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Fuzzy Delphi Technique for Forecasting and Screening Items

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Abstract

Delphi technique is a group knowledge acquisition method that has been used for over half a century. Delphi technique calculations are based on experts‘ opinions. Therefore, any error or inconsistency in the assessment of experts‘ opinions affects the result of calculations. In traditional Delphi approaches, although experts‘ mental competencies and abilities are used for comparisons, the quantification of experts‘ opinions cannot completely reflect the human thinking style. Using fuzzy sets is more consistent with human linguistic and sometimes vague descriptions and it is better for decision-makings in the real world by applying fuzzy numbers. The error level is reduced using fuzzy sets. A traditional challenge of Delphi method is solving the rounds of Delphi technique. This study indicated that the fuzzy Delphi technique could be used in a single round for screening criteria. A clear solution was also given for ending the rounds of Delphi technique.

Keywords: Traditional Delphi Technique; Fuzzy Logic; Fuzzy Delphi; Forecasting; Screening

1. Introduction

There was a temple in the ancient city of Delphi attributed to Apollo, god of sun, music and poetry. The oracle of Delphi was named. Pythia was widely credited for her prophecies inspired by Apollo and she had been consulted before implementing any major decision. Now, the ancient city Delphi has become a modern city and still remains. Pythia prophecies have also been replaced with a modern approach that is known as Delphi technique.
For the first time in the late 1950s, in a research by U.S. RAND Corporation, Delphi was introduced for the scientific study of experts' opinions on military defense project (Powell, 2003; Okoli& Pawlowski, 2004).

The main objective of Delphi method is to acquire the most reliable consensus of a group of experts ‘opinions by a series of intensive questionnaires together with controlled feedback (Dalkey and Helmer, 1963: 458).

By obtaining the consensus of a group of experts using the process, researchers can identify and prioritize problems and develop a framework for recognizing them (Greatorex J and T Dexter, 2000; Okoli and Pawlowski, 2004). Linstone and Turoff (1975) have defined Delphi technique as " a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem" (Linstone and Turoff, 1975: 3). This definition has been accepted by several researchers (Gupta and Clarke, 1996; Robertson and MacKinnon, 2002; Wang et al, 2003).

Hasson et al. (2000) argued that there are many types of Delphi techniques; however, modified Delphi, policy Delphi, and real-time Delphi have been used (Hasson et al, 2000).

Generally, three broad categories of Delphi are used including classical Delphi, policy Delphi and decision Delphi (van Zolingen and Klaassen, 2003).

The Delphi technique is applied as a tools and method for building consensus using a series of questionnaires for data collection from a panel of selected participants (Dalkey and Helmer, 1963; Dalkey, 1969; Linstone and Turoff, 1975; Lindeman, 1981; Martino, 1983; Young & Jamieson, 2001). Several studies have been carried out for using fuzzy Delphi technique. Kaufmann and Gupta (1988) developed the application of Fuzzy Delphi technique for forecasting (Kaufmann and Gupta, 1988). Ishikawa (1993) also developed the Delphi technique with triangular fuzzy numbers (Ishikawa, 1993). Delphi technique is a structured process for data collection during successive rounds and ultimately group consensus. Despite over half a century of Delphi technique application in scientific and academic research, there are still many ambiguitcies about this technique. In this study, first the basics of traditional Delphi approach are described. Then, two main applications of Delphi technique in screening and forecasting are discussed. Finally, an algorithm is presented for the fuzzy Delphi technique based on fuzzy logic and triangular fuzzy numbers.

2. Classic Delphi Technique

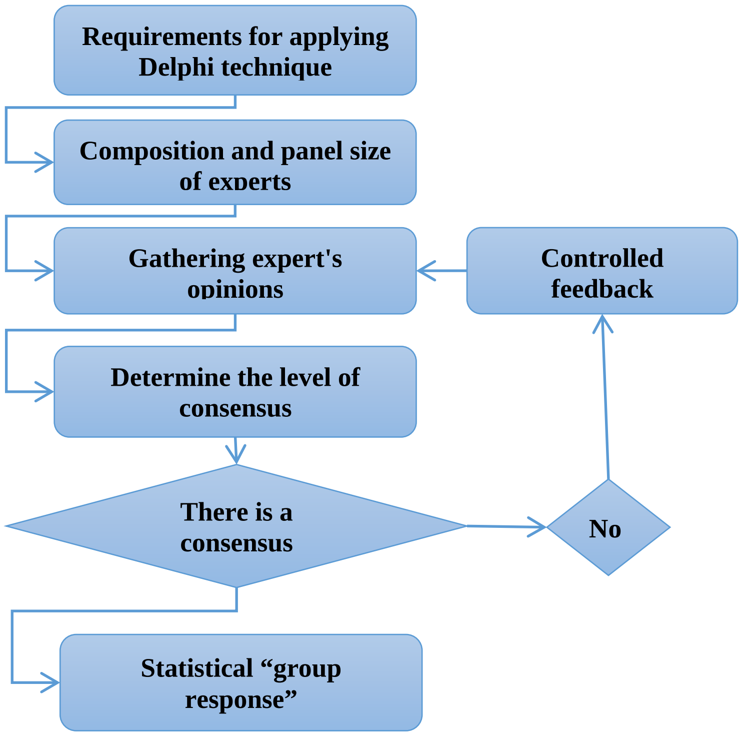
In the late 1950s, in a research by U.S. RAND Corporation, the Delphi was introduced for the scientific study of experts' opinions on military defense project. However, for the security reasons, this technique was not proposed over ten years and in 1963, Dalkey and Helmer introduced it (Kent & Saffer, 2014; Kauko & Palmroos, 2014; Keil et al, 2013). Its first non-military use was suggested for economic development planning (Turoff & Linstone, 2008;

Landeta, 2006; Meijering, 2013). Among the various characteristics of Delphi technique, four features are usually unchanged including anonymity, iteration, controlled feedback, and statistical "group response" (Rowe& Wright, 2001; vonder Gracht, 2012; Jünger et al, 2013; Förster & Gracht, 2014).

Delphi technique's goal is to acquire the group consensus of experts 'opinions by a series of intensive questionnaires together with controlled feedback (Dalkey and Helmer, 1963: 458). using the process, researchers can identify, categorize, and prioritize problems and develop a framework for forecasting (Greatorex J and T Dexter, 2000; Okoli and Pawlowski, 2004). In Delphi technique, the anonymity principle is used to avoid groupthink. The experts and people who are used in the survey do not know each other. Anonymity ensures overcoming the groupthink barriers (Mitroff & Turoff, 1975; Browne at al, 2002; McKenna et al; 2002; Powell; 2003; Somerville, 2008).

A coordinator collects the experts' opinions and then he/she provides other members with the summarized results. Then, based on the summarized results in the previous step, individuals again adjust and express their opinions. Finally, after reaching a consensus, the results are discussed in terms of a statistical report (usually mean or median) and are used for decision-making (vonderGracht, 2012; Antcliff et al, 2013; Cowan et al, 2013). The major weakness of Delphi is the lack of a theoretical framework. According to previous studies, Habibi et al (2014) have provided a framework for applying Delphi technique in qualitative decision-makings (figure 1).

Figure 1- Theoretical framework of Delphi technique in qualitative research



Based on this framework, selecting eligible panel members is the first step of Delphi technique. The validity of the results depends on panel members' competence and knowledge. Although there are some disagreements about the composition and panel size of Delphi technique, a dominant pattern can be detected. It is better to use a combination of individuals with multiple specialties (Powell, 2003; Somerville, 2008; van Zolingen and Klaassen, 2003; Hsu and Sandford, 2007) and for selecting such sample, the snowball sampling technique can be used. In this method, the researcher first identifies some eligible people and after receiving information, he/she requests them to introduce other people (Babbie, 2002; Macnee & McCabe, 2008). Hogarth (1978) argued that between six and twelve members are ideal for Delphi technique and according to Clayton (1997), if a mixture of experts with different specialties is used, between five and ten members are sufficient (Somerville, 2008: 5). While some Delphi studies considered fewer than 10 members in their panels (Malone et al, 2005; Strasser et al, 2005), other studies included more than 100 participants (Kelly and Porock, 2005; Meadows et al, 2005).

Different types of Likert scale can be easily used for gathering experts' opinions. After gathering the experts' opinions, the mean of their opinions on each dimension is calculated. According to the theoretical framework, if there is no consensus, the experts will be provided with the calculated mean as a controlled feedback together with questionnaire. After several rounds, when the consensus was achieved, based on the average of the final round, the items are screened (Lin and Chuang, 2012). Various studies have proposed different methods for determining consensus. In a study, von der Gracht (2012) has presented 15 ways to reach a consensus based on reviewing 114 articles on Delphi technique (von der Gracht, 2012). Kendall's coefficient of concordance can be used to determine the degree of panels' consensus (Schmidt, 1977; Siegel and Castellan, 1988; Habibi et al, 2014).

3- Fuzzy Delphi Technique

Delphi technique is based on respondents' views. In this technique, verbal expressions are used to measure views. Verbal expressions have limitations to reflect fully respondent's mental latencies. For example, the phrase "high" for A who is a stringent person is different with phrase "high" for B. If a crisp number were used to quantify both individuals' views, the results would have been skewed. In other words, although the experts' competence and mental abilities are used for decision-making, the quantification of experts' opinions cannot completely reflect the human thinking style. Using fuzzy sets is more consistent with human linguistic and sometimes vague descriptions and it is better to make decisions in the real world by applying fuzzy numbers.

Kaufmann and Gupta (1988) presented the application of Fuzzy Delphi technique for forecasting [5]. Ishikawa (1993) also developed the Delphi technique with triangular fuzzy numbers [6]. Since then, numerous studies have been done for using fuzzy Delphi technique. Extended fuzzy Delphi methods as the traditional Delphi method are very diverse and there is no consensus in this regard. There are several approaches in fuzzy spectrum development, aggregation of experts' opinions, defuzzification, and reaching a consensus. For describing the fuzzy Delphi technique implementation algorithm, two applications of Delphi technique must be distinguished.

- Delphi technique for "screening criteria"
- Delphi technique for "forecasting"

Therefore, two types of qualitative research should be distinguished in using Delphi technique. Some studies are exploratory and heuristic. In such studies, researchers are seeking to identify the most fundamental elements of a phenomenon. Some studies are also being conducted aimed at forecasting. In this study, fuzzy Delphi technique implementation algorithm is proposed in each case based on the previous research.

Triangular Fuzzy Numbers

fuzzy numbers are a particular type of fuzzy sets. Hence, by understanding the concept of fuzzy sets, fuzzy numbers can be easily learned. In classical logic, each number is crisp and certain; however, in fuzzy logic, each number has approximate value. Fuzzy number is a fuzzy set with the following three conditions:

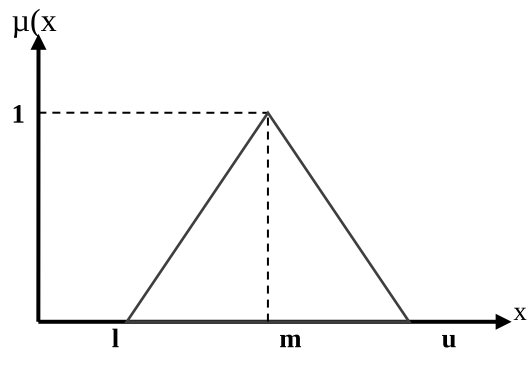
- Being normalized
- Be convex
- Its supporting set is bounded

Triangular fuzzy number (TFN) is a fuzzy number, which is displayed with three real numbers (F= (l, m, u)). The upper bound denoted by u is maximum values of fuzzy number F. The lower bound denoted by l is minimum values of fuzzy number F. m is the most probable value of a fuzzy number. Membership function of a triangular fuzzy number is as follows:

$$\mu_f(x) = \begin{cases} \frac{x-l}{m-l} l < x < m \\ \frac{u-x}{u-m} m < x < u \\ 0 \quad otherwise \end{cases}$$

Triangular fuzzy number F = (l, m, u) is displayed geometrically in figure 2.

Figure 2- triangular fuzzy number



Given the membership function of triangular numbers, it is revealed that if x is between l and m, then the larger x is the larger its membership function is so that for x=m, the membership degree is 1. If x is between m and u, the larger x is the smaller its membership function is and in x=u the membership degree is 0. Therefore, it can be said that the membership degree of x in the interval [l, m] is monotonically incremental and in the interval [m, u] monotonically decreases. If l = m = u, the fuzzy number will become a crisp number. Membership function of a triangular fuzzy number includes both left and right linear parts that are joined together at (m, 1). Triangular fuzzy numbers are formed based on partial information. Suppose when dealing with uncertain values, the smallest and largest possible values can be determined. Hence, the supporting interval [l, u] can be defined. If we can determine m as the most probable uncertain value, then the peak will be at (m, 1). Therefore, with three l, m, u, triangular fuzzy number can be generated and its membership function is written.

Due to its simple mathematical operations, the computational efficiency of triangular fuzzy numbers is very high. Mathematical operations on fuzzy numbers F1 and F2 can be done simply as follows:

$F_1 = (l_1, m_1, u_1)$

$F_2 = (l_2, m_2, u_2)$

$F_1 \oplus F_2 = (l_1 \oplus l_2, m_1 \oplus m_2, u_1 \oplus u_2)$

$F_1 \oplus F_2 = (l_1 \oplus l_2, m_1 \oplus m_2, u_1 \oplus u_2)$

Multiplication, division, and inversion of two triangular fuzzy numbers are not a triangular fuzzy number. However, since the difference is generally small, for the simplicity of calculations, the result is also a triangular fuzzy number.

$F_1 \otimes F_2 = (l_1 \otimes l_2, m_1 \otimes m_2, u_1 \otimes u_2)$

$$\frac{F_1}{F_2} = \left(\frac{l_1}{u_2}, \frac{m_1}{m_2}, \frac{u_1}{l_2}\right)$$

$$F_1^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right)$$

$$\mathrm{k} \otimes \mathrm{F} = (\mathrm{k} \otimes \mathrm{l}, \mathrm{k} \otimes \mathrm{m}, \mathrm{k} \otimes \mathrm{m})$$

3-1 fuzzy Delphi technique algorithm for screening

Delphi technique with fuzzy approach can be used for determining the importance of criteria and screening key criteria. One of the major advantages of fuzzy Delphi technique compared to the traditional Delphi technique to screen criteria is that a round can be used for summarizing and sorting items.

Fuzzy Delphi technique algorithm includes the following steps:

- ◊ Identifying an appropriate spectrum for fuzzification of linguistic expressions
- ◊ Fuzzy aggregation of fuzzified values
- ◊ Defuzzification
- ◊ Selecting the threshold and screening criteria

Step 1. Collect and fuzzify expert opinions

In fuzzy Delphi technique algorithm for screening, first an appropriate fuzzy spectrum should be developed for the fuzzification of respondents' linguistic expressions. For this purpose, fuzzy spectrum development methods or common fuzzy spectra can be used. For example, triangular fuzzy number for 5, 7 and 9 point scale on the significance of criteria is as follows:

Table 1- triangular fuzzy numbers for five-point scale

Linguistic expressions	Fuzzy number
Very Important	(0.75, 1, 1)
Important	(0.5, 0.75, 1)
Moderately Important	(0.25, 0.5, 0.75)
Unimportant	(0, 0.25, 0.5)
Very Unimportant	(0, 0, 0.25)

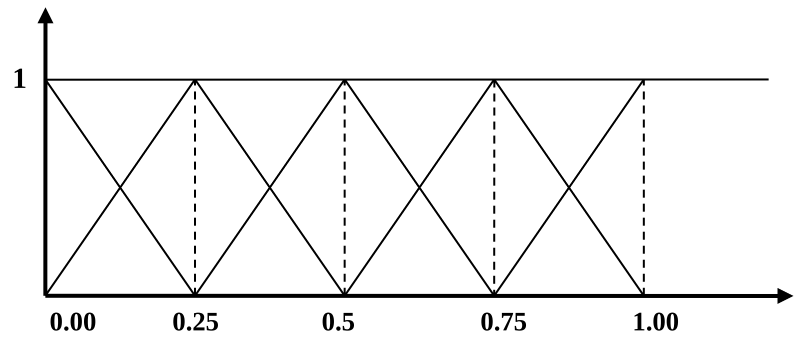
Table 2- triangular fuzzy numbers for seven-point scale

Linguistic expressions	Fuzzy number
Extremely Important	(0.9, 1, 1)
Very Important	(0.75, 0.9, 1)
Important	(0.5, 0.75, 0.9)
Moderately Important	(0.3, 0.5, 0.75)
Unimportant	(0.1, 0.3, 0.5)
Very Unimportant	(0, 0.1, 0.3)
Extremely Unimportant	(0, 0, 0.1)

Table 3- triangular fuzzy numbers for nine-point scale

Linguistic expressions	Fuzzy number
Extremely important	(8, 9, 9)
Between very and extremely important	(7, 8, 9)
Very important	(6, 7, 8)
Between moderately and Very important	(5, 6, 7)
Moderately important	(4, 5, 6)
Between very unimportant and Moderately important	(3, 4, 5)
Very unimportant	(2, 3, 4)
Between extremely and very unimportant	(1, 2, 3)
Extremely unimportant	(1, 1, 1)

Figure 3- triangular fuzzy numbers for five-point scale



Step 2. Fuzzy aggregation of opinions

After the selection or development of appropriate fuzzy spectrum, experts' opinions are collected and fuzzified. In the second step, experts' opinions should be aggregated. Several methods have been proposed for fuzzy aggregation of experts' opinions. If any expert's opinion is displayed as a triangular fuzzy numbers (l, m, u), the simplest method is to calculate the fuzzy average of experts' opinions:

$$F_{AVE} = \frac{\sum l}{n}, \frac{\sum m}{n}, \frac{\sum u}{n}$$

Instead of using fuzzy average, various other methods are also used for the aggregation of experts' opinions. In fact, these aggregation methods are experimental methods that have been presented by various researchers. For example, a conventional method for aggregating a set of triangular fuzzy numbers is minimum l, mean m, and maximum u.

$$F_{AGR} = \left(min\{l\}, \left\{ \frac{\sum m}{n} \right\}, max\{u\} \right)$$

(Hsu et al, 2010)

In some sources, geometric mean is proposed rather than simple arithmetic mean.

$$F_{AGR} = \left(min\{l\}, \prod \{m\}, max\{u\} \right)$$

(Hsu and Chen, 2007; Sue & Young, 2000; Cheng et al, 2009; Wu and fang, 2011)

In other sources, it has been suggested to calculate upper and lower bounds with geometric mean. Selecting the aggregation method of experts' opinions depends on the researcher's view. Using fuzzy aggregation methods rather than fuzzy mean is caused to consider maximum dispersion of individuals' opinions. However, a problem of these methods is that the opinion of an optimist or a pessimist strongly affects the results. For an expert, if u_i is less than $\frac{\sum l}{n}$, he \ she is considered as a pessimistic expert. In addition, for or an expert, if l_i is larger than $\frac{\sum u}{n}$, he \ she is considered as an optimistic expert. For further assurance, pessimistic and optimistic experts' opinions can be neglected.

Step 3. Defuzzification

After fuzzy aggregation of experts' opinions, the values should be defuzzified. In different methods that are done with fuzzy approach, the researcher ultimately converts final fuzzy values into a crisp and understandable number. Typically, the aggregation of triangular and trapezoidal fuzzy numbers can be summarized by a crisp value, which is the best average. This operation is known as defuzzification. There are several and complex methods for defuzzification. One of the simple methods for defuzzification is average triangular fuzzy numbers:

$$\text{if } \tilde{F} = (L, M, U) \ \ Then \ \ \mathrm{F} = \frac{L + M + U}{3}$$

(Cheng et al, 2009; Hsu et al, 2010; Wu and fang, 2011)

Or we can use more complex method as:

$$F_{ave} = (L, M, U)$$

$x_m^1 = \frac{L+M+U}{3}$; $x_m^2 = \frac{L+2M+U}{4}$; $x_m^3 = \frac{L+4M+U}{6}$

$$\text{Crisp number} = Z* = \max(x_{max}^1, x_{max}^2, x_{max}^3)$$

x_{max}^i values aren't much different and they are constantly close to M. M is the average obtained from the aggregation of possible values of m from different triangular fuzzy numbers. However, the crisp value of maximum x_{max}^i is considered (Bojadziev & Bojadziev, 2007).

There are several other methods for defuzzification including center of gravity (COG), center of area (COA), and mean of maxima. Teng and Tzeng (1993) presented a simple method for defuzzification of triangular fuzzy numbers based on COA. Modified COA method for defuzzification of triangular fuzzy numbers is as follows:

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

After selecting appropriate method and defuzzification of values for screening items, a threshold should be calculated. The threshold is typically 0.7 but it varies based on the researcher's opinion in different studies. If the crisp value of defuzzification of aggregated experts' opinions is larger than threshold, the criterion is conformed. If the criterion is less than threshold, it is removed.

3-2 fuzzy Delphi technique algorithm for forecasting

Kaufmann and Gupta (1988) presented the application of Fuzzy Delphi technique for forecasting. The structure of triangular fuzzy numbers is such a way that makes it very suitable for forecasting through Delphi method. In the method that is used to predict time, price, and other quantitative values, the experts are asked to offer their predictions based on minimum, maximum, and the most probable value. Hence, it is no longer necessary to provide a crisp and absolute value.

Fuzzy Delphi technique algorithm for forecasting is as follows:

First, each expert's forecasting is provided as a triangular fuzzy number:
$A_i = (l_i, m_i, u_i)$

Fuzzy average method is used for the aggregation of forecasts:

$$A_{AVE} = \left(\frac{\sum l}{n}, \frac{\sum m}{n}, \frac{\sum u}{n}\right)$$

The difference between any expert's opinion and the average of opinions is calculated and is again given the relevant expert.

$$A_{AVE} - A_i = \left(\frac{\sum l}{n} - l_i, \frac{\sum m}{n} - m_i, \frac{\sum u}{n} - u_i\right)$$

Experts' opinions are again collected and new fuzzy average is calculated.
$A_i = (l_i, m_i, u_i)$

$$B_{AVE} = \left(\frac{\sum l}{n}, \frac{\sum m}{n}, \frac{\sum u}{n}\right)$$

The difference between any expert's opinion and the average of opinions is calculated and the Delphi cycle is repeated. This process stops when two consecutive averages $A_{ave}, B_{ave}, C_{ave}, \ldots$ are clearly close together.

4. Numeric example

In a study, 10 basic criteria have been identified based on the literature. Using seven-point Likert scale, five experts' opinions are gathered to determine the importance of these criteria.

Table 4- Gathering experts' opinions with seven-point Likert scale

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
Criterion 1	Important	Unimportant	Very Important	Very Important	Extremely Important
Criterion 2	Moderately Important	Extremely Important	Important	Very Important	Extremely Important
Criterion 3	Extremely Important	Very Important	Very Important	Unimportant	Unimportant
Criterion 4	Moderately Important	Important	Extremely Important	Important	Important
Criterion 5	Extremely Important	Moderately Important	Unimportant	Very Important	Very Important
Criterion 6	Extremely Important	Important	Very Important	Very Important	Very Unimportant
Criterion 7	Important	Very Unimportant	Important	Extremely Important	Important
Criterion 8	Very Important	Moderately Important	Unimportant	Unimportant	Moderately Important
Criterion 9	Important	Extremely Unimportant	Unimportant	Very Important	Important
Criterion 10	Important	Extremely Important	Unimportant	Extremely Important	Important

Using fuzzy spectrum (table 2), experts' opinions are fuzzified.

Table 5- Fuzzification of linguistic expressions for the importance of criteria

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
C1	(0.5, 0.75, 0.9)	(0.1, 0.3, 0.5)	(0.75, 0.9, 1)	(0.75, 0.9, 1)	(0.9, 1, 1)
C2	(0.3, 0.5, 0.75)	(0.9, 1, 1)	(0.5, 0.75, 0.9)	(0.75, 0.9, 1)	(0.9, 1, 1)
C3	(0.9, 1, 1)	(0.75, 0.9, 1)	(0.75, 0.9, 1)	(0.1, 0.3, 0.5)	(0.1, 0.3, 0.5)
C4	(0.3, 0.5, 0.75)	(0.5, 0.75, 0.9)	(0.9, 1, 1)	(0.5, 0.75, 0.9)	(0.5, 0.75, 0.9)
C5	(0.9, 1, 1)	(0.3, 0.5, 0.75)	(0.1, 0.3, 0.5)	(0, 0.1, 0.3)	(0.75, 0.9, 1)
C6	(0.9, 1, 1)	(0.5, 0.75, 0.9)	(0.75, 0.9, 1)	(0.75, 0.9, 1)	(0, 0.1, 0.3)
C7	(0.5, 0.75, 0.9)	(0, 0.1, 0.3)	(0.5, 0.75, 0.9)	(0.9, 1, 1)	(0.5, 0.75, 0.9)
C8	(0.75, 0.9, 1)	(0.3, 0.5, 0.75)	(0.1, 0.3, 0.5)	(0.1, 0.3, 0.5)	(0.3, 0.5, 0.75)
C9	(0.5, 0.75, 0.9)	(0, 0, 0.1)	(0.1, 0.3, 0.5)	(0.75, 0.9, 1)	(0.5, 0.75, 0.9)
C10	(0.5, 0.75, 0.9)	(0.9, 1, 1)	(0.1, 0.3, 0.5)	(0.9, 1, 1)	(0.5, 0.75, 0.9)

Fuzzy average method is used for the aggregation of experts' opinions. The simple equation $\frac{l+m+u}{3}$ is also utilized for the defuzzification of opinions' means. The threshold is also 0.7. The results of the above steps are summarized as follows.

Table 6- Defuzzification results of aggregated experts' values

	Opinion's mean	Crisp value	Result
C1	(0.6, 0.77, 0.88)	0.750	Accepted
C2	(0.67, 0.83, 0.93)	0.810	Accepted
C3	(0.52, 0.68, 0.8)	0.667	Rejected
C4	(0.54, 0.75, 0.89)	0.727	Accepted
C5	(0.41, 0.56, 0.71)	0.560	Rejected
C6	(0.58, 0.73, 0.84)	0.717	Accepted
C7	(0.48, 0.67, 0.8)	0.650	Rejected
C8	(0.31, 0.5, 0.7)	0.503	Rejected
C9	(0.37, 0.54, 0.68)	0.530	Rejected
C10	(0.58, 0.76, 0.86)	0.733	Accepted

As it was noted, different methods could be used for fuzzy aggregation and defuzzification of calculated values. The acceptance and rejection of criteria are also subject to the threshold value that is determined by the investigator.

5- Conclusion

Delphi technique is defined as a research approach to gain consensus using a series of questionnaires and the provision of feedback to participants who have expertise in key areas. Extended fuzzy Delphi methods as traditional Delphi methods are very diverse and there is no consensus in this regard. There are several approaches in fuzzy spectrum development, aggregation of experts' opinions, defuzzification, and reaching a consensus. For describing the fuzzy Delphi technique algorithm, two applications of Delphi technique must be distinguished i.e. Delphi technique for "screening criteria" and "forecasting". Using fuzzy logic underlying principles, a clear framework was provided for Delphi technique. Therefore, first, experts' opinions were fuzzified using an appropriate fuzzy spectrum. Then, experts' opinions were integrated through fuzzy aggregation. In Delphi technique for screening, in the first stage the result could be achieved with defuzzification and selecting the threshold value. However, in Delphi technique for forecasting, any expert's opinion with the calculated mean and Delphi cycle was repeated. This process was stopped when two consecutive averages $A_{ave}, B_{ave}, C_{ave}$, ... were clearly close together.

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