square \ \square C_j \qquad (l_i l_j ,m_i \square m\ u_j ,\ _i \square u_j)$$

On the contrary, again when i=j, the difference of the two, R_i-C_j shows the net effect and influence that factor i has on the system. Specifically, if the value of R_i–C_j is positive, the factor i is a net cause, exposing net causal effect on the system.

$$R_i \square \ \square \ \square C_j \qquad (l_i\ u_j ,m_i \square m_j ,u_i \square l_j)$$

When R_i–C_j is negative, the factor is a net result clustered into effect group. Values of (D+R) and (DR) are shown in Table. 5.

Table 5. Values of(R+C) and (R-C)

	(R+C)	(R-C)
C1	(0.63,1.6,4.15)	(-1.3,0.48,2.22)
C2	(0.83,1.95,4.6)	(-1.23,0.69,2.53)
C3	(1.21,2.56,5.42)	(-1.61,0.52,2.6)
C4	(0.45,1.18,3.53)	(-1.46,0.05,1.62)
C5	(0.8,1.86,4.43)	(-2.14,-0.33,1.49)
C6	(0.59,1.39,3.81)	(-1.41,0.25,1.82)
C7	(0.62,1.49,3.89)	(-1.66,-0.02,1.61)
C8	(1.09,2.32,4.94)	(-3.07,-1.23,0.78)
C9	(0.65,1.55,3.98)	(-1.99,-0.33,1.34)
C10	(0.56,1.36,3.76)	(-1.43,0.18,1.77)
C11	(0.63,1.6,4.1)	(-1.99,-0.25,1.47)

4.9. Obtaining Crisp Scores of (R+C) and (R-C)

We use BNP here for gaining crisp scores of (R+C) and (R-C) since it is needed for drawing impactrelation map.

$$(R\ C_i \square\ _j)_{def} \square BNP\ R\ \tilde{C}(\ _i \square\ _j)$$

$$(R\ C_i \square\ _j)_{def} \square BNP\ R\ \tilde{C}(\ _i \tilde{\square}\ _j)$$

Crisp values of $(R+C)^{def}$ and $(R-C)^{def}$ can be seen in Table. 6.

Table 6. Values of $(R+C)^{def}$ and $(R-C)^{def}$

	$(R+C)^{def}$	Rank	$(R-C)^{def}$	Rank
C1	2.124		0.465	
C2	2.459		0.666	
C3	3.063		0.502	
C4	1.718		0.074	
C5	2.364		-0.326	
C6	1.928		0.224	
C7	1.998		-0.024	
C8	2.784		-1.173	
C9	2.060		-0.327	
C10	1.893		0.175	
C11	2.109		-0.256	

4.10. Drawing Cause-Effect Relationship Map Based on $(R + C)^{def}$ and $(R - C)^{def}$

A cause-effect diagram can be drawn by mapping the dataset of $(R+C)^{def}$ and $(R-C)^{def}$. And the complex interrelationship among factors is visualized through the diagram construction process. Crisp scores are used to construct cause-effect relation diagram. The horizontal axis (R+C) is made by adding R to C and the vertical axis (R-C) is made by subtracting R from C. This diagram is shown in Fig. 3.

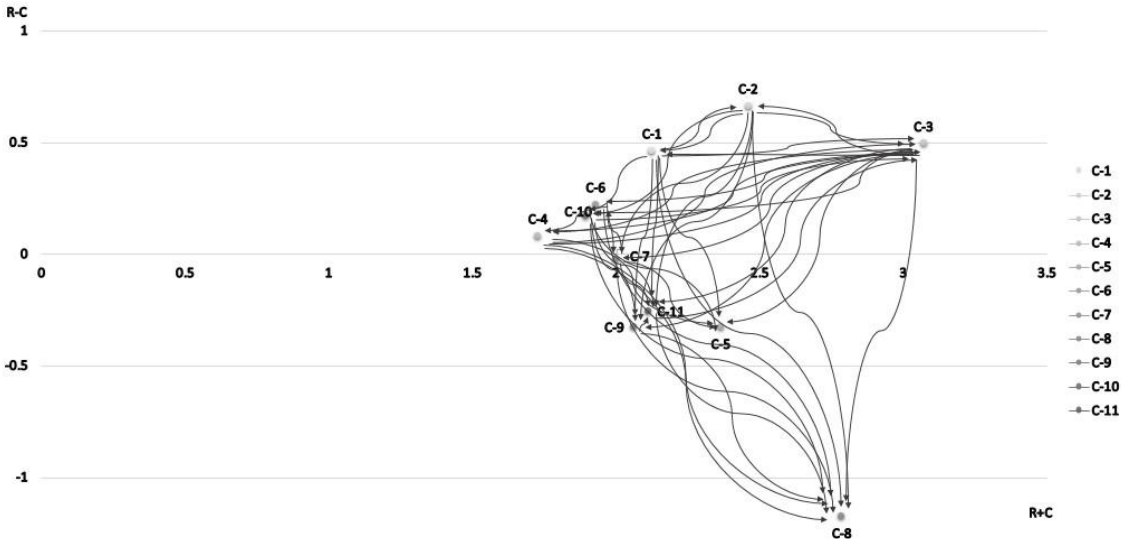

Figure 3. Impact-Relation map

5. FUZZY ANP

ANP incorporates feedback and interdependent relationships among decision attributes and alternatives (Saaty, 1996). Conventional ANP seems inadequate to capture decision makers' requirements explicitly because of uncertainty in human preference. Fuzzy ANP approach allows a more accurate description of the decision-making process. Fuzzy sets could be incorporated with the pairwise comparison as an extension of ANP (Ayag and Ozdemir, 2012).

The steps of the Fuzzy ANP analysis proposed in this study, developed based on (lee, Kang, Yang and Lin, 2010) is conducted as follows:

5.1. Defining Fuzzy Linguistic Variables

Fuzzy Linguistic scale adopted in this paper for analyzing Fuzzy ANP is shown in Table. 7. Zhou(2012) has been used this fuzzy scale in Fuzzy ANP calculation.

Table 7. Fuzzy Linguistic variables

Linguistic scale for importance	Fuzzy scale	Fuzzy reciprocal scale
Equally important	(1,1,1)	(1,1,1)
Intermediate	(1,2,3)	$(\frac{1}{3},\frac{1}{2},1)$
Moderately important	(2,3,4)	$(\frac{1}{4},\frac{1}{3},\frac{1}{2})$
Intermediate	(3,4,5)	$(\frac{1}{5},\frac{1}{4},\frac{1}{3})$
Important	(4,5,6)	$(\frac{1}{6},\frac{1}{5},\frac{1}{4})$
Intermediate	(5,6,7)	$(\frac{1}{7},\frac{1}{6},\frac{1}{5})$
Very importantly	(6,7,8)	$(\frac{1}{8},\frac{1}{7},\frac{1}{6})$
Intermediate	(7,8,9)	$(\frac{1}{9},\frac{1}{8},\frac{1}{7})$
Absolutely important	(9,9,9)	$(\frac{1}{9},\frac{1}{9},\frac{1}{9})$

5.2. Constructing Network Structure and Questionnaire

The problem is decomposed into a rational system like a network. The structure is obtained according to experts' opinions through filtered total relation matrix of fuzzy DEMATEL analysis. The problem is composed of a network, as shown in Fig. 4. Base on the relation between criteria in network structure, the questionnaire is constructed.

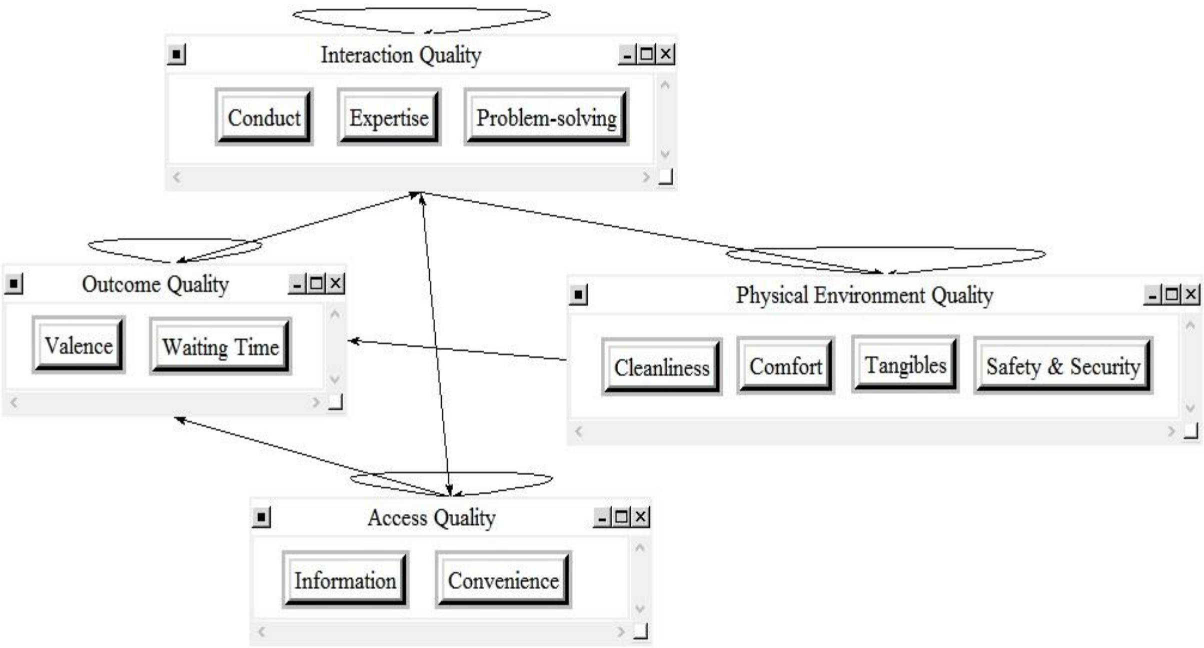

Figure 4. Network structure of airline service quality evaluation

5.3. Employing Fuzzy Pairwise Comparisons and Checking Consistency of Comparison Matrices

Decision makers are asked to pairwise compare the elements in a questionnaire. The scores of pairwise comparison of each part of the questionnaire from all experts are transformed into linguistic variables by the transformation concept listed in Table. 6 and for each decision maker, pairwise comparison Matrices are formed. For getting accurate results in our survey, adequate explanations on survey questions were given to experts, so the experts could understand the questionnaire clearly.

The quality of ultimate decision of the ANP process is strongly related to the consistency of judgments that decision makers demonstrate during the series of pairwise comparisons. When CR is less than 0.1, the comparisons are acceptable, otherwise not (Saaty, 1996). If the consistency test fails, the expert is asked to fill out the specific part of the questionnaire again. Since consistency ratio for all of the comparisons filled by experts in the questionnaires is less than 0.1, the experts' judgment is consistent.

5.4. Making Aggregated Pairwise Comparison Matrix

When all pairwise comparison matrices of the experts have passed the consistency test, we can aggregate experts' opinions with making aggregated pairwise comparison matrix. For doing this, the fuzzy pairwise comparison matrices with respect to the same element are aggregated into one single fuzzy pairwise comparison matrix through the geometric mean method. If there are k experts, every pairwise comparison between criteria has k positive reciprocal triangular fuzzy numbers. The Geometric average approach is employed to aggregate decision-maker's responses.

$$\tilde{r}_{ij} = \left(\tilde{a}_{ij1} \otimes \tilde{a}_{ij2} \otimes \ldots \otimes \tilde{a}_{ijk}\right)^{\frac{1}{k}}$$

5.5. Defuzzifying Aggregated Fuzzy Pairwise Comparison Matrix

Applying the Center of Area (COA) method, fuzzy aggregated pairwise comparison matrix is Deffuzified into an equivalent matrix with crisp data using best non-fuzzy values.

$$BNP_{ij} = l_{ij} + \frac{\left[(r_{ij} - l_{ij}) + (m_{ij} - l_{ij})\right]}{3}$$

5.6. Calculating Priority Vectors and Forming Unweighted Super Matrix

Derive priority vectors for all aggregated comparison matrices can be calculated as follows:

$$A*\omega=\lambda_{max}*\omega$$

Where **A** is the matrix of pairwise comparison, w is the eigenvector, and λ_{max} is the largest eigenvalue of **A**. Saaty (1996) declares that for obtaining global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix, known as an unweighted supermatrix, as follows:

$$S = \begin{array}{l} \text{Goal} \\ \text{Criteria} \\ \text{Subcriteria} \end{array} \begin{bmatrix} I & & \\ W_{21} & W_{22} & \\ & W_{32} & W_{33} \end{bmatrix}$$

In the supermatrix, W_{21} is a vector that represents the impact of the goal on the criteria, W_{32} is a matrix that represents the impact of criteria on sub-criteria, W_{22} indicates the interdependency of the criteria, W_{33} indicates the interdependency of the sub-criteria, and I is the identity matrix. Due to Priority vectors of aggregated comparison matrices, the unweighted supermatrix is calculated in Table. 8.

Table 8. Unweighted supermatrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1		0.1488	0.1609								
C2	0.1615		0.839								
C3	0.8384	0.8511									
C4		0.0675	0.0428			0.0604					
C5		0.1848	0.2510			0.2274	0.1468				
C6			0.1286				0.8531				
C7		0.7476	0.5774			0.7120					
C8	0.8731	0.8195	0.8605							0.83222	
C9	0.1268	0.1804	0.1394							0.16778	
C10	0.2529	0.1403	0.1452								
C11	0.7470	0.8596	0.8547								

5.7. Transforming Unweighted Supermatrix into Weighted Supermatrix

For transforming an unweighted supermatrix to a weighted supermatrix, the supermatrix must be transformed first to make it stochastic; that is, each column of the matrix sums to unity. The relative importance of the clusters in the supermatrix with the column cluster (block) as the controlling component, should be determined (Saaty1996). Giving equal weights to the blocks in the same column makes each column sums to unity. The weighted supermatrix is shown in Table. 9. **Table 9. Weighted supermatrix**

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
C1		0.0372	0.04022								
C2	0.04039		0.20977								
C3	0.20961	0.2128			0.5					0.09278	0.11111
C4		0.01689	0.01071			0.03024					
C5	0.25	0.04621	0.06276	0.5		0.11374	0.07342				
C6			0.03216				0.42658				
C7		0.1869	0.14436			0.35602					
C8	0.21829	0.20488	0.21513	0.5	0.5	0.5	0.5		0.5	0.61773	0.88889
C9	0.03171	0.04512	0.03487							0.12454	
C10	0.06324	0.0351	0.03632						0.5		

C11	0.18676	0.2149	0.21369	0.16495

5.8. Calculating the Limit Supermatrix

Raising a matrix to powers gives the long-term relative influences of the elements on each other (saaty, 1996). To achieve a convergence of importance weights, the weighted supermatrix will be raised to powers to capture all the interactions between criteria and to reach stability. The weighted supermatrix is raised to the power of $2k+1$, where k is an arbitrarily large number, to obtain the limit supermatrix. The entries in the same row show the global weights of each measurement criterion. Priorities generated from limit supermatrix are shown in Table. 10.

Table 10. Priorities generated from limit supermatrix

Dimension	Criteria	Priorities in Cluster	Rank in Cluster	Overall Priorities	Overall Rank
Interaction Quality	Conduct(C1)	0.06975	3	0.010458	
	Expertise(C2)	0.26949		0.040405	
	Problem-solving(C3)	0.66076		0.099067	
Physical environment Quality	Cleanliness(C4)	0.03233		0.008452	
	Comfort(C5)	0.23713		0.062000	
	Tangibles(C6)	0.34037		0.088996	
	Safety & Security(C7)	0.39017		0.102017	
Outcome Quality	Valence(C8)	0.96521		0.475208	
	Waiting time(C9)	0.03479		0.017127	
Access Quality	Information(C10)	0.28187		0.027136	
	Convenience(C11)	0.71813		0.069135	

CONCLUSIONS

After reviewing the literature and different factors in evaluating airline service quality and according to experts' opinions, the SSQAI model with its eleven criteria was selected for evaluating Iran's airline industry in domestic flights. According to fuzzy DEMATEL results, factors with more influence and effective power on the other factors (positive R-C) include expertise, Problem-solving, conduct, tangibles, Information, and cleanliness, that are placed in cause factors category and the other factors which are impressed by other factors (negative R-C) involve Valence, Waiting Time, Comfort, Convenience, and Safety&Security that are placed in effect group. Getting advantage of fuzzy DEMATEL analysis, also the factors were ranked based on the degree of relationship (R+C) that sequentially are Problem-solving, Valence, Expertise, Comfort, Conduct, Convenience, Waiting Time, Safety & Security, Tangibles, Information, and Cleanliness.

Since expertise and problem-solving have the most influence on other evaluation criteria in the airline industry, it is suggested that airlines pay more attention to professional training methods for improving airline personnel Skills. So, they can better serve customers and passengers, especially in critical circumstances. Also, airline managers should take advantage of focus group meetings with the involvement of managers and employees for finding suitable and proper solutions for decreasing passenger problems and subsequently increasing passengers' satisfaction with the airline services. After mentioning relation between criteria with fuzzy DEMATEL, fuzzy ANP was used to obtain weight and priorities of criteria.in fuzzy ANP analysis. So, the evaluation criteria network map was constructed based on SSQAI scale, then experts' opinions were collected as linguistic variables to perform analysis in the Fuzzy environment.

After checking consistency for each pairwise comparison matrix, the Geometric mean of fuzzy data was calculated in excel software (2016). Superdecision (2.4.0) software was used to obtain criteria improvement priorities. Due to results, criteria weights which need improvement, in order to the most important are Valence, Convenience, Problem-solving, Safety&Security, Tangibles, Information, Expertise Comfort, Conduct, Waiting Time, Cleanliness that placed in first to the eleventh rank, respectively. Results of this study, offer a clearer perspective for airline providers, enabling them in better strategic planning, identifying airline passengers' needs and gaining remarkable market share in the airline industry.

DISCUSSION AND RECOMMENDATIONS

According to our findings valence is the most important factor in airline service quality evaluation. Similarly, previous studies stated that quality is positively related to customer satisfaction (Anderson and Sullivan, 1993; Cronin and Taylor, 1992) and corporate image (Grönroos, 1984). Results of our study about the minor importance of Waiting time is inconsistent with the study of Suki (2014) who indicated that service quality is widely developed by providing uphold punctuality of the flight departures and arrivals. Also, findings of Gilbert and Wong (2003) show passengers consistently ranked assurance as the most important service dimension.

In our study waiting time got minor importance for the improvement of airline service quality. This is because some other criteria need more importance for improvement. This result is similar to findings of Chow (2014); and Andotra, Gupta and Pooja (2008) that indicated the on-time performance of scheduled flights has no significant effect on the customer complaints and influence on their choice of airlines. We found Convenience as the most important factor after valence which is inconsistent with Andotra et al. (2008) that stated ticket prices, in-flight services, facilities and ticketing procedures have not played key roles in determining airline service quality and influencing passengers' choice of airlines.

Nadiri and Hussain (2005) found that consumers put less emphasis on aspects such as airline tangibles, because of insignificantly impact on the customers, however in our study tangibles has an intermediate importance among all criteria. Findings of Suki (2014) stated that attentiveness of in-flight cabin crews has great influence on customer experience but his research implied that airline tangible characteristics like the cleanliness of airplane interior toilets, quality of catering and design of aircraft have little impact on the customers' level of satisfaction with airline service quality. As well, in our study Cleanliness has the least importance for improvement from the experts' views.

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