Application of a Fuzzy Delphi Method in Marketing: A Review

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Abstract

The Delphi method has been widely utilized in a number of scientific domains to aid forecasting and decision-making. Created by Dalkey and Helmer (Manag Sci 9:458–467, 1963), the method was developed to forecast future scenarios based on the consensus of expert opinions collected through several iterations of structured questionnaires. Although the approach was adopted in various disciplines, several shortcomings of the method, such as lack of consistent standards for result interpretation, limited generalization, the long-time needed for implementation, and susceptibility to the subjective interpretation of the qualitative results, have been identified over time. The purpose of the study is to review the available scientific literature on the application of a Fuzzy Delphi method in the marketing domain, in order to measure the interest in the method, identify the studies that have utilized the fuzzy Delphi method for marketing related topics, and determine the areas of marketing where the method has been applied so far. Fuzzy Delphi method has found the most extensive application in operation management, decision sciences, and business intelligence and has not been widely adopted as a method of choice in marketing studies.

Keywords

Delphi method · Fuzzy data · Forecasting (marketing process)

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1 Introduction

In the conditions of fast and continuous changes that take place in the environment, achievement of the most critical strategic and operational goals highly depend on accurate and timely decision making. This applies to all areas of business operations, including marketing operations. For marketing strategic and operational plans to be successful, enable the organization to preserve the market position and increase competitiveness, marketing managers have to make the right decision at the right time based on the reliable and valid market information. To provide input for marketing decision-making and development of strategic and operational plans, various methods and techniques in marketing research and analytics are used. These methods are typically qualitative or quantitative, and in quantitative methods, we strongly rely on statistical tools and techniques. However, although successful forecasting in the various areas should be one of the essential tasks of the marketing managers, decision-making and forecasting tools are not often applied in the marketing decision making. Moreover, even in cases where forecasting tools are used, the techniques traditionally applied in marketing typically do not account for the uncertainty in marketing decision-making.

Obtaining useful demand forecasts can help decision-makers to determine production size, production costs as well as to assess and calculate market prices. Similarly, forecasting market and consumer trends can contribute to the development of successful marketing strategies. Effective predictive analytics can help decision-makers estimate various relevant market indices based on the historical data and/or expert opinion: market demand, market potential, production size, production costs market prices. A group of managers from different departments can bring various perspectives, knowledge, judgment, and intuition to the planning process (Minkes 1987). This is especially relevant when ideas related to new products,

A. Salman and A. Tharwat (eds.), *Smart Designs for Business Innovation*,
Advances in Science, Technology & Innovation, https://doi.org/10.1007/978-3-031-49313-3_1

processes, services, technologies, and markets are elaborated (Selaković et al. 2018).

Based on the literature, forecasting methods can be divided into two groups: (1) qualitative forecasting methods and (2) quantitative forecasting methods. By using the qualitative forecasting methods, the projected demand values are based on decision-makers' (D.M.s) estimates. Decision-makers base their assessments mainly on their expertise–knowledge, and previous experience. Therefore, it can be said that the predicted values of demands which are provided by using qualitative methods are highly burdened by the subjective opinions and attitudes of decision-makers. This subjectivity, as in any qualitative research, can be denoted as one of the main shortcomings and limitations of the qualitative forecasting methods. However, in a case when there is a sufficient amount of accurate historical data from the records, marketing forecasting can be conducted using quantitative methods; in this way, more accurate values of forecasted consumer demand can be obtained. Increased accuracy and objectivity are some of the primary advantages of quantitative methods; however, the quality of output is highly dependent on the reliability and validity of the historical quantitative data.

At the same time, qualitative forecasting and decision-making employ a variety of methods and approaches, including direct contact with customers, analysis of potential customers, analysis of potential customers, and the Delphi method (Tadić and Nestić 2019). Delphi method is one of the most widely used qualitative forecasting techniques in decision making. The Delphi method has been widely utilized in a number of scientific domains to aid forecasting and decision-making. Created by Dalkey and Helmer (1963), the method was developed to forecast future scenarios based on the consensus of expert opinions collected through several iterations of structured questionnaires. Later, the application of this technique was represented in risk assessment of project success (Evangelidis et al. 2002), social, cultural, and ethical impacts of e-services (Asgarkhani 2005), strategic alignment of e-services with macro policies (Viscusi et al. 2008) and economic development planning (Meijering et al. 2013). The Delphi technique is an iterative method that is realized through steps. The four features of the Delphi technique are usually unchanged, including anonymity, iteration, controlled feedback, and statistical "group response" (Förster and Gracht 2014). Aggregation estimates of D.M.s can be performed in different ways. The procedure is repeated until consensus is reached, or the number of given iterations is performed in advance. Although the approach was adopted in various disciplines, several shortcomings of the method, such as lack of consistent standards for result interpretation, limited generalization, lack of theoretical framework, the long time needed for implementation, and susceptibility to the subjective interpretation of the qualitative results have been identified over time.

To overcome the challenges of the traditional qualitative Delphi method, Hsu and Yang (1999) suggested a Fuzzy Delphi method—a modified version of the Delphi method, based on the combination of fuzzy theory and traditional decision making. It is believed that D.M.s may express their estimates significantly better by using words than precise numbers. However, the developments in mathematics, such as set theory (Zadeh 1975), has enabled linguistic expression to be quantified. There is a large body of scientific literature where D.M.s estimates are further analyzed using type 1 fuzzy numbers (Zimmermann 2010; Dubois and Prade 1980). The fundamental characteristic of these fuzzy numbers is membership functions, which can be of different forms. In the literature, modeling of estimates of D.M.s was most often performed by using triangular fuzzy numbers (TFNs) (Nestić et al. 2019). The handling of these fuzzy numbers does not require complex mathematical operations, and at the same time, the accuracy of the obtained results is satisfactory. Several authors believe that the uncertainty and vagueness of words can be better represented by using:

(a) Interval type 2 fuzzy numbers (Mendel 2017) which are characterized by two membership functions, and
(b) The intuitionistic fuzzy sets introducing another degree of freedom into a set description (membership function, non-membership function, and intuitionistic index foundation) (Atanassov 1999).

The article provides an overview of the Fuzzy Delphi method application in marketing in scholarly articles published from 2000 until 2019 and indexed in EBSCO, ProQuest, DOAJ, or Emerald scientific databases. A comprehensive database search with the keyword search "fuzzy Delphi" and "Marketing" confirmed that the Fuzzy Delphi method is rarely applied in marketing studies. This paper is organized in the following way: in Sect. 2, the primary considerations and application of the DELPHI technique are presented. The fuzzy Delphi techniques are analyzed in Sect. 3. The comparative analysis of the discussion is presented in Sect. 4. The conclusion is presented in Sect. 5.

2 Basic Considerations of DELPHI Technique

The Delphi technique can be defined as a structured process for data collection during several successful rounds conducted with subject matter experts. There are no rules about the number of experts involved in the decision-making process and the sampling process. For instance,

Somerville (2008) suggest that the choice of experts included in traditional Delphi study is better based on a combination of individuals with multiple specialties than on the snowball sampling technique based on the recommendations. The proposed approach is applied by Macnee and McCabe (2008). Somerville (2008) suggests that in Delphi, the team should present a mixture of experts with different specialties, arguing that between five and ten members are sufficient. Some researchers (Malone et al. 2005) suggested that in Delphi rounds should be conducted with fewer than 10 D.M.; however, at the same time, some other studies included more than 100 participants (Meadows et al. 2005).

The obtained result from the traditional Delphi study can be presented as a group consensus. For data collection, a set of questions measured on a Likert scale is created and distributed for expert feedback. After the first round of data collection, the mean value for each variable of interest is calculated, and in a case where there is no consensus, experts are provided with another round of questionnaires until the consensus is reached. Different studies have proposed different approaches for determining consensus in the Delphi study. Based on Habibi et al. (2015), Kendall's coefficient of concordance can be used to determine the degree of consensus of expert opinions.

2.1 Combining Delphi Technique and Other Methods

Many management problems can be solved by the Delphi technique integration with other methods. Some hybrid methods proposed in the literature are further briefly analyzed. Strategic analysis, based on provided data, judgments, intuition, and personal vision of decision-makers, is analyzed by Li (2005). His study proposed that a web-based expert system performs a rule-based intelligent reasoning process for generating outputs or strategic recommendations. The proposed web-based expert system can be conducted through several stages. The Delphi technique is then used to select criteria and their sub-criteria in the second stage of the proposed model. As it is mentioned, the demand forecast problem can be solved by using a different hybrid method. Hicham et al. (2012) have suggested the method which integrates Enterprise Resource Planning, Delphi technique, fuzzy clustering, and Back-propagation Neural Networks with adaptive learning rate. The proposed model is developed for demand forecasting in the packaging industry. The Delphi technique is used to identify the factors that represent the input data in the decision-making process. Pre-defined questionnaires were submitted to the experts, and experts expressed their estimates on a measurement scale from 1 to 5. The evaluation process is then repeated until a consensus is reached.

Many companies are aware of the strategic importance of technology commercialization and have been trying to develop innovative technology products. Several research studies have focused on exploring the general market trends or business factors for successful new product development utilizing some variation of the Delphi technique. For example, Cho and Lee (2013) have considered 25 factors according to which product development is evaluated, and the choice of factors, as well as their subfactors, was based on the Delphi technique. All participants in the decision-making process have expressed their assessment on a Likert scale, and the aggregation of decision-makers' estimates was determined based on the results of statistical analysis. These researchers considered four factors: marketability, business feasibility, technological competitiveness, and research and development capabilities.

3 The Fuzzy DELPHI Technique

Unlike the traditional Delphi method, the Fuzzy Delphi method takes into account fuzziness in the selection of the relevant criteria and interpretation of the results and includes less iteration in the data collection process.

Some studies preferred the fuzzy Delphi method to the conventional Delphi method (Kumar and Dash 2017). Argued that by taking the completeness and consistency of experts' opinions and taking into account fuzziness in the iterative process, the fuzzy Delphi technique provides more objective insights. It should be noticed that all four features of the Delphi technique are preserved in the fuzzy Delphi technique. In the fuzzy Delphi technique, expert estimates are described by linguistic variables that can be quantified by fuzzy numbers. The number and type of fuzzy numbers are determined by experts depending on the size and type of problem. Fuzzy Delphi method is mostly applied in operation management, decision sciences, and business intelligence and is not widely adopted as a method of choice in marketing studies.

3.1 Fuzzy Sets Theory

A fuzzy number is a number that does not refer to a single value but to several different possible values where each possible value has its weight. This approach enables us to incorporate uncertainty into decision making and thus make the analysis more realistic. Fuzzy sets are sets with a degree of membership, and they are determined with their membership function.

To facilitate an understanding of the methods that combine fuzzy sets theory and other methods in this Section, the basics of fuzzy sets theory are presented.

Definition 1 A linguistic variable is a variable whose values are expressed in linguistic terms.

Definition 2 A fuzzy set $\widetilde{A}$ is defined as a set of organized pairs:

$$\widetilde{A} = \left\{ x,\ \mu_{\widetilde{A}}(x) \;\middle|\; x \in X,\ 0 \le \mu_{\widetilde{A}}(x) \le 1 \right\}$$

where:

A fuzzy set $\widetilde{A}$ is defined on the universe set $X \in R$. In general, set X can be either finite or infinite. $\mu_{\widetilde{A}}(x)$ is a membership function of fuzzy set $\widetilde{A}$. Each fuzzy set is completely and uniquely determined by its membership function.

Definition 3 A fuzzy number $\widetilde{A}$ is a convex normalized fuzzy set $\widetilde{A}$ of the real line R such that:

(a) if exist $x_0 \in R$ such that $\mu_{\widetilde{A}}(x_0) = 1$, and (b) $\mu_{\widetilde{A}}(x)$ is piecewise continuous.

Definition 4 The triangular fuzzy number can be denoted by (l, m, u). Where $l \le m \le u$, l and u stand for the lower and upper value of the support of X respectively, and m for the modal value. The support of X is the set of elements $\{x \in R | \, l < x < u\}$. When $l = m = u$, it is a non-fuzzy number by convention.

Definition 5 If X is a set of real numbers, then a type-2 fuzzy set and an interval type-2 fuzzy set in X are called a type-2 fuzzy number and an interval type-2 fuzzy number, respectively.

Definition 6 If the upper membership function and lower membership function of $\tilde{\tilde{A}}$ are two triangular type-1 fuzzy numbers, than $\widetilde{\widetilde{A}}$ is referred to as triangular interval type-2 fuzzy number, $\widetilde{\widetilde{A}} = \left(\tilde{A}^{U}, \tilde{A}^{L}\right)$ so that:

$$\tilde{\tilde{A}} = \left(\tilde{A}^{U}, \tilde{A}^{L}\right) = \left(\left(a_1^U, a_2^U, a_3^U, \alpha\right), \left(a_1^L, a_2^L, a_3^L, \beta\right)\right)$$

where:

The lower and upper bound in the domain are denoted as a_1^U, a_3^U respectively, and $a_{1'}^L, a_3^L$ respectively. The modal values are a_2^U, respectively, and a_2^L, respectively. The values of the membership function are defined as:

$$(\alpha, \beta) \in [0, 1]$$

Definition 7 Let a non-empty set is given X. An IFS from the set X may be presented in the following way (Atanassov 1999):

$$\tilde{A} = \left(x, \mu_{\tilde{A}}(x), \vartheta_{\tilde{A}}(x) | x \in X\right)$$

$$\mu_A(x) \to [0, 1] \, \mathrm{I} \, \nu_A(x) \to [0, 1]$$

where:

Membership function, $\mu_{\tilde{A}}(x) \to$ [0,1] and non-membership function, $\vartheta_{\tilde{A}}(x) \to$ [0,1].

So the following condition is present:

$$0 \le \mu_{\tilde{A}}(x) + \vartheta_{\tilde{A}}(x) \le 1, \forall x \in X$$

For each IFS denoted as $\tilde{A}$ from the set X is valid:

$$\pi_{\tilde{A}}(x) = 1 - \mu_{\tilde{A}}(x) - \vartheta_{\tilde{A}}(x)$$
$$0 \le \pi_{\tilde{A}}(x) \le 1, \forall x \in X$$

where $\pi_{\tilde{A}}(x)$ indicates intuitive index. The smaller $\pi_{\tilde{A}}(x)$, the more certain $\tilde{A}$.

Definition 8 An IFS $\tilde{A} = \left(x, \mu_{\tilde{A}}(x), \vartheta_{\tilde{A}}(x) | x \in X\right)$ of the real line is called a triangular intuitionistic fuzzy number (TIFN), so that: $\tilde{A} = \left([a, b, c, d], [a_1, b, c, d_1]; \mu_{\tilde{A}}(x), \vartheta_{\tilde{A}}(x)\right)$ and a, b, c, d, a_1, d_1 are real numbers, and $a_1 \le a \le b \le c \le d \le d_1$.

3.2 Fuzzy Delphi Method in Marketing Studies

The majority of decisions that we make in today's complex environment are formulated under a state of uncertainty. Conditions of uncertainty exist when the decision-maker is not aware of all available alternatives, the risks associated with each, and the consequences of each alternative or their probabilities. In the current market situation globally, most decisions that businesses need to make will have some level of uncertainty. However, in the traditional approach to marketing research and analytics, the uncertainty is often not accounted for Ljepava (2018).

Majority of publications in marketing use only traditional, non-fuzzy (crisp) methods for forecasting. To

explore the application of the fuzzy Delphi method in marketing, a comprehensive review of the available scientific literature has been conducted.

One of the first studies that considered the application of this technique in marketing is a study conducted by Li et al. (2002). In their study, they proposed an integrated approach utilizing group Delphi, fuzzy logic, and expert systems for marketing strategy development. The strategy development process includes a high level of uncertainty and ambiguity, so the Delphi technique can be applied to conduct the SWOT analysis with experts. After collecting the feedback from D.M.s, results can be fuzzified using the fuzzy logic and expert systems and further utilized for setting up marketing strategies.

Buyukozkan (2004) explored digital marketplaces that were extensively developing at that time, especially business-to-business commerce, one of the dominant segments in e-business. To get more benefit from this digital marketplace, he suggested applying the fuzzy set theory and AHP. The experts' opinions, in this case, are described by linguistic terms, which are expressed in triangular fuzzy numbers (TFNs). Expert group members compared and rated various e-marketplaces available at the time. The results are derived from their initial and subsequent responses and analyzed using appropriate fuzzy algebra. Expert group members were then requested to re-examine their comparisons, and the results are derived from their initial and subsequent responses until they are completely satisfied (Buyukozkan 2004).

The market segmentation problem was considered by Hanafizadeh and Mirzazadeh (2011). They have explored market segmentation of Iranian telecommunication companies by using 19 variables divided into four groups—demographics, psychological, behavioral, and geographic. Seven marketing and sales managers (D.M.s) have participated as experts in the research. Subject matter experts expressed their estimates using a five-point Likert scale. The corresponding linguistic expression accompanied each value of the Likert scale, and these linguistic variables were further modeled with TFNs. The proposed model was obtained by the aggregation of the estimates of D.M.s into a single score. The modal values of the TFNs describing the aggregated estimates of D.M.s were calculated using the fuzzy averaging operator. The lower and the upper bounds were given as minimum or maximum of the lowest or uppers bounds of used TFNs. After conducting the analysis, the results were visualized to identify the relevant market segments.

Mir and Rashidpoor (2019) explored the factors relevant to promoting the brand personality. They conducted the study with the purposive expert sample of 15 university experts who rated the most significant factors that can impact the promotion of the brand personality. Data were further analyzed using a Fuzzy Delphi technique, and six factors were identified as leading factors in promoting the brand personality: brand, language, profitability, reliability, prestige, activism, and color.

One of the critical challenges the marketing managers face is evaluating client retention. The period of client retention within the company depends on several external and internal factors, and it can be treated as uncertain data (Gil-Lafuente et al. 2013). These authors suggested that TFNs could well describe the estimation of the lifetime period of the client staying with an enterprise. Obtaining group consensus was based on the rules of the algebra phase.

Identification of the most significant attributes for the development of a tourism strategy was considered by Liu and Chou (2016). They have divided all possible attributes into three groups: marketing strategy, brand equity, and travel motivation. Under each marked group, decision-makers rated the importance of attributes by using linguistic variables. These linguistic variables were modeled by TFNs. The consensus of decision-makers was given by using the proposed model.

The problem of assessing the importance of factors influencing digitalization in the public sector was considered by Kamalian et al. (2017). These authors considered ten groups, including education, healthcare, communication, transportation, law and justice, culture and religion, agriculture and ecology, security and citizenship rights, finance, and business services. Fuzzy rating of the relative importance and values of factors is given by using the fuzzy Delphi technique. The authors emphasized that the application of the fuzzy Delphi technique has certain advantages over other methods. Those are: (a) it is more time-effective compared to other qualitative methods of data collection, (b) it reduces the possible bias arisen from individual comments, and (c) it displays the semantic presentation of expert opinions. The decision-making process involved 32 experts belonging to development, employment, national security, communication, transportation, education, agriculture, and culture workgroups (four participants per each workgroup). D.M.s used seven linguistic expressions modeled by TFNs. The aggregation is performed by the fuzzy averaging method. Ten criteria were selected, which were associated with the highest values of the respective scales of TFNs, which described the aggregate values of D.M.s.

In recent decades, many companies worldwide have implemented end-of-life strategies such as product remanufacturing. A study conducted by Vafadarnikjoo et al. (2018) explored applying the fuzzy Delphi method for

understanding consumers' motivation, which leads them to purchase a remanufactured product (bike). The study explored the major motivational factors for buying a remanufactured bike based on the consumers' and experts' opinions. The survey involved 104 participants from different universities. University students were contacted by email to fill out the online questionnaire, and for some of them, the questionnaire forms were printed out to be filled in (Vafadarnikjoo et al. 2018). Each participant used seven different linguistic terms, which are modeled by single-valued trapezoidal neutrosophic numbers (Ji et al. 2016). The consensus of D.M.s opinions is given by using the trapezoidal neutrosophic weighted arithmetic averaging proposed by Ye (2017).

After reaching the consensus, results were fuzzified to account for uncertainty in subjective judgments.

Quality and warranty were identified as the main factors influencing the purchasing decision.

The prediction of factors influencing online consumers' behavior problems is widely covered in the marketing literature (Röllecke et al. 2018). The construct of the list of changing pattern factors of the consumer perspective is performed by the fuzzy Delphi technique (Kumar et al. 2018). The preference of decision-makers is described by linguistic expressions and corresponding to TFNs. The summarized estimate of expert opinions is given by using fuzzy algebra rules, which are described by TFNs. Using the defuzzification procedure (Mardani et al. 2016), the summarized assessment is presented by crisp values. The weights vector of the possible pattern factors of the consumer perspective is calculated by the fuzzy analytical hierarchy process (FAHP).

Assessment of antecedents of customer engagement problem is considered by Jani and Zakaria (2018). It is assumed that D.M.s express their estimates by linguistic themes modeled by TFNs. The group consensus is given by using the fuzzy averaging method. It should be noted that those antecedents of customer engagement are selected where the smallest difference between individual assessments and the aggregate value of D.M.s opinions. The authors used Euclidian distance to determine marked differences.

4 Comparative Analysis and Discussion

In this Section, a comparative analysis of the proposed fuzzy Delphi techniques and its applications in marketing studies, which have been identified in the previous studies, is conducted and presented in Table 1. The advantages and disadvantages of the analyzed fuzzy Delphi techniques are further discussed.

Based on the comparative analysis presented in Table 1, it can be concluded that there is no consensus in using the number of experts (decision-makers) in different studies where authors used a different number of D.M.s ranging from 7 to 32. This finding is in line with the previous literature on the Delphi method since there are no rules on how to choose D.M.s, nor is the optimal number of D.M.s recommended, so it can be concluded that the number of D.M.s depends on the nature and problem size.

In almost all analyzed papers, D.M.s use linguistic expressions that are modeled by TFNs. The number of linguistic variables ranges from 3 to 9. Similarly, as in the case of the number of expert decision-makers (D.M.s), the choice of the number of linguistic expressions depends on the problem. Vafadarnikjoo et al. (2018) believe that modeling the opinions of D.M.s can be significantly better described by using the Trapezoidal neutrosophic fuzzy numbers.

The aggregation of D.M.s opinions into a single score can be performed using different aggregation methods. The obtained unique score is modeled by TFNs, according to fuzzy algebra rules. The lowest and upper bounds of these aggregated TFNs are given as the lowest and uppers bounds of used TFNs, respectively. The modal values are calculated by using the fuzzy arithmetic operator (Hsu et al. 2010; Habibi et al. 2015; Jani et al. 2018) and the fuzzy geometric operator (Hanafizadeh and Mirzazadeh 2011; Liu and Chou 2016; Kumar et al. 2018). Some researchers suggest a fuzzy averaging operator (Kamalian et al. 2017; Vafadarnikjoo et al. 2018) for obtaining aggregated estimates of D.M.s. All researchers believe that D.M.s involved in the decision-making process are of equal importance. In practice, this assumption cannot always be introduced. In these cases, aggregation estimates of D.M.s should be performed using the Fuzzy Ordered Weighted Average Operator (Merigó and Casanovas 2008).

The choice of treated factors is based on the proposed procedure (see Table 1). Many authors have mapped aggregated fuzzy estimates of D.M.s into precise numbers by using different defuzzification procedures. It should be emphasized that there is no rule as to the limit for accepting factors. Therefore, the decision to accept factors is highly burdened by subjective assessments of D.M.s. This can be considered as one of the basic shortcomings of the proposed fuzzy Delphi techniques. However, even with this disadvantage, it can be said that the choice of factors based on the application of the fuzzy Delphi techniques gives better results than using an affinity diagram.

Table 1 The comparative analysis of existing research integrating marketing and fuzzy Delphi technique

Author and year of the publication	Number of D.M.s	The number of considered items	The domain of application/combination with some other method	The type of fuzzy numbers/the number of linguistic expressions	Aggregation method	Defuzzification procedure
Li et al. (2002)	–	–	Development of marketing strategies	–	–	–
Buyukozkan (2004)	–	–	e-marketplaces selection/FAHP	TFNs/5	–	–
Hsu et al. (2010)	–	17	Critical factors are used as criteria for the assessment of regenerative technologies/FAHP	TFNs/9	The proposed model with the fuzzy averaging operator	Center of gravity method
Hanafizadeh and Mirzazadeh (2011)	7	19	Choosing Market segmentation variables/techniques of visualization	TFNs/5	The proposed model with Fuzzy geometric operator	–
Gil-Lafuente et al. (2013)	–	–	The estimation of the lifetime period of the client within an enterprise	TrFNs	Fuzzy algebra rules based on cuts of membership functions	The maximum presumption
Mir and Rashidpoor (2019)	15	–	Factors impacting the promotion of the brand personality	–	–	–
Liu and Chou (2016)	–	11	Attributes problem of tourism strategy/DEMATEL	TrFNs/3	The proposed model with Fuzzy geometric operator	The method of maximum possibility
Kamalian et al. (2017)	32	10	Assessment of the weights of criteria/electronic government domain	TFNs/7	Fuzzy averaging method	–
Vafadarnikjoo et al. (2018)	8	47	Assessment of the weights of motivations for potential consumers to buy a remanufactured product/FAHP	Trapezoidal neutrosophic fuzzy numbers/9	Weighted arithmetic averaging	–
Kumar et al. (2018)	–	35	Choosing factors related to the changing pattern of consumer decision making in the digital market / FAHP	TFNs/9	The proposed model with Fuzzy geometric operator	Defuzzification procedure (Mardani et al. 2016)
Jan et al. (2018)	12	–	Assessment of antecedents of customer engagement	TFNs/7	Fuzzy averaging method/Euclidean distance	The simplest defuzzification method, alpha-cut

5 Conclusion

In the conditions of various changes taking place in the environment, it can be said that even though there is more than a sufficient number of data records, in many cases, the available data cannot be considered to be completely valid and reliable. Therefore, the application of quantitative methods for forecasting demand should be applied cautiously. Considering that, many researchers suggest the application of modified qualitative methods in forecasting studies. In the literature, many management problems are stated as multi-criteria optimization problems. This can be applied in all areas of management, including marketing management and marketing decision-making.

The number of factors by which possible alternatives are assessed is determined by the assessment of D.M.s and depends on their knowledge and experiences. In order to reduce the scope of calculations, the number of factors must be optimal. Determining the optimal number of factors can be based on an estimate of D.M.s. In this case, this decision would be highly burdened by subjective assessments of D.M.s. In order to reduce subjectivity in determining the number of factors, many authors suggest the application of the fuzzy Delphi technique. The rank of alternatives is based on applying different multi-criteria optimization methods, such as FAHP. Recently, TFNs have gained popularity in the evaluation and choosing problems in a wide range of applications. Based on the literature review, a summary of the typical research conducted in marketing utilizing this method has been provided, and three main areas of application identified: consumer behavior and consumer decision-making, market segmentation, and support in the development of marketing and branding strategies.

The paper contributes to the current body of literature with two main aspects as follows: (1) it identifies the various models based on the Delphi framework which have been integrated with fuzzy sets theory and utilized in marketing studies (2) identifies various potential application areas for utilization of this method in marketing.

Although the published studies indicated that the Fuzzy Delphi method is showing as very useful in various areas of marketing, the method is relatively unexploited in marketing studies. One of the reasons behind that might be the current scope of marketing research curriculum, which is traditionally based on social sciences (Babin and Zikmund 2015; McDaniel and Gates 2010), and is not focused on training prospective graduates to apply tools and techniques from decision making and business analytics in marketing research and analytics. Future research can aim to develop fuzzy Delphi models for forecasting in marketing areas of interest by employing fuzzy sets that are not yet thoroughly examined within this domain. Additionally, researchers should not rely only on the traditional methods and techniques in their respective disciplines but aim to integrate techniques and approaches from various business disciplines to utilize the opportunities that this integration can offer fully.

References

Asgarkhani M (2005) The effectiveness of e-service in local government: a case study. Case Stud eGov 3(4):157–166

Atanassov K (1999) Intuitionistic fuzzy sets: theory and applications. Physica-Verlag, Wyrzburg

Babin B, Zikmund W (2015) Essentials of marketing research, 6th edn. Cengage Learning

Buyukozkan G (2004) Multi-criteria decision making for e-marketplace selection. Internet Res 14(2):139–154. https://doi.org/10.1108/10662240410530853

Cho J, Lee J (2013) Development of a new technology product evaluation model for assessing commercialization opportunities using Delphi method and fuzzy AHP approach. Expert Syst Appl 40(13):5314–5330

Dalkey N, Helmer O (1963) An experimental application of the Delphi method to the use of experts. Manag Sci 9(3):458–467

Dubois D, Prade H (1980) Fuzzy sets and systems: theory and applications. Academic Press Inc., London

Evangelidis A, Akomode J, Taleb-Bendiab A, Taylor M (2002) Risk assessment & success factors for e-Government in a U.K. establishment. In: Traunmüller R, Lenk K (eds) Electronic government, vol 2456. Lecture notes in computer science. Springer, Berlin Heidelberg, pp 395–402

Förster B, von der Gracht H (2014) Assessing Delphi panel composition for strategic foresight—a comparison of panels based on company-internal and external participants. Technol Forecast Soc Chang 84:215–229

Gil-Lafuente, Anna M, Mauricio OH, Ma Luisa S M (2013) Customer retention in noncontractual relationships: The Fuzzy-Delphi method and the counter-expertise through uncertain values. In Decision Making Systems in Business Administration, pp. 143–161

Habibi A, Jahantigh FF, Sarafrazi A (2015) Fuzzy Delphi technique for forecasting and screening items. Asian J Res Bus Econ Manag 5(2):130–143

Hanafizadeh P, Mirzazadeh M (2011) Visualizing market segmentation using self-organizing maps and Fuzzy Delphi method–ADSL market of a telecommunication company. Expert Syst Appl 38(1):198–205

Hicham A, Mohammed B, Anas S (2012) Hybrid intelligent system for sale forecasting using Delphi and adaptive fuzzy back-propagation neural networks. Editorial preface

Hsu YL, Lee CH, Kreng VB (2010) The application of Fuzzy Delphi Method and Fuzzy AHP in lubricant regenerative technology selection. Expert Syst Appl 37(1):419–425

Hsu, Tsuen-Ho, Tzung-Hsin Y (1999) A new fuzzy synthetic decision model to assist advertisers select magazine media. In FUZZ-IEEE'99. 1999 IEEE International Fuzzy Systems. Conference Proceedings (Cat. No. 99CH36315), IEEE vol. 2, pp. 922–927

Jani NM, Zakaria MH, Maksom Z, Haniff MSM, Mustapha R (2018) Consequences of customer engagement in social networking sites: Employing fuzzy delphi technique for validation. International Journal of Advanced Computer Science and Applications 9(9)

Ji P, Wang J, Zhang H (2016) Frank prioritized Bonferroni mean operator with single-valued neutrosophic sets and its application in selecting third-party logistics providers. Neural Comput Appl. https://doi.org/10.1007/s00521-016-2660-6

Kamalian A, Shahmehr FS, Ajdari P, Khaksar SMS (2017) Empirical study on electronic government in developing countries by using fuzzy Delphi and TOPSIS techniques. Int J Electron Bus 13(4):295–322

Kumar A, Dash MK (2017) Causal modelling and analysis evaluation of online reputation management using fuzzy Delphi and DEMATEL. Int J Strat Decis Sci (IJSDS) 8(1):27–45

Kumar A, Mangla SK, Luthra S, Rana NP, Dwivedi YK (2018) Predicting changing pattern: building model for consumer decision making in digital market. J Enterp Inf Manag

Li S, Davies B, Edwards J, Kinman R, Duan Y (2002) Integrating group Delphi, fuzzy logic and expert systems for marketing strategy development: the hybridisation and its effectiveness. Mark Intell Plan

Liu CHS, Chou SF (2016) Tourism strategy development and facilitation of integrative processes among brand equity, marketing and motivation. Tour Manag 54:298–308

Ljepava N (2018) Marketing research. 2.0. Marketing research practices in digital era. Foundation Andrejevic

Macnee CL, McCabe S (2008). SRN. Understanding nursing research: using research in evidence-based practice, 2nd ed. Wolters Kluwer Health/Lippincott Williams & Wilkins, Philadelphia, PA

Malone D, Abarca J, Hansten P, Grizzle A, Armstrong E, Bergen RV, Duncan-Edgar B, Solomon S, Lipton R (2005) Identification of serious drug-drug interactions: results of the partnership to prevent drug-drug interactions. Am J Geriatr Pharmacother 3(2):65–76

Mardani A, Zavadskas EK, Streimikiene D, Jusoh A, Nor KM, Khoshnoudi M (2016) Using fuzzy multiple criteria decision making approaches for evaluating energy saving technologies and solutions in five star hotels: a new hierarchical framework. Energy 117:131–148

McDaniel C, Gates R (2010) Marketing research with SPSS. International Edition John Wiley and Sons Inc.

Meadows AB, Maine LL, Keyes EK, Pearson K, Finstuen K (2005) Pharmacy executive leadership issues and associated skills, knowledge, and abilities. J Am Pharm Assoc 45(1):55–62

Merigó JM, Casanovas M (2008) Using fuzzy numbers in heavy aggregation operators. Int J Inf Technol 4(3):177–182

Meijering JV, Kampen JK, Tobi H (2013) Quantifying the development of agreement among experts in Delphi studies. Technol Forecast Soc Chang 80(8):1607–1614

Mendel JM (2017) Type-2 fuzzy sets. Uncertain rule-based fuzzy systems. Springer, Cham, pp 259–306

Mir S, Rashidpoor A (2019) Prioritizing the describing factors in promoting brand personality using fuzzy Delphi technique. Consum Behav Stud J 6(2):134–148

Minkes AL (1987) The entrepreneurial manager, decisions goals and business ideas. Penguin Books, Harmondsworth

Nestic S, Lampón JF, Aleksic A, Cabanelas P, Tadic D (2019) Ranking manufacturing processes from the quality management perspective in the automotive industry. Expert Syst 36(6):e12451

Röllecke FJ, Huchzermeier A, Schröder D (2018) Returning customers: the hidden strategic opportunity of returns management. Calif Manage Rev 60(2):176–203

Selaković M, Ljepava N, Đeletović M (2018) Upravljanje inovacijskim promenama u savremenom okruženju. Vojno Delo 70(3):448–459

Somerville JA (2008) Effective use of the Delphi process in research: its characteristics, strengths, and limitations

Li S (2005) A Web-enabled hybrid approach to strategic marketing planning: Group Delphi+a Web-based expert system. Expert Syst Appl 29:393–400

Tadić D, Nestić S (2019) Organization work. The University of Kragujevac, Faculty of Engineering

Vafadarnikjoo A, Mishra N, Govindan K, Chalvatzis K (2018) Assessment of consumers' motivations to purchase a remanufactured product by applying Fuzzy Delphi method and single valued neutrosophic sets. J Clean Prod 196:230–244

Viscusi G, Thevenet LH, Salinesi C (2008) Strategic alignment in the context of e-services-an empirical investigation of the INSTAL approach using the Italian egovernment initiative case study. In: Bellahsène Z, Léonard M (eds) Advanced information systems engineering, vol 5074. Lecture notes in computer science. Springer, Berlin Heidelberg, pp 163–166

Ye J (2017) Some weighted aggregation operators of trapezoidal neutrosophic numbers and their multiple attribute decision making method. Informatica (in press)

Zimmermann HJ (2010) Fuzzy set theory. Wiley Interdiscip Rev Comput Stat 2(3):317–332

Zadeh LA (1975) The concept of a linguistic variable and its application to approximate reasoning—I. Inf Sci 8(3):199–249