Evaluating Airline Service Quality Using Fuzzy DEMATEL and ANP

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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 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 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 demonstrates that expertise, Problem-solving, 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

1. 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 technology developments in 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 and significant advances in communication and transportation technology has changed the world into a global village and let to raise of air travel rates. So researches in airline service quality, has obtained a major significance. Although a lot of researches has been conducted in airline service quality in different countries, there is still a little research concerning airline service quality in Iran. Delivering high-quality service leads to satisfaction and loyalty of the airline passengers (Kotler, 1991) and enhances airlines to stay up in competitive environment of passenger transportation (Nathanail, 2008). Airlines are required to keep the essential services and

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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 accepted level and they have to understand what passengers expect from their services in order to better serve their needs.

With different daily decision making problems in many different aspects of the airline service quality evaluation, it is better to analysis the results in the fuzzy environment. So, this study get the advantage of fuzzy decision-making theory, which considers the fuzzy subjective judgment of evaluators in the airline service quality evaluation process.

2. Literature Review

In today's competitive environment, delivering desirable service quality is vital for the airline's survival, competitiveness, profitability and sustained growth. High quality service, 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) mentioned employees service, Safety and reliability, On-board 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) Suggest 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, over sold tickets, refunding, animal death, services for disabled, ticket price, flight cancelation, 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	12criteria 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	34criteria 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	15criteria 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 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 models dimensions and criteria, based on Wu and Cheng (2013) are described to reduce ambiguity as follows: Interaction quality dimension; focuses on 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 employee's task-oriented skills; outcome dimension; focuses on 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.
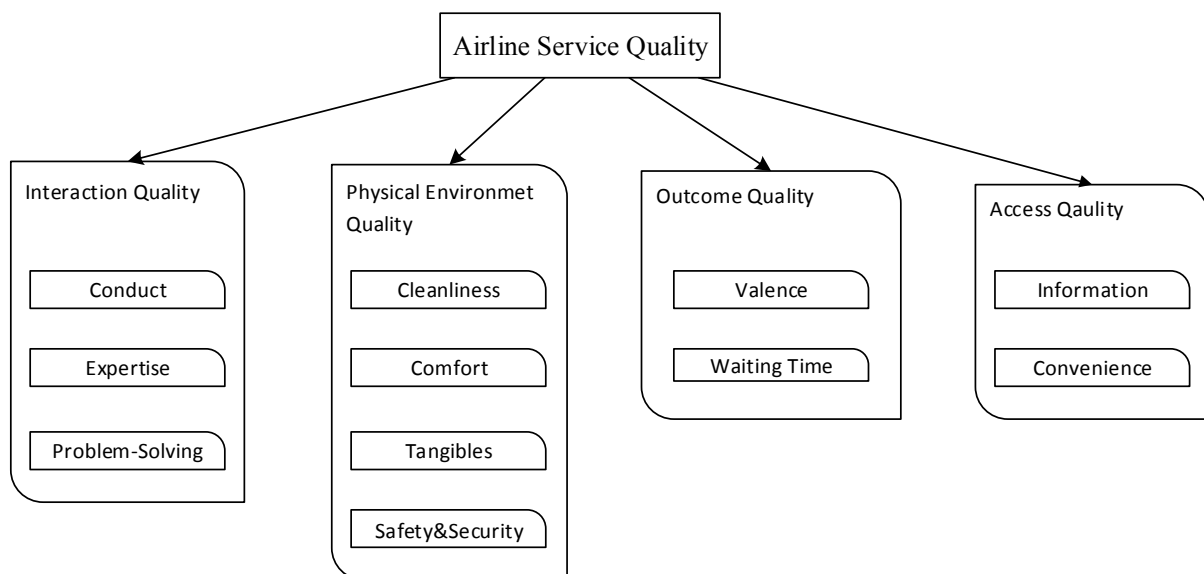

Figure 1. Airline measurement dimensions and criteria construct

3. 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 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 need for improvement importance of each evaluation criteria, with calculating criteria rank due to expert's opinions. Sum of criteria in each cluster demonstrates 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.

4. Fuzzy Set Theory

The terms of expressions ''Not very clear'', ''probably so'', ''very likely'', can be heard very often in daily life, and their commonality is that they are more or less tainted with uncertainty. It is very difficult for conventional quantification to express reasonably those situations that are overtly complex or hard to define; thus, notion of a linguistic variable is necessary in 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.
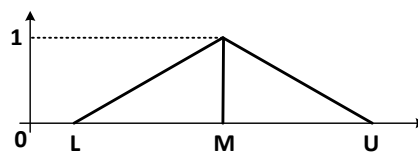

Figure 2. A triangular fuzzy number

5. Fuzzy DEMATEL

All factors in a complex system may be either directly or indirectly related; therefore, it is difficult for a decision maker to evaluate a single effect from a single factor while avoiding 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:

5.1. 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)

5.2. 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 triangular fuzzy number (l, m, u) is averaged. The average Matrix Z is calculated as follows:

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

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

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

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

$$Z' = (l', m', u')$$

$$\widetilde{Z} = \frac{\left(\widetilde{Z}^1 \oplus \widetilde{Z}^2 \oplus ... \oplus \widetilde{Z}^n \right)}{N}$$

5.3. 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 through Eq. (1) and (2), in which all Z fuzzy numbers are divided by r,

$$r = \max_{i} \left(\sum_{j=1}^{n} u_{ij} \right)$$

$$\widetilde{x}_{ij} = \frac{\widetilde{z}_{ij}}{r} = \left(\frac{l_{ij}}{r}, \frac{m_{ij}}{r}, \frac{u_{ij}}{r} \right)$$

$$\widetilde{X} = \begin{pmatrix} \widetilde{x}_{11} & \cdots & \widetilde{x}_{1n} \\ \vdots & \ddots & \vdots \\ \widetilde{x}_{m1} & \cdots & \widetilde{x}_{mn} \end{pmatrix}$$

5.4. Acquiring total relation matrix T

Each part of the total-relation matrix T can be acquired through eq. (3), 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 $\widetilde{T}$ these relations should be calculated:

$$\widetilde{T} = \lim_{k \to \infty} (\widetilde{X} + \widetilde{X^2} + ... + \widetilde{X^k}) \simeq X \times (I - X)^{-1}$$

$$\left[l''_{ij} \right] = X_l \times (I - X_l)^{-1}$$

$$\left[m''_{ij} \right] = X_m \times (I - X_m)^{-1}$$

$$\left[u''_{ij} \right] = X_u \times (I - X_u)^{-1}$$

With combining $\left[l''_{ij} \right], \left[m''_{ij} \right], \left[u''_{ij} \right]$ matrices, total relation matrix is generated.

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

$$\tilde{t}_{ij} = \left(l''_{ij}, m''_{ij}, u''_{ij} \right)$$

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

5.5.   Defuzzification of matrix T

"Defuzzification" is 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:

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

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 judgement. Defuzzificated Total influence matrix T is shown in Table. 3.

Table 3. Defuzzificated 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

5.6. Setting a threshold value and Filtering data lower than the threshold value

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 defuzzificating matrix T, due to experts' opinions, the average of defuzzificated 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	0.114	0.164	0	0.151	0	0	0.198	0.129	0.117	0.134
C2	0.122	0	0.178	0.115	0.153	0	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	0	0	0	0.131	0	0	0.166	0	0	0
C5	0	0	0.139	0	0	0	0	0.180	0	0	0
C6	0	0	0	0.117	0.146	0	0.138	0.185	0	0	0
C7	0	0	0	0	0.153	0.115	0	0.178	0	0	0
C8	0	0	0	0	0	0	0	0	0	0	0
C9	0	0	0	0	0	0	0	0.168	0	0	0.134
C10	0	0	0.112	0	0	0	0	0.178	0.151	0	0.138
C11	0	0	0.120	0	0	0	0	0.174	0	0	0

5.7. 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 rows as R_i and sum of each column as C_j in matrix T through Eqs below. Respectively. R is generated as follows:

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

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

Similarly, C is generated as follows:

$$C_j = (L_j, M_j, U_j)$$

$$L_j = \sum_{i=1}^{n} l_{ij}; M_j = \sum_{i=1}^{n} m_{ij}; U_j = \sum_{i=1}^{n} u_{ij}$$

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.

5.8. 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 factors' 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.

$$R_i \oplus C_j = (l_i + l_j, m_i + m_j, u_i + u_j)$$

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.

$$R_i - C_j = (l_i + u_j, m_i + m_j, u_i + l_j)$$

When $R_i–C_j$ is negative, the factor is a net result clustered into effect group. Values of (D+R) and (D-R) 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)	(1.95,4.6,-1.23)
C3	(1.21,2.56,5.42)	(2.56,5.42,-1.61)
C4	(0.45,1.18,3.53)	(1.18,3.53,-1.46)
C5	(0.8,1.86,4.43)	(1.86,4.43,-2.14)
C6	(0.59,1.39,3.81)	(1.39,3.81,-1.41)
C7	(0.62,1.49,3.89)	(1.49,3.89,-1.66)
C8	(1.09,2.32,4.94)	(2.32,4.94,-3.07)
C9	(0.65,1.55,3.98)	(1.55,3.98,-1.99)
C10	(0.56,1.36,3.76)	(1.36,3.76,-1.43)
C11	(0.63,1.6,4.1)	(1.6,4.1,-1.99)

5.9. Obtaining crisp scores of (R+C) and (R-C)

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

$$(R_i + C_j)^{def} = BNP(\tilde{R}_i + \tilde{C}_j)$$

$$(R_i - C_j)^{def} = BNP(\tilde{R}_i - \tilde{C}_j)$$

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	3
C2	2.459		0.666	1
C3	3.063		0.502	2
C4	1.718		0.074	6
C5	2.364		-0.326	9
C6	1.928		0.224	4
C7	1.998		-0.024	7
C8	2.784		-1.173	11
C9	2.060		-0.327	10
C10	1.893		0.175	5
C11	2.109		-0.256	8

5.10. 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.

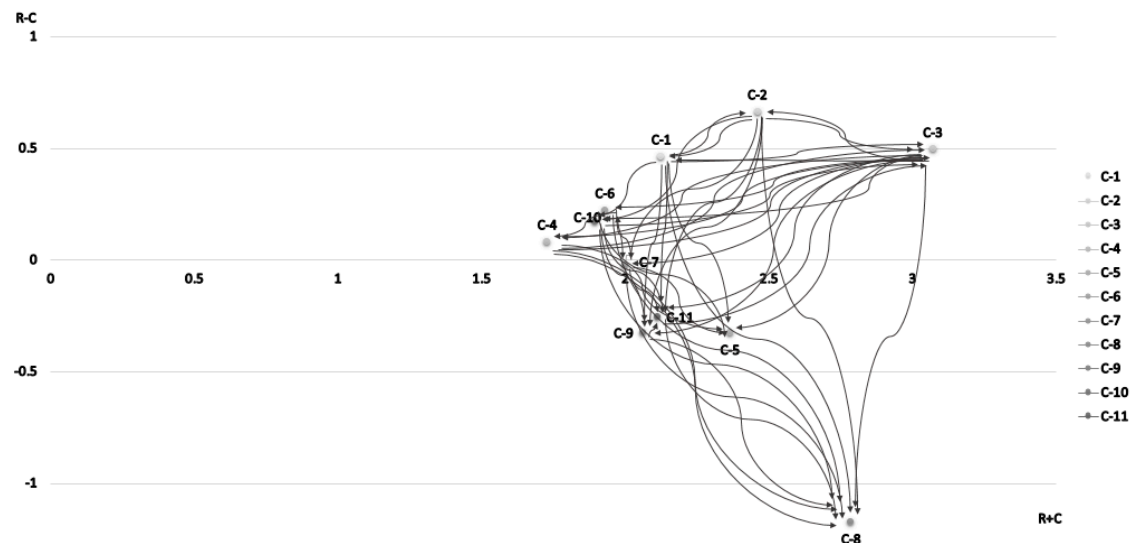*Figure 3. Impact-Relation map*

6. Fuzzy ANP

ANP incorporates feedback and interdependent relationships among decision attributes and alternatives (Saaty, 1996).conventional ANP seems inadequate to capture decision maker's 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:

6.1. Defining fuzzy linguistic variables

Fuzzy Linguistic scale adopted in this paper for analyzing Fuzzy ANP (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)	$(\frac{1}{9}, \frac{1}{9}, \frac{1}{9})$

6.2. 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 into a network, as shown in Fig. 4. Base on the relation between criteria in network structure, the questionnaire is constructed.
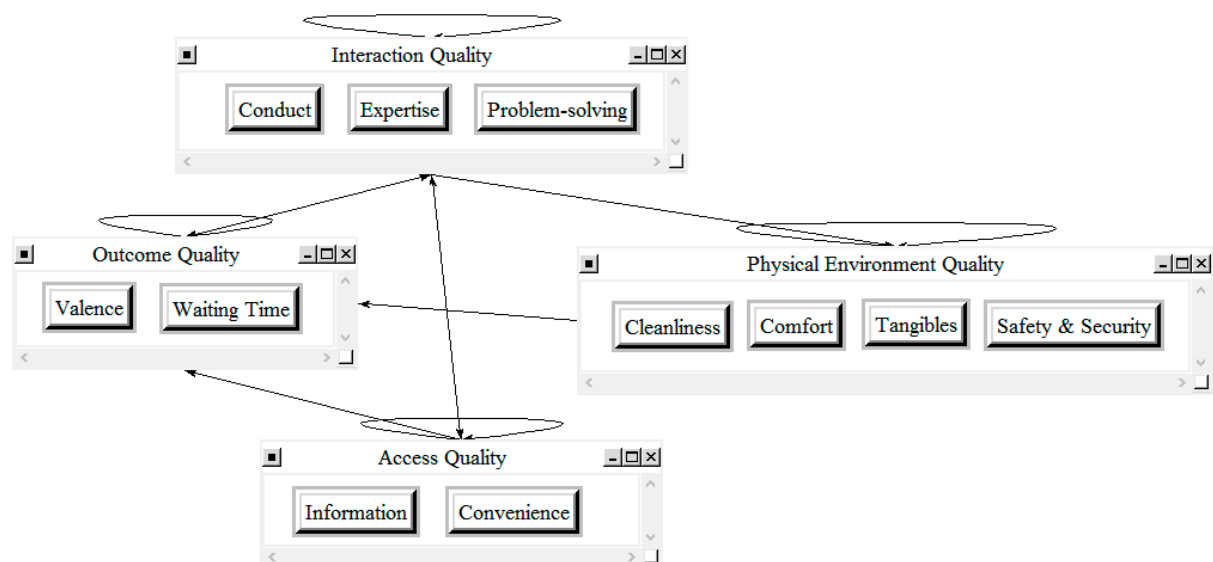

Figure 4. Network structure of airline service quality evaluation

6.3. 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 0.10, 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 comparisons filled by experts in the questionnaires is less than 0.1, the expert's judgment is consistent.

6.4. Making aggregated pairwise comparison matrix

When all pairwise comparison matrices of the experts have passed the consistency test, we can aggregate expert's 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. Geometric average approach is employed to aggregate decision-makers' responses.

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

6.5. Defuzzificating aggregated fuzzy pairwise comparison matrix

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

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

6.6. 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:

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

In the supermatrix, *w*21 is a vector that represents the impact of the goal on the criteria, W32 is a matrix that represents the impact of criteria on sub-criteria, W22 indicates the interdependency of the criteria, W33 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	0.1488	0.1609	0	0	0	0	0	0	0	0
C2	0.1615	0	0.839	0	0	0	0	0	0	0	0
C3	0.8384	0.8511	0	0	1	0	0	0	0	1	1
C4	0	0.0675	0.0428	0	0	0.0604	0	0	0	0	0
C5	1	0.1848	0.2510	1	0	0.2274	0.1468	0	0	0	0
C6	0	0	0.1286	0	0	0	0.8531	0	0	0	0
C7	0	0.7476	0.5774	0	0	0.7120	0	0	0	0	0
C8	0.8731	0.8195	0.8605	1	1	1	1	0	1	0.83222	1
C9	0.1268	0.1804	0.1394	0	0	0	0	0	0	0.16778	0
C10	0.2529	0.1403	0.1452	0	0	0	0	0	1	0	0
C11	0.7470	0.8596	0.8547	0	0	0	0	0	0	1	0

6.7. 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	0.0372	0.04022	0	0	0	0	0	0	0	0
C2	0.04039	0	0.20977	0	0	0	0	0	0	0	0
C3	0.20961	0.2128	0	0	0.5	0	0	0	0	0.09278	0.11111
C4	0	0.01689	0.01071	0	0	0.03024	0	0	0	0	0
C5	0.25	0.04621	0.06276	0.5	0	0.11374	0.07342	0	0	0	0
C6	0	0	0.03216	0	0	0	0.42658	0	0	0	0
C7	0	0.1869	0.14436	0	0	0.35602	0	0	0	0	0
C8	0.21829	0.20488	0.21513	0.5	0.5	0.5	0.5	0	0.5	0.61773	0.88889
C9	0.03171	0.04512	0.03487	0	0	0	0	0	0	0.12454	0
C10	0.06324	0.0351	0.03632	0	0	0	0	0	0.5	0	0
C11	0.18676	0.2149	0.21369	0	0	0	0	0	0	0.16495	0

6.8. Calculating the limit supermatrix

To achieve a convergence on importance weights, the weighted supermatrix is raised to powers to capture all interactions and to reach stability. The weighted supermatrix is raised to the power of $2k +1$ to obtain the limit supermatrix. The entries in the same row are the global weights of each measurement criterion. Priorities generated from limit supermatrix are shown in Table. 10.

Raising a matrix to powers gives the long-term relative influences of the elements on each other.to achieve a convergence on the importance weights, the weighted supermatrix is raised to the power of 2k+1,where k is an arbitrarily large number, and this new matrix is called the limit supermatrix (saaty,1996).

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	9
	Expertise(C2)	0.26949	2	0.040405	7
	Problem-solving(C3)	0.66076	1	0.099067	3
Physical environment Quality	Cleanliness(C4)	0.03233	4	0.008452	11
	Comfort(C5)	0.23713	3	0.062000	8
	Tangibles(C6)	0.34037	2	0.088996	5
	Safety & Security(C7)	0.39017	1	0.102017	4
Outcome Quality	Valence(C8)	0.96521	1	0.475208	1
	Waiting time(C9)	0.03479	2	0.017127	10
Access Quality	Information(C10)	0.28187	2	0.027136	6
	Convenience(C11)	0.71813	1	0.069135	2

7. 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 from 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 airline industry, it is suggested that airlines pay more attention on 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 involvement of managers and employees for finding suitable and proper solutions for decreasing passenger problems and subsequently increasing passenger's satisfaction of 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 Fuzzy environment.

After checking consistency for each pairwise comparison matrix, 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 importance are: Valence, Convenience, Problem-solving, Safety&Security, Tangibles, Information, Expertise Comfort, Conduct, Waiting Time, Cleanliness that placed in first to 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 airline industry.

8. 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 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 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 on-time performance of scheduled flights has no significant effect on the customer complaints and influencing 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 customer, 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 costumer experience but his research Implied that airline tangible characteristics like 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 expert views.

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