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Article

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OPERATIONS, INFORMATION & TECHNOLOGY | RESEARCH ARTICLE

An integrated approach for prioritizing the barriers to airport service quality in an intuitionistic-fuzzy environment

S. Habibollah Mirghafoori^{1*}, Mohammad Reza Izadi² and Ali Daei²

Abstract: Airports today, despite the complexity of their service environment and multicultural nature, are expected to provide high-quality services to satisfy their passengers. This way they will be able to gain competitive advantages. Hence, improving the quality of airport services has become increasingly significant. In this paper, the main components of the airport services quality with the greatest impact on the customer satisfaction have been derived based on previous articles as well as interviews with experts in this field and travelers. Subsequently, the comments of passengers were received by distributing questionnaires. Eventually, using failure mode and effects analysis (FMEA) approach along with entropy and VIKOR techniques, the risk factors were evaluated and ranked in an intuitionistic triangular fuzzy environment. The findings of this research can be addressed to the airport management team to review and reform their services and facilities. Yazd international airport was considered as a case study of this paper.

Subjects: Operations Research; Service Operations Management; Quality Management

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PUBLIC INTEREST STATEMENT

The service quality is one of the important issues in service industries. Airports provide services for vast section of countries' internal and external community. So airports managers must permanently investigate their services' quality. To investigate the quality of services, variation models are used. SERVQUAL model is the most important one. To gather customers' opinion in this model, questionnaire is used and data are analyzed as rigid data. Since in the SERVQUAL model we are deal with customers' judgments, using fuzzy logic can help us in more accurate analyses. In this paper, at first obstacles of the airports' service quality were detected then by using questionnaire the opinions of the passengers of the airport of the historical city of Yazd were collected on the basis of intuitionistic fuzzy data then by using FMEA, obstacles were ranked. The most important obstacles are as follows: Low perception of safety and security, Lack of staff helpfulness/responsibility, Long processing time in general (such as inspections, luggage delivery).

| **Keywords:** airports; FMEA; Intuitionistic fuzzy; barriers; service quality; VIKOR; entropy

1. Introduction

By entering the new millennium and increasing air travels, airports as the main section involved with this subject, have faced a lot of challenges ahead of them. These challenges are directly tied to the satisfaction of the passengers with the services. Therefore, improving the quality of airport services has been considered as one of the main strategies of the airports (Arif, Gupta, & Williams, 2013; Dimitriou, 2018; Graham, 2009).

Also, the nature of airports where there are passengers with different cultures and travel purposes, creates multiple standards in this area which must be comprehended (Pantouvakis & Renzi, 2016). These standards will be accessible with providing efficient and high-quality services to the passengers and these services can intensively affect their overall impression of the travel (Martín-Cejas, 2006). Since service is not a physical component and it is a kind of personal experience, Service quality is strongly linked to the customer satisfaction. As a matter of fact, the customer's understanding of the service determines his satisfaction (Bezerra & Gomes, 2015; Kaartemo, 2018; Park, Cho, Jung, & Main, 2015).

On the other hand, the impact of various airport services on customer satisfaction hasn't been completely studied (Fevzi Okumus, Bogicevic et al. 2013). This point is also significant that compared with other service sections, the airport managers still need to find a good framework to evaluate the quality of their services (Fodness & Murray, 2007; Lupo, 2015; Zidarova & Zografos, 2011). Considering this need for evaluating the quality of airport services and its components, this article attempts to present an efficient framework for assessing the barriers to achieve high quality services using failure mode and effects analysis (FMEA) method. In this method, identification and ranking of potentially defeat states of a product or service is accomplished by means of an indicator called RPN (Risk Priority Number) which includes three concepts: Severity(S), Occurrence (O), and Detectability(D) (Segismundo & Augusto Cauchick Miguel, 2008). The occurrence is defined as the probability of occurrence of an event. Severity is the potential effect of failure on the subsystem or customer. Detectability is the capacity to identify potential cause before failure (Geum, Shin, & Park, 2011; Meng Tay & Peng Lim, 2006). These three factors are determined by experts based on a scale of 1-10 (RPN) which is a scale to the risk of failure that can be used for leveling failure causes and prioritizing the required actions. In calculating RPN the severity and occurrence numbers are used directly but the numeric value of detectability is inversely used in the calculation of RPN. Therefore, the higher value of RPN index indicates a higher probability of failure of an event that should be a higher priority. So this technique can provide a measurement to reduce the likelihood of errors and failures. It also helps the designers to determine the key features of design and processes that need specific controls (Enrico, 2007).

Another significant point is the different combinations of S, O, and D which may lead to the same RPN while the value of hidden risk of each one may be various. For example when S, O, and D are 2, 3, and 2 or 4, 3, and 1, RPN for both condition will be 12 while the hidden risk of these scenarios is different. This can lead to wasted time and resources and in some cases the high-risk conditions might be neglected. The dependent importance of S, O, and D is not identified and these risk factors' importance is assumed to be equal. But, for the operational implementation of FMEA, this cannot be assumed. In order to prevent this case in this paper, entropy weighting method is applied to rate user view about S, O, and D. In this way, we will have a more precise result about each of these factors importance. In the final stage, VIKOR was used to prioritize the failure modes. (Meekhof & Bailey, 2017)

On the other hand, it is obvious that the risk factors are not assessed easily and accurately. So using a fuzzy concept, the appraisers can use the linguistic factors to assess risk factors for each failure mode, and then they can convert these linguistic terms to the convenient structural

qualitative members for more precise analysis of the various functions. Furthermore, since the issues and decision making factors become more and more complicated constantly and hesitation increases, a more powerful and intelligible tool of fuzzy theory was needed (Chen & Li, 2011; Deschrijver, Cornelis, & Kerre, 2004; Wu & Zhang, 2011). Hence, Atanassov developed fuzzy theory in 1986, introducing an intuitionistic-fuzzy concept. In this paper, a hybrid method using Entropy and VIKOR in an intuitionistic-fuzzy environment is applied to investigate the failure modes in the quality of airport services.

2. Literature review

2.1. Airport services quality

ACI (Airport council international) introduced the concept of airport service quality ASQ (airport service quality) in order to assess the satisfaction of passengers with different airport facilities and services (Fevzi Okumus et al., 2013). The literature in this area represents that the Researchers in the field of airport services have tried to list the core services through interviews with managers and staff of the airports while a few researches have been accomplished based on the views and perceptions of the travelers. For instance, (Yeh & Kuo, 2003) has derived six key factors for assessing service quality with a survey of airport managers and staff in Taiwan. These service attributes were; comfort, processing time, convenience, courtesy of staff, information visibility and security. The collected data was analyzed by a MADM model and eventually, the major factors were identified, but the passengers view wasn't received.

Another research in this field without considering passengers point of view is made by (Rhoades, Waguespack Jr et al. 2000) who reviewed existing literature to develop a list of key airport quality factors from the perspective of various stakeholders. Airport operators and consultants were asked to weight the relative importance of the factors of airport services quality. They were also asked to rate these factors from a passenger point of view. Factor analysis of the data identified four factors: passenger service issues, airport access, airline-airport interface and inter-terminal transport. But as stated, these categories are without considering passengers perspective therefore, we can't consider them perfectly and accurately because they neglected the opinions of the passengers which has been proven today as an undeniable factor in the service industries.

Recent reports and journals in this field obviously represent that airport administrators have recognized the importance of passengers perception of services (Bomenblit, 2002). But airport managers needed a more accurate measurement tool for airport services assessment. According to (Popovic, Kraal, & Kirk, 2009) from the perspective of the passengers, there are two categories of activities within the airport. First, the legal and formal processes that take place at the airport and the second is the processes that travelers take between the formal processes in the restaurants, coffee shops, stores et cetera. One of the main dimensions that affects the passenger perception of airport service quality is the internal and external physical environment of the airport that was introduced by (Bitner, 1992) with "servicescape" title according to which the airport is an environment with different sections that the right design and the beautiful building should demonstrate visual appeal, comfort and productivity of its users.

(Correia et al., 2008a) focused on the design of internal structure such as; the distance and time of walking in the airport, the availability of sufficient signs and information and the presence of enough chairs in the waiting room. In this paper, the level of service (LOS) at Sao Paulo international airport was evaluated. For this purpose, service factors were listed and using analytical hierarchy process (AHP) the relative weights were determined and finally it was concluded that the building, the beauty and security of an airport leads to the creation of a positive feeling in the passenger and these factors are widely effective in his general picture of the airport.

In another research, (Lupo, 2015) considered a fuzzy extension of ServPerf to evaluate quality scores of fundamental service criteria. The main components in providing quality services from the

perspective of travelers were introduced as; security, which includes the complete and effective security equipment, comfort such as adequate lighting, equipment cleaning, lounge comfort and environmental features, staff such as their courtesy, cooperation, intimacy and availability, convenience including access to restaurants, shops, currency exchange facilities and rental facilities, information including a sufficient number of boards and banners, their clarity and installation in suitable places and processing time for example the time of migration processes, customs inspections, and load delivery. Finally, the multicriteria decision making ELECTRE III method was applied to point out the quality ranking of service and consequently, different ranking of services was observed in various airports. For instance, the processing time was ranked first at Catania-Fontanarossa airport and at Trapani-Birgi the highest quality score was the service criterion staff.

One other paper conducted by (Pandey, 2016), demonstrates and signifies that the Fuzzy MCDM method is an appropriate and practical decision-making tool for the airport service quality assessment and based on this approach the service quality criteria which were classified in seven main dimensions, were prioritized. The most significant criteria according to their scores were identified as: ease of finding your way through airport, waiting time at security inspection, cleanliness of washrooms/toilet, value for money of restaurant/eating facilities, ground transportation to/from airport, walking distance inside terminal and courtesy of airport staff.

2.2. FMEA, VIKOR, and entropy

There are no similar standards for evaluating service quality in different service conditions therefore, different services require the adaptation of their factors to ensure quality in their processes (Ladhari, 2009). Today, FMEA has been extensively used as an appropriate tool to evaluate quality of products and services in a wide range of industries (Liu, Liu, & Li, 2014). However, the performance of the traditional FMEA wasn't as precise as expected. To increase the performance of traditional FMEA, a large number of approaches were presented. Such as applying MCDM methods like TOPSIS (Liu, You et al., 2015c), DEMATEL (Liu, You et al., 2015b), VIKOR. (Liu, Liu, Liu, & Mao, 2012) applied VIKOR in a fuzzy environment to reach the priority ranking of failure modes in general anesthesia process. The hybrid methods such as VIKOR, DEMATEL, and AHP have been jointly applied in FMEA (Liu, You et al., 2015a). This fields literature obviously shows the most emphasis on the determination and identification of failure modes but, the weights of risk factors is less considered and traditional FMEA takes no account of the relative importance of the risk factors (Liu et al., 2014).

To determine the weight vector of the three risk factors a variety of methods have been used. For example, an approach for FMEA based on AHP and VIKOR methods is accomplished to deal with the risk factors and the most serious failure modes for corrective action were identified (Liu, You et al., 2015a). In this article, the most important aspects of service quality in the airports are identified. Next, their weights vector according to the perceptions of travelers are determined with entropy. Finally, the failure modes are ranked by means of VIKOR.

2.3. Intuitionistic-fuzzy theory

Fuzzy logic was presented to explain the circumstances in which the data are vague and imprecise. This theory explains this ambiguity by associating a degree of membership with a particular subject that the degree of membership belongs to a set (Zadeh, 1965). In the theory of fuzzy sets there is no tool to embed this uncertainty in membership degrees. But one possible solution to solve this problem is to use intuitionistic-fuzzy set (IFS) presented by Atanassov (1983) (Atanassov, 1983).

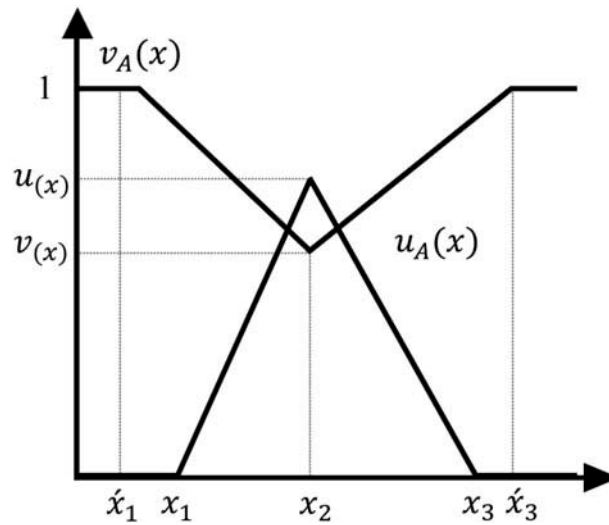
Intuitionistic-fuzzy set A on the finite and bounded set X is defined as: $A = \{x, \mu_A(x), \nu_A(x) | x \in X\}$ that is determined by a membership function $\mu_A(x)$ and a nonmembership function $\nu_A(x)$ that $\mu_A(x), \nu_A(x) : x \rightarrow [0, 1]$ is determined under $0 \leq \mu_A(x) + \nu_A(x) \leq 1$ (Wan & Li, 2015). The third parameter of the intuitionistic-fuzzy sets $\pi_A(x)$ called the intuitionistic-fuzzy index or the degree of uncertainty shows whether X belongs to A and it is defined as follows:

$\pi_A(x) = 1 - \mu_A(x) - v_A(x), 0 \leq \pi_A(x) \leq 1$. The fuzzy sets are a particular form of intuitionistic-fuzzy sets that in the fuzzy sets $v_A(x) = 1 - \mu_A(x)$ and $\pi_A(x) = 0$ (Li, 2011) the intuitionistic-fuzzy numbers are used as triangular, trapezoidal, and interval intuitionistic-fuzzy numbers that in this study the triangular intuitionistic-fuzzy number is applied. A triangular intuitionistic-fuzzy number A (TIF) on X (the bounded set) is indicated as:

$$A = [(x_1, x_2, x_3); \mu_A], [(x'_1, x_2, x'_3); v_A] \text{ (Liu, You et al., 2015c).}$$

A triangular intuitionistic-fuzzy set A has been shown in Figure 1 (Li, 2010)

Figure 1A. Triangular Intuitionistic Fuzzy Number



For two similar intuitionistic-fuzzy numbers as:

$$A = [(x_1, x_2, x_3); \mu_A], [(x'_1, x_2, x'_3); v_A], B = [(y_1, y_2, y_3); \mu_B], [(y'_1, y_2, y'_3); v_B]$$

If $\mu_A \neq \mu_B, v_A \neq v_B$, the arithmetic operators on the set are defined as follows: (Devi, 2011)

$$A + B = [(x_1 + y_1, x_2 + y_2, x_3 + y_3); \min(\mu_A, \mu_B)],$$

$$[(x'_1 + y'_1, x_2 + y_2, x'_3 + y'_3); \max(v_A, v_B)]$$

$$A - B = [(x_1 + y_1, x_2 + y_2, x_3 + y_3); \min(\mu_A, \mu_B)],$$

$$[(x'_1 - y'_3, x_2 - y_2, x'_3 - y'_1); \max(v_A, v_B)]$$

Moreover, for $A > 0$ and $B > 0$

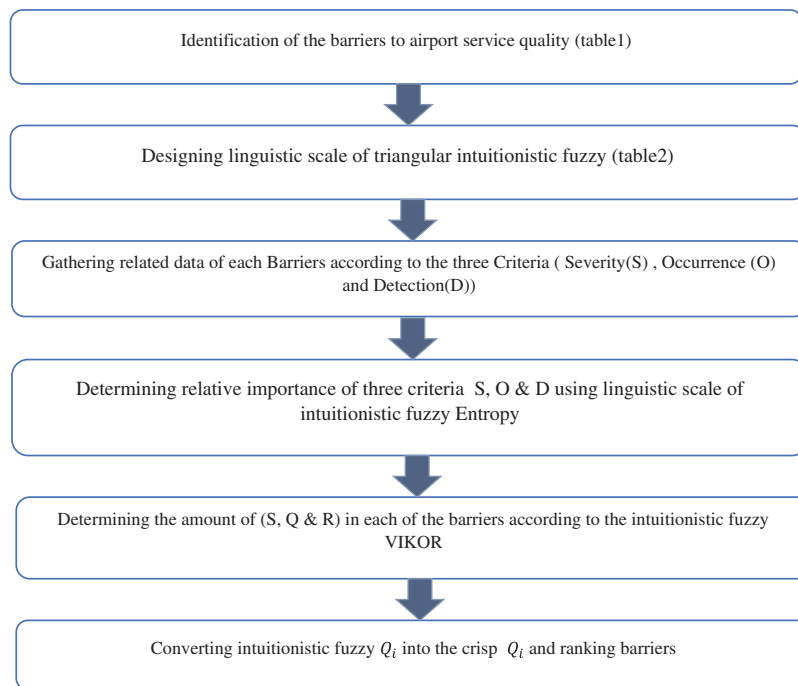
$$A \times B = [(x_1 \cdot y_1, x_2 \cdot y_2, x_3 \cdot y_3); \min(\mu_A, \mu_B)],$$

$$[(x'_1 \cdot y'_1, x_2 \cdot y_2, x'_3 \cdot y'_3); \max(v_A, v_B)]$$

$$A/B = [(x_1/y_3, x_2/y_2, x_3/y_1); \min(\mu_A, \mu_B)],$$

$$[(x'_1/y'_3, x_2/y_2, x'_3/y'_1); \max(v_A, v_B)]$$

Figure 1. Research methodology.



$$\text{Max}(A, B) = \left[\begin{matrix} \max(x_1, y_1), \max(x_2, y_2), \max(x_3, y_3); \min(\mu_A, \mu_B), \\ \max(x'_1, y'_1), \max(x_2, y_2), \max(x'_3, y'_3); \max(v_A, v_B) \end{matrix} \right]$$

$$\text{Min}(A, B) = \left[\begin{matrix} \min(x_1, y_1), \min(x_2, y_2), \min(x_3, y_3); \min(\mu_A, \mu_B), \\ \min(x'_1, y'_1), \min(x_2, y_2), \min(x'_3, y'_3); \max(v_A, v_B) \end{matrix} \right]$$

$$\ln A = [\ln(x_1), \ln(x_2), \ln(x_3); \mu_A], [\ln x'_1, \ln(x_2), \ln x'_3); v_A]$$

Fuzzy MADM and intuitionistic fuzzy MADM have been examined from different aspects by researchers. For instance, (Wei, Alsaadi, Hayat, & Alsaedi, 2017) applied MADM methods with hesitant bipolar fuzzy aggregation to evaluate constructional engineering software quality. Also (Zeng, Chen, & Li, 2016) presented a hybrid method for Pythagorean fuzzy MCDM. In another study, (Lu, Wei, Alsaadi, Hayat, & Alsaedi, 2017) studied hesitant Pythagorean fuzzy hamacher aggregation operators and utilized these hamacher operators to develop some hesitant Pythagorean fuzzy aggregation operators. Finally they presented a practical example to verify their new approach and its advantage.

3. Methodology

In this research, to review and evaluate the barriers affecting service level provided at the airports, the combination of FMEA and VIKOR and entropy were used in triangular intuitionistic fuzzy environment. The steps in this research are described in Figure 1.

3.1. Identification the barriers

First, based on the literature review and ACI, the barriers affecting the improvement of airport services quality are identified which is given in Table 1.

3.2. Failure mode and effect analysis

Failure Mode and Effect Analysis is a proactive process to evaluate several potential failures in the system through the comparison of some predefined factors, and as a result, it helps increase the sustainability of that system (Mirghafoori, Ardakani, & Azizi, 2014). FMEA is an effective problem prevention method by the broad impact on representing the potential process failures, FMEA establishes an effective risk management environment (Meng Tay & Peng Lim, 2006). Each failure mode will be

Table 1. Effective barriers to airport service quality

| Barrier | Reference |
|---|---|
| 1. Lack of staff helpfulness/responsibility | (Fodness & Murray, 2007, Fevzi Okumus et al., 2013, Hoang, Thu, Ha, & Quy, 2016, Pandey, 2016, Pantouvakis & Renzi, 2016) |
| 2. Lack of overall cleanliness at the airport | (Bezerra & Gomes, 2015, Lupo, 2015, Pandey, 2016, Pantouvakis & Renzi, 2016) |
| 3. Lack of courtesy and competence of security staff | |
| 4. The high level of noise at the airport (acoustic) | (Yeh & Kuo, 2003, Fodness & Murray, 2007, Hoang et al., 2016, Jiang & Zhang, 2016, Pandey, 2016, Pantouvakis & Renzi, 2016) |
| 5. Insufficient information screens and signs | |
| 6. Inaccessibility of shopping facilities | (Correia et al. 2008b, Bezerra & Gomes, 2015, Bezerra & Gomes, 2016, Pantouvakis & Renzi, 2016) |
| 7. High prices in general (restaurant/eating facilities, parking, etc.) | |
| 8. Lack of Comfort in the waiting/gate area | (Lupo, 2015, Bezerra & Gomes, 2016, Jiang & Zhang, 2016, Pandey, 2016) |
| 9. Inaccessibility of parking | |
| 10. Inconvenient terminal temperature/air conditioning | (Yeh & Kuo, 2003, Lupo, 2015, Bezerra & Gomes, 2016, Jiang & Zhang, 2016) |
| 11. Lack of available washrooms/toilets | |
| 12. Low perception of safety and security | (Correia et al. 2008b, Bezerra & Gomes, 2015, Del Chiappa, Martin, & Roman, 2016, Pandey, 2016) |
| 13. Lack of available ATM/Bank/Money exchange | |
| 14. Lack of entertainment in terminals | (Fodness & Murray, 2007, Lupo, 2015, Pandey, 2016, Pantouvakis & Renzi, 2016) |
| 15. Lack of clear and convenient signs | (Rhoades et al., 2000, Fevzi Okumus et al., 2013, Jiang & Zhang, 2016, Pandey, 2016) |
| 16. Lack of ground transportation to/from airport | (Correia et al. 2008b, Bezerra & Gomes, 2015, Jiang & Zhang, 2016, Pantouvakis & Renzi, 2016) |
| 17. Lack of available restaurants/food facilities | |
| 18. Inconvenient terminal decor/aesthetics/style | (Lupo, 2015, Hoang et al., 2016, Jiang & Zhang, 2016, Pandey, 2016) |
| 19. Long processing time in general (such as inspections, luggage delivery) | (Yeh & Kuo, 2003, Bezerra & Gomes, 2015, Lupo, 2015, Del Chiappa et al., 2016, Pandey, 2016, Pantouvakis & Renzi, 2016) |
| 20. Low quality of restaurants/food facilities | ((Yeh & Kuo, 2003, Bezerra & Gomes, 2015, Lupo, 2015, Hoang et al., 2016, Jiang & Zhang, 2016, Pandey, 2016) |
| 21. Inaccessibility of Internet/Wi-Fi | |
| 22. Inconvenient airport internal lighting | (Correia et al. 2008b, Hoang et al., 2016, Jiang & Zhang, 2016) |
| 23. Insufficient/ineffective security facilities and inspections | (Yeh & Kuo, 2003, Fodness & Murray, 2007, Lupo, 2015, Jiang & Zhang, 2016, Pantouvakis & Renzi, 2016) |
| 24. Lack of baggage transportation/claiming facilities | (Fodness & Murray, 2007, Fevzi Okumus et al., 2013, Hoang et al., 2016, Jiang & Zhang, 2016, Pandey, 2016) |
| 25. Lack of battery recharge facilities | |
| 26. Lack of escalators/elevators/moving walkways | ((Yeh & Kuo, 2003, Fodness & Murray, 2007, Bezerra & Gomes, 2015, Lupo, 2015, Del Chiappa et al., 2016, Hoang et al., 2016, Pandey, 2016) |
| | (Correia et al. 2008b, Jiang & Zhang, 2016) |
| | (Correia, et al. 2008b, Bezerra & Gomes, 2015, Lupo, 2015, Jiang & Zhang, 2016, Pandey, 2016, Pantouvakis & Renzi, 2016) |
| | (Fodness & Murray, 2007, Bezerra & Gomes, 2015, Del Chiappa et al., 2016) |

(Continued)

Table 1. (Continued)

| Barrier | Reference |
|---------|--|
| | (Fevzi Okumus et al., 2013, Hoang et al., 2016, Jiang & Zhang, 2016, Pandey, 2016) |
| | (Yeh & Kuo, 2003, Lupo, 2015, Jiang & Zhang, 2016) |
| | (Fevzi Okumus et al., 2013, Lupo, 2015, Hoang et al., 2016, Jiang & Zhang, 2016, Pandey, 2016) |
| | (Fevzi Okumus et al., 2013, Hoang et al., 2016, Jiang & Zhang, 2016, Pandey, 2016) |
| | (Fevzi Okumus et al., 2013, Jiang & Zhang, 2016) |
| | (Rhoades et al., 2000, Correia et al. 2008b, Bezerra & Gomes, 2015, Jiang & Zhang, 2016, Pandey, 2016) |

Table 2. Definitions of linguistic variables for the ratings

| Linguistic term | Intuitionistic fuzzy triangular number |
|----------------------|--|
| Very poor (VP) | [(0, 0, 1); 0.10], [(0, 0, 1.5); 0.90] |
| Poor (P) | [(0, 1, 2.5); 0.20], [(0.5, 1, 2.5); 0.75] |
| Moderately poor (MP) | [(0, 3, 4.5); 0.35], [(1.5, 3, 5.5); 0.60] |
| Fair (F) | [(2.5, 5, 6.5); 0.50], [(3.5, 5, 7.5); 0.45] |
| Moderately good (MG) | [(4.5, 7, 8); 0.65], [(5.5, 7, 9.5); 0.35] |
| Good (G) | [(5.5, 9, 9.5); 0.80], [(7.5, 9, 10); 0.15] |
| Very good (VG) | [(8.5, 10, 10); 0.90], [(9.5, 10, 10); 0.10] |

assessed in three parameters, namely severity(S), likelihood of occurrence (O), and difficulty of detection of the failure mode (D). A typical evaluation system gives a number between 1 and 10 (with 1 being the best and 10 being the worst case) for each of the three parameters. By multiplying them a risk priority number (RPN) is determined. These risk priority numbers highlights the parts or processes that need the improvements more than the others Depending on the company policy. For instance, if an individual number or overall RPN is more than a predefined threshold, action must be required, or for the highest RPN regardless of a threshold (Liu et al., 2014). Fuzzy logic has also been applied for improving the failure risk assessment and prioritization abilities of FMEA (Mirghafori, Takalo, & Dastranj, 2016).

In this stage the questionnaire on the users' comments about the identified obstacles was collected based on FMEA. The users provided their comments on each of the barriers' indicators (S, O, and D) in the form of linguistic variable. Qualitative linguistic variables refer to the variables whose values of which are not expressed with numbers but determined by word or phrases (Herrera & Herrera-Viedma, 1996). The concept of linguistic variables presents a useful solution to tag the phenomena explaining of which is difficult in common frameworks (Devi, 2011). Using intuitionistic fuzzy sets, we can quantify the values of linguistic variables and use mathematical operators for them.

3.3. Intuitionistic triangular fuzzy VIKOR

The numerical criteria of dependent characteristic importance is very important in VIKOR method (Zhu, Hu, Qi, Gu, & Peng, 2015). On the other hand, accurate data measurement is very difficult since the human judgment is uncertain and under different circumstances. Fuzzy sets and others nonstandard fuzzy sets are effective in connecting with these uncertainties. Therefore, it seems practical to generalize the VIKOR method to a fuzzy nonstandard environment. Among these nonstandard fuzzy sets, the intuitionistic fuzzy sets (IFSs) are one of the most convenient tools

in making connection with hesitation. There should be available information to define the exact degree of membership and non-membership in many cases; hence, due to the lack of available information in most real problems, the intuitionistic fuzzy sets (IFSs) can be useful in solving the uncertainty problem by defining the degree of uncertainty.

If $D = [x_{ij}]_{m \times n}$ is an intuitionistic fuzzy decision matrix for solving a multiple criteria decision making (MCDM) problem, and consider A_1, A_2, \dots, A_m as possible m options for decision makers and C_1, C_2, \dots, C_n as n criteria, then x_{ij} is the situation of option A_i according to criterion C_j and weight w_j . It is defined as triangular intuitionistic fuzzy value. The situation of each option is measured in a group decision-making environment with K people according to criteria.

$$x_{ij} = \frac{1}{K} [x_{ij}^1 + x_{ij}^2 + \dots + x_{ij}^k]$$

Next, we calculate the best rank of x_j^+ and the worst rank of x_j^- for each criterion. If they express a positive criterion, we have:

$$x_j^+ = \max x_{ij}, \quad x_j^- = \min x_{ij}.$$

$$A^+ = \{x_1^+, x_2^+, \dots, x_n^+\}, \quad A^- = \{x_1^-, x_2^-, \dots, x_n^-\},$$

In the second step, we calculate S_i and R_i for $i = 1, 2, 3, \dots, m$ as the mean and worst group ranks for A_i option according to the following equations:

$$S_i = \sum_{j=1}^n w_j \times \left(\frac{x_i^+ - x_{ij}}{x_i^+ - x_j^-} \right) = [(S_{1i}, S_{2i}, S_{3i}); \mu_{S_i}], [(S'_{1i}, S'_{2i}, S'_{3i}); \nu_{S_i}].$$

$$R_i = \max \left(w_j \times \left(\frac{x_i^+ - x_{ij}}{x_j^- - x_j^-} \right) \right) = [(R_{1i}, R_{2i}, R_{3i}); \mu_{R_i}], [(R'_{1i}, R'_{2i}, R'_{3i}); \nu_{R_i}].$$

We measure the ranking index of Q_i ; $i = 1, 2, 3, \dots, m$ according to the following equation:

$$Q_i = V \left(\frac{S_i^+ - S_j^-}{S_i^+ - S_j^-} \right) + (1 - V) \left(\frac{R_i^+ - R_j^-}{R_i^+ - R_j^-} \right) = [(Q_{1i}, Q_{2i}, Q_{3i}); \mu_{Q_i}], [(Q'_{1i}, Q'_{2i}, Q'_{3i}); \nu_{Q_i}]$$

Finally, the calculated intuitionistic fuzzy Q_i must be converted to crisp Q_i according to the following equation:

$$\text{Crisp } Q_i = \frac{[(Q_{1i} + Q_{2i} + Q_{3i} \times \mu_{Q_i})] + [(Q'_{1i} + Q'_{2i} + Q'_{3i} \times \nu_{Q_i})]}{6}$$

3.4. Intuitionistic triangular fuzzy entropy method

Since the weights of indices in VIKOR method are essential as the input data, we should determine the relevant importance of all criteria namely D , O , and S . The intuitionistic fuzzy entropy method with triangular numbers is used to calculate weights of these indices. The stages are described as follows.

3.4.1. Normalize the fuzzy decision matrix intuitionistic

$$n_{ij} = \frac{x_{ij}}{\sum_{i=1}^m x_{ij}} \quad \forall j \in S, O, D$$

3.4.2. Obtain the trust of each criterion through the following

$$-\frac{1}{\ln m} \sum_{i=1}^m n_{ij} \ln n_{ij} = [(E_{1j}, E_{2j}, E_{3j}); \mu_{E_j}], [(E'_{1j}, E'_{2j}, E'_{3j}); \nu_{E_j}] \quad \forall j \in S, O, D$$

3.4.3. The entropy of each criterion is determined by the formula

$$d_j = 1 - E_j = [(d_{1j}, d_{2j}, d_{3j}); \mu_{dj}], [(d'_{1j}, d'_{2j}, d'_{3j}); \nu_{dj}] \forall j \in S, O, D$$

3.4.4. The weight of each criterion through will be

$$w_j = \frac{d_j}{\sum d_j} = [(w_{1j}, w_{2j}, w_{3j}); \mu_{wj}], [(w'_{1j}, w'_{2j}, w'_{3j}); \nu_{wj}]$$

Table 3. Weight on the entropy

| Criterion | Triangular Intuitionistic-Fuzzy W | | | | | | | |
|----------------|-----------------------------------|-------|-------|--------|-------|--------|-------|-----|
| | x_1 | x_2 | x_3 | x'_1 | x_2 | x'_3 | μ | W |
| Severity (S) | 0.001 | 0.20 | 1 | 0.001 | 0.23 | 1 | 0.1 | 0.9 |
| Occurrence (O) | 0.0005 | 0.24 | 1 | 0.0005 | 0.28 | 1 | 0.1 | 0.9 |
| Detective (D) | 0.004 | 0.54 | 1 | 0.004 | 0.47 | 1 | 0.1 | 0.9 |

Table 4. Intuitionistic-fuzzy and certain S value for each barrier

| Barriers | s | | | | | | | |
|----------|----------|-------|-------|----------|-------|--------|-------|-----|
| | x_1 | x_2 | x_3 | x'_1 | x_2 | x'_3 | μ | W |
| A1 | -0.0001 | 0.61 | 26.6 | -0.0008 | 0.58 | 20.3 | 0.1 | 0.9 |
| A2 | -0.0007 | 0.31 | 14.89 | -0.001 | 0.28 | 8.05 | 0.1 | 0.9 |
| A3 | 0.0005 | 0.77 | 29.96 | -0.0003 | 0.73 | 23.51 | 0.1 | 0.9 |
| A4 | 0.0009 | 0.87 | 31.07 | 0.0002 | 0.82 | 24.39 | 0.1 | 0.9 |
| A5 | 0.0006 | 0.76 | 28.22 | -8.3E-05 | 0.71 | 21.63 | 0.1 | 0.9 |
| A6 | 0.0006 | 0.79 | 29.36 | -2.7E-05 | 0.76 | 22.97 | 0.1 | 0.9 |
| A7 | 7.88E-05 | 0.65 | 27.64 | -0.0007 | 0.62 | 21.26 | 0.1 | 0.9 |
| A8 | -0.001 | 0.23 | 24.45 | -0.002 | 0.21 | 17.82 | 0.1 | 0.9 |
| A9 | -0.0009 | 0.34 | 20.11 | -0.001 | 0.32 | 13.30 | 0.1 | 0.9 |
| A10 | 0.0002 | 0.69 | 27.61 | -0.0005 | 0.66 | 21.03 | 0.1 | 0.9 |
| A11 | 0.001 | 0.90 | 34.41 | 0.0003 | 0.86 | 26.80 | 0.1 | 0.9 |
| A12 | 0.001 | 0.91 | 30.59 | 0.0006 | 0.87 | 24.32 | 0.1 | 0.9 |
| A13 | -0.002 | 0.17 | 23.58 | -0.002 | 0.15 | 16.22 | 0.1 | 0.9 |
| A14 | -0.001 | 0.30 | 18.17 | -0.001 | 0.29 | 12.01 | 0.1 | 0.9 |
| A15 | -0.0004 | 0.47 | 24.08 | -0.001 | 0.46 | 16.04 | 0.1 | 0.9 |
| A16 | 0.0008 | 0.79 | 28.58 | 0.0001 | 0.75 | 22.21 | 0.1 | 0.9 |
| A17 | 0.0002 | 0.77 | 35.83 | -0.0003 | 0.73 | 28.02 | 0.1 | 0.9 |
| A18 | 0.0006 | 0.69 | 24.63 | -2.3E-05 | 0.66 | 17.68 | 0.1 | 0.9 |
| A19 | -0.0008 | 0.37 | 23.52 | -0.001 | 0.35 | 16.23 | 0.1 | 0.9 |
| A20 | 0.0008 | 0.79 | 28.70 | 8.98E-05 | 0.75 | 22.32 | 0.1 | 0.9 |
| A21 | -0.0005 | 0.45 | 21.72 | -0.001 | 0.44 | 15.40 | 0.1 | 0.9 |
| A22 | -0.0002 | 0.53 | 23.70 | -0.0008 | 0.50 | 17.09 | 0.1 | 0.9 |
| A23 | 0.0003 | 0.73 | 28.82 | -0.0004 | 0.70 | 22.71 | 0.1 | 0.9 |
| A24 | 0.0001 | 0.67 | 28.60 | -0.0005 | 0.64 | 22.14 | 0.1 | 0.9 |
| A25 | -0.0002 | 0.58 | 26.04 | -0.0009 | 0.56 | 19.68 | 0.1 | 0.9 |
| A26 | 0.0001 | 0.67 | 27.98 | -0.0005 | 0.64 | 21.25 | 0.1 | 0.9 |

Table 5. Intuitionistic-fuzzy and certain R value for each barrier

| Barriers | R | | | | | | | |
|----------|----------|-------|-------|----------|-------|--------|-------|-----|
| | x_1 | x_2 | x_3 | x_1' | x_2 | x_3' | μ | W |
| A1 | 0/0002 | 0/39 | 19/41 | -0/0001 | 0/37 | 14/9 | 0.1 | 0.9 |
| A2 | -2/6E-05 | 0/31 | 9/41 | -0/0002 | 0/28 | 4/58 | 0.1 | 0.9 |
| A3 | 0/0004 | 0/43 | 19/08 | -0/0001 | 0/40 | 14/58 | 0.1 | 0.9 |
| A4 | 0/0008 | 0/50 | 20 | 0/0003 | 0/47 | 15/25 | 0.1 | 0.9 |
| A5 | 0/0007 | 0/48 | 18/41 | 0/0002 | 0/45 | 13/91 | 0.1 | 0.9 |
| A6 | 0/0006 | 0/46 | 18/91 | 0/0001 | 0/43 | 14/25 | 0.1 | 0.9 |
| A7 | 0/000217 | 0/37 | 18/75 | -0/0001 | 0/35 | 14/25 | 0.1 | 0.9 |
| A8 | -7/6E-05 | 0/14 | 18/91 | -0/0001 | 0/14 | 14/25 | 0.1 | 0.9 |
| A9 | -0/0001 | 0/20 | 13/91 | -0/0001 | 0/19 | 8/83 | 0.1 | 0.9 |
| A10 | 0/0004 | 0/435 | 18/41 | -5/1E-05 | 0/41 | 13/91 | 0.1 | 0.9 |
| A11 | 0/001 | 0/54 | 24/41 | 0/0006 | 0/52 | 18/5 | 0.1 | 0.9 |
| A12 | 0/001 | 0/54 | 19/66 | 0/0007 | 0/52 | 15/08 | 0.1 | 0.9 |
| A13 | -9/3E-05 | 0/12 | 19/08 | -0/0001 | 0/12 | 13/5 | 0.1 | 0.9 |
| A14 | -0/0001 | 0/22 | 13 | -0/0002 | 0/21 | 8/58 | 0.1 | 0.9 |
| A15 | 0/0001 | 0/37 | 17/75 | -0/0002 | 0/36 | 11/58 | 0.1 | 0.9 |
| A16 | 0/001 | 0/53 | 19/41 | 0/0005 | 0/49 | 14/9 | 0.1 | 0.9 |
| A17 | 0/0003 | 0/40 | 26/75 | -6E-05 | 0/38 | 21 | 0.1 | 0.9 |
| A18 | 0/001 | 0/53 | 15/91 | 0/0006 | 0/50 | 10/91 | 0.1 | 0.9 |
| A19 | -0/0001 | 0/19 | 16/91 | -0/0001 | 0/18 | 11/5 | 0.1 | 0.9 |
| A20 | 0/001 | 0/52 | 19/41 | 0/0005 | 0/49 | 14/91 | 0.1 | 0.9 |
| A21 | -0/0001 | 0/31 | 14/83 | -0/0002 | 0/30 | 10/25 | 0.1 | 0.9 |
| A22 | 0/0001 | 0/35 | 16/33 | -0/0001 | 0/33 | 11/58 | 0.1 | 0.9 |
| A23 | 0/0003 | 0/41 | 19/41 | -7E-05 | 0/391 | 15/08 | 0.1 | 0.9 |
| A24 | 0/0003 | 0/40 | 19/83 | -0/0001 | 0/37 | 15/41 | 0.1 | 0.9 |
| A25 | 0/0001 | 0/36 | 18/41 | -0/0001 | 0/34 | 13/9 | 0.1 | 0.9 |
| A26 | 0/0004 | 0/43 | 19/66 | -6/4E-05 | 0/40 | 14/91 | 0.1 | 0.9 |

4. Result

To collect data, designed Questionnaires were distributed among 150 people who received Yazd International Airport services. User comments were gathered for each of the barriers in the form of linguistic variable (Table 2). Next, these linguistic variables were converted to the intuitionistic triangular fuzzy numbers. By integrating respondents' views, the decision matrix was formed. In the first step, the weight of each criterion(S, O, and D) is achieved using intuitionistic fuzzy entropy method using the formulas introduced in Section 3.4. The results are shown in Table 3. In the next step, by determining the weight of each criterion, S, R, and Q values for each barrier were calculated in the form of intuitionistic triangular fuzzy numbers as shown in Tables 4, 5, and 6.

5. Conclusion

Based on the results of this research, the barriers affecting the quality of airport services were ranked in the Table 6. It shows, the most important barriers to the quality of airport services are:

- Low perception of safety and security
- Lack of staff helpfulness/responsibility

Table 6. Intuitionistic-fuzzy and crisp Q value for each barrier

| Barriers | Q Intuitionistic-Fuzzy | | | | | | | | crisp Qi | Rank |
|----------|------------------------|-------|-------|--------|--------|--------|-------|-----|----------|------|
| | x_1 | x_2 | x_3 | x_1' | x_2' | x_3' | μ | W | | |
| A1 | 0/38 | 0/60 | 1/92 | 0/38 | 0/56 | 1/47 | 0/1 | 0/9 | 0/41 | 2 |
| A2 | 0/38 | 0/32 | 1 | 0/38 | 0/26 | 0/51 | 0/1 | 0/9 | 0/20 | 14 |
| A3 | 0/38 | 0/76 | 2/01 | 0/38 | 0/71 | 1/56 | 0/1 | 0/9 | 0/45 | 9 |
| A4 | 0/38 | 0/92 | 2/10 | 0/38 | 0/85 | 1/62 | 0/1 | 0/9 | 0/48 | 13 |
| A5 | 0/38 | 0/82 | 1/92 | 0/38 | 0/75 | 1/46 | 0/1 | 0/9 | 0/44 | 19 |
| A6 | 0/38 | 0/82 | 1/99 | 0/38 | 0/76 | 1/52 | 0/1 | 0/9 | 0/45 | 8 |
| A7 | 0/38 | 0/62 | 1/92 | 0/38 | 0/57 | 1/47 | 0/1 | 0/9 | 0/41 | 21 |
| A8 | 0/38 | 0/06 | 1/82 | 0/38 | 0/04 | 1/35 | 0/1 | 0/9 | 0/30 | 15 |
| A9 | 0/38 | 0/20 | 1/41 | 0/38 | 0/17 | 0/91 | 0/1 | 0/9 | 0/25 | 22 |
| A10 | 0/38 | 0/71 | 1/90 | 0/38 | 0/66 | 1/44 | 0/1 | 0/9 | 0/42 | 25 |
| A11 | 0/38 | 0/99 | 2/45 | 0/38 | 0/93 | 1/88 | 0/1 | 0/9 | 0/54 | 18 |
| A12 | 0/38 | 1 | 2/07 | 0/38 | 0/93 | 1/61 | 0/1 | 0/9 | 0/49 | 1 |
| A13 | 0/38 | 0 | 1/80 | 0/38 | 0/01 | 1/26 | 0/1 | 0/9 | 0/28 | 7 |
| A14 | 0/38 | 0/20 | 1/30 | 0/38 | 0/18 | 0/85 | 0/1 | 0/9 | 0/24 | 10 |
| A15 | 0/38 | 0/49 | 1/75 | 0/38 | 0/46 | 1/15 | 0/1 | 0/9 | 0/34 | 26 |
| A16 | 0/38 | 0/90 | 1/99 | 0/38 | 0/83 | 1/53 | 0/1 | 0/9 | 0/46 | 24 |
| A17 | 0/38 | 0/73 | 2/62 | 0/38 | 0/67 | 2/05 | 0/1 | 0/9 | 0/52 | 5 |
| A18 | 0/38 | 0/83 | 1/67 | 0/38 | 0/77 | 1/17 | 0/1 | 0/9 | 0/39 | 23 |
| A19 | 0/38 | 0/22 | 1/68 | 0/38 | 0/19 | 1/15 | 0/1 | 0/9 | 0/29 | 3 |
| A20 | 0/38 | 0/88 | 1/99 | 0/38 | 0/82 | 1/54 | 0/1 | 0/9 | 0/46 | 6 |
| A21 | 0/38 | 0/41 | 1/51 | 0/38 | 0/38 | 1/06 | 0/1 | 0/9 | 0/31 | 20 |
| A22 | 0/38 | 0/50 | 1/66 | 0/38 | 0/46 | 1/18 | 0/1 | 0/9 | 0/34 | 16 |
| A23 | 0/38 | 0/72 | 1/99 | 0/38 | 0/66 | 1/56 | 0/1 | 0/9 | 0/44 | 4 |
| A24 | 0/38 | 0/66 | 2/01 | 0/38 | 0/61 | 1/56 | 0/1 | 0/9 | 0/43 | 12 |
| A25 | 0/38 | 0/56 | 1/85 | 0/38 | 0/52 | 1/39 | 0/1 | 0/9 | 0/39 | 17 |
| A26 | 0/38 | 0/69 | 1/98 | 0/38 | 0/64 | 1/50 | 0/1 | 0/9 | 0/43 | 11 |

- Long processing time in general(such as inspections, luggage delivery)
- Insufficient/ineffective security facilities and inspections
- Lack of available restaurants/food facilities
- Low quality of restaurants/food facilities
- Lack of available ATM/bank/money exchange

Today, the issue of security is one of the most important parameters in the society, particularly in the tourism industry and as a result of this article, it is the most important factor affecting the satisfaction of Yazd airport users. In other studies such as (Lupo, 2015), security is also considered as one of the most important factors. This issue is so important that in (Sakano, Obeng, & Fuller, 2016) article, various parameters affecting security at the airport have been studied. Therefore, increasing the level of perceived security should be placed at the top of the airports management strategy map. The helpfulness/responsibility of staff has been determined as the second important factor in the quality of airport services. Therefore, employing knowledgeable and trained staff can increase perceived quality of airport services.

Long processing time in general is another barrier in front of airports which can intensively endanger passengers' satisfaction. It is possible to prevent this situation with the increase of

effective equipment and staff in different sections. The fourth barrier is the insufficient security facilities and inspections which improvement in this operation can also reduce the overall waiting times. It shows the importance of this factor, hence the need to improve it at Yazd airport is seriously felt.

Next ranks are food related. Those are respectively the availability and the quality of restaurants/food facilities which have been mentioned in many articles as two effective factors on the satisfaction of travelers. Another significant factor from the passenger's point of view is the Availability of ATM/bank/money exchange which are considered essential and definite requirements at the airports today, whereas the lack of them causes a lot of dissatisfaction. Other barriers have been prioritized as shown in Table 6. As an advantage of this research, determining the weight vector of the three risk factors can be referred, which has been ignored in most studies in this field. As a suggestion for future researches, use of other weighting methods such as AHP or other prioritizing methods like DEMATEL is recommended to researchers. On the other hand, applying other approaches in the quality assessment subject, such as EFQM, SERVQUAL in intuitionistic fuzzy environment seems to be useful.

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