# Analysing the voice of customers by a hybrid fuzzy decision-making approach in a developing country's automotive market

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# Analysing the Voice of Customers by a Hybrid Fuzzy Decision-Making Approach in a Developing Country's Automotive Market


**Abstract**

**Purpose.** This paper analyses the Voice of Customer (VoC) using a hybrid clustering multi-criteria decision-making (MCDM) approach. The proposed method serves as an efficient tool for how to approach multiple decision making involving a large set of countrywide customer complaints in the Iranian automotive sector.

**Design.** The countrywide data comprising 3342 customer complaints (VoC) were gathered. Seven determinant complaint criteria were identified in brainstorming sessions with three groups (six each) of experts employing the fuzzy Delphi method. The weights of these criteria were assigned applying the fuzzy best-worst method (FBWM) to identify the severity of the complaints. Subsequently, the complaints were clustered into five categories with respective customer locations (province), car type, and manufacturer using the K-Mean method and further prioritized and ranked employing the fuzzy complex proportional assessment of alternatives (FCOPRAS) method.

**Findings.** The results illustrate that the majority of complaints (1027) from the various regions of the country belonged to one specific model of car made by a particular producer. The analyses revealed that only a few complaints related to product quality, with the majority related to service and financial processes including delays in automobile delivery, delays in calculating monthly installments, price variation, failure to provide a registration (license), and failure to supply the agreed product. The proposed method is an efficient way to solve large-scale multi-dimensional problems and provide a robust and reliable set of results.

**Originality.** This paper proposes a comprehensive approach to critically analyse the voice of customers by combining qualitative and decision-making approaches including K-mean, FCOPRAS, fuzzy Delphi, and FBWM. This is the first paper that analyses VoC in the automotive sector in a developing country context involving large-scale decision-making problem-solving.

**Managerial Implication.** The proposed method makes it much easier for management to deal with complaints by significantly reducing their number. The highest-ranked complaints from customers of the car industry in Iran are those relating to delivery time, price alternations, customer service support, and quality issues. Surveying the list of complaints shows that paying attention to the four most voiced complaints can reduce them more than 54 percent. Management can make appropriate strategies to improve the production quality as well as those business processes, producing a significant number of customer complaints.



**Keywords:** Voice of Customers; Fuzzy Delphi; K-mean; Fuzzy Best-Worst Method; Fuzzy COPRAS.

## 1. Introduction

The success of goods or services is reliant on customer satisfaction; therefore, one of the principal missions of every company is responding to its customers' needs. Determining customers' exact requirements and interpreting their expectations is critical to satisfying them in an effective manner. Customer satisfaction can be addressed through a wide range of analyses which are conducted to minimise costs and time, maximise automation, manage customer relationships and develop other product-based methods, for instance, new product development (Matzler and Hinterhuber, 1998; Olya, 2014). VoC is a vital procedure that scrutinises customers' inputs to decipher their demands. In particular, VoC, as a marketing method, is an organised hierarchical structure that generates an exhaustive set of customer requirements and prospects. According to research from the Troubled Asset Relief Programme (TARP) Institute, 90% of unsatisfied customers do not complain, but rather just 'blacklist' the company in question. Moreover, 70% of satisfied customers still tend to purchase from competitors or at least form relations with them (Flint *et al.*, 2011). In conjunction with TARP's research, a further survey clarified that fully satisfied customers are only 42% more interested in loyalty. Simultaneously, a study by AT&A shows that 70% of customers announcing their satisfaction are prepared to shop with competitors given an appropriate opportunity (Armstrong *et al.*, 2014). In consonance with this research, a report by the Boston Consulting Group illustrates that gaining a new customer is 5-10 more expensive than repeating a transaction with a current customer (Flint *et al.*, 2011). To sum up, the ultimate goal of marketing is one of ensuring customer satisfaction through the identification of their needs, demands, tastes, attributes, tendencies, abilities, and limits. Moreover, treatments in human science are complicated, and consequently uncertainty and ambiguity should be expected in any associated research.

To this end, fuzzy logic is an acceptable paradigm as a solution. In recent years, various research in the field of VoC analysis has been undertaken using various techniques. A number of significant problems with previous VoC analyses have resulted in not understanding customer needs to the fullest extent possible. Direct use of raw text data as excerpts of customers' opinions is challenging, hence in most studies, qualitative techniques and numerical data analysis are used. Furthermore, in some industries customer needs vary as a function of time (Pyon *et al.*, 2010; Jia *et al.*, 2013; Liu *et al.*, 2019). To achieve this goal, numerous methods can be applied, e.g., dynamic optimisation, cost-time analysis, machine learning, data mining, etc. (Cooper and Kleinschmidt, 1994; Radharamanan and Godoy, 1996; Fung *et al.*, 1998; Mahdiraji *et al.*, 2015). Even though numerous studies have been performed in the area of VoC, few have concentrated on the automotive industry. The automotive industry is crucial to Iranian economics, hence merits in-depth investigation.

In this research, a hybrid clustering-MCDM approach is adopted using fuzzy linguistic terms to evaluate the VoC in the Iranian automotive industry. To accomplish this, customer complaints from automobile manufacturers are analysed and 53 criteria are extracted, after which 26 criteria are designated by experts, and fuzzy Delphi is executed. As a result of fuzzy Delphi, seven criteria were selected and their weights extracted via FBWM. Following this, 3342 customer complaints were clustered into five classes found in four features including province (31 provinces), automobile type (19 types), automakers (three automakers), and the causes of the complaints (53 causes). Finally, the clusters were prioritised via FCOPRAS. The results showed that the top cluster included 1027 complaints for a specific automobile model

(PRIDE), which is made by a particular producer (SAIPA Corporation) from all provinces. Considering that complaint is not the only part of VoC, collecting suggestions and criticisms was not possible due to the limitation of the customer relationship systems. It is interesting to note that majority of the complaints were not about the product, rather about the financial and operational service offered by the company. These findings provide guidelines for the management to improve various aspects of their product and service. Nevertheless, this is a novel research effort that concentrates on VoC in the Iranian automotive industry.

The remainder of this research is organised as follows. First, basic concepts including detailed information related to the voices of customers are presented and the related literature is reviewed and analysed. The research method and pertinent tools, including FBWM, FCOPRAS, K-Mean, and fuzzy Delphi, are then described. Subsequently, the Iranian automotive industry is introduced, and the proposed approach is described and the results are given. Finally, the results are discussed, and a number of the associated implications, and suggestions for future research, are indicated.

## 2. Basic Concepts and Literature Review

### 2.1. Voice of Customer

VoC is a critical analysis method that provides accurate information to stand on customers' needs input to attain goods/service output. Decision-makers can understand customers' requirements, demands, perceptions, and preferences by the ability to manage and analyse VoC, which is gained through direct and indirect questions. Thus, the information gathered is transformed into strategic goals and, consequently, fulfills the customers' needs. Four aspects of VoC are customer needs, a hierarchical structure, priorities, and customers' perceptions of performance (Aguwa *et al.*, 2012).

In recent years, the supply of automobiles has overtaken demand because of the rapid development of technology and the presence of numerous players in the market. Accordingly, industrial manufacturers should respect and attempt to satisfy customers not only by virtue of compassion or valorisation but also to increase revenue and earn a profit (Bell, 1995). It is notable that the most influential tool with which to survey customer satisfaction is VoC, the use of which has increased significantly in companies.

### 2.2. A Brief History of VoC

There have been several and, distinct views on VoC including the product-based view, sales-based view, marketing-based view, and customer-based view. A brief explanation of each is given as follows.

- **Production-based view.** In the early 19$^{th}$ century following the industrial revolution to the end of the First World War, companies concentrated on their goods and services (Hafeez *et al*., 2002 and 2006). This was by the idea that there would be a reasonable customer for well-qualified products (Cartwright, 2003). In this view, producers had a more prominent role in comparison with customers.
- **Sales-based view.** Between 1920-1950, companies became aware that customers would not necessarily buy their products, and that they, therefore, needed to take action to sell their goods (Harvey, 2002). This view changed the producer-customer equation in favor of the customer.

- **Marketing-based view.** In early 1980, companies found that they could improve the sales process considerably by identifying customers' needs to a greater extent (Jay, 2001). This view ultimately highlighted the role of VoC (Hafeez *et al.*, 2006; Hafeez and Mazouz, 2011).
- **Customer-based view.** In the late 20th century, companies concluded that the way to survive was to lay not only in recognising their customers but also in communicating with them (Johnson *et al.*, 2001). "Close contact with customers" means that a company should recognise that its competitors will connect with their customers in the absence of their communication (Peters *et al.*, 1982). The optimal application of VoC is an effective method for starting a conversation with one's customers (Hafeez *et al.*, 2007 and 2010).

There are various approaches to addressing customers' needs and comments. Some considered customers to be rational or emotional decision-makers or that customer surprise is more important than customer satisfaction. Furthermore, other approaches were introduced to better understand customer needs, including the Behavioral Impact approach, Perception of Performance approach, Customer Orientation and Royalty approach, and Cognitive Model. (Based upon Tse and Wilton, 1988; Gronholdt *et al.*, 2000; Salegna and Goodwin, 2005; Hicks *et al.*, 2005; Çoban *et al.*, 2006; Mowen and Minor, 2006). Numerous methods to analyse VoC have been proposed since its introduction. In this regard, methods such as Questionnaire Surveys, Expert Interviews (Delphi Method), Conjoint Analysis, Idea Workshops, Idea Competitions, Lead Users Analysis, Focus Groups, Netnography, Toolkits, and Automobile Clinics are applicable (Found in Green and Srinivasan, 1978; Fern, 1982; Urban and von Hippel, 1988; Urban *et al.*, 1990; von Hippel and Katz, 2002; Kozinets, 2002; Ebner *et al.*, 2009; Geusen *et al.*, 2013; Hafeez *et al.*, 2016; Kumar and Dash, 2017). However, in this research, other methods are proposed in this regard. Table 1 elaborates previous research on VoC.

Please Insert Table 1 Here

Analysing the previous research indicates that combining VoC with other tools has been proposed. Two types of research can be determined. The first is research that offered different frameworks by integrating VoC and other means, theories and methods (e.g., Wang *et al.*, 2014; You *et al.*, 2015; Koklic *et al.*, 2017; Beal & Sabadie, 2018; Walker, 2019). The second is research that considered the applications of the numerous frameworks of VoC analysis in particular cases, (e.g., Zhang, 2019; Milan *et al.*, 2018; Vlaanderen *et al.*, 2019). Regarding the application of decision-making methods or fuzzy approaches in the automotive industry, no relevant research for analysing customer voices or complaints could be identified by the authors. Previous scholars have, for the most part, focused on the application of MCDM models in sustainability (e.g., Ghadimi *et al.*, 2012; Stoycheva *et al.*, 2018; Singh *et al.*, 2020), production planning issues (e.g., Petrani *et al.*, 2019; Djordjevic *et al.*, 2019) and supplier selection issues (e.g., Gupta *et al.*, 2019; Liu *et al.*, 2019) for the car or automotive industry. According to previous research (indeed, domestic references in Iran), there has been no framework offered to analyse the voice of automobile customers. With due regard to the limitations on automobile company databases, customers' complaints have been considered to be VoC. Furthermore, this research was performed according to the fuzzy theory that can reflect the exiting uncertainty in considered industry and economy.

## 3. Proposed Approach

This research encompasses two phases, namely data collection followed by preparation and data analysis**.** These phases are illustrated in Figure 1.

Please Insert Figure1 Here

According to Figure 1, in the first phase, the customer's information is gathered through special access to the automotive industry database, in addition to complaints registered in customer relationship management departments in different car factories. This information is employed to determine the key factors of VoC and decision-making criteria based on more significant complaints. These criteria are the selected complaints from the databases studied. Determinant factors that cover more than 95% of registered complaints are chosen for further analysis. In the following, these selected criteria are screened and adapted to the Iranian automotive industry through a questionnaire whose content was derived through expert opinion and as prioritised by fuzzy Delphi. Finally, the weights of the extracted criteria can be calculated by FBWM.

In the second phase, data from the selected criteria are collected and customers are clustered via the K-Means method. To present implications for policymakers, information obtained from the databases is applied to determine any useful implications. These clusters were investigated and ranked via FCOPRAS and based upon determinant complaints/criteria resulting from the first phase. As a result, the most important cluster of customers is ranked on more critical complaints. Detailed information about each tool and step can be described as follows.

### 3.1. Fuzzy Delphi Method

Helmer and Dalkey of the Research ANd Development (RAND) Corporation proposed a fuzzy Delphi method in 1963. The Delphi method was combined with Fuzzy Theory (Zade, 1965) to model uncertainty in a real environment. In the following, the steps to this algorithm are discussed (Pham and Hafeez, 1993; Hajiagha *et al.*, 2015; Mokhtarzadeh *et al.*, 2018, Mahdiraji *et al.*, 2019).

- Expert opinion is according to a linguistic spectrum. These terms are translated into one of the triangular fuzzy numbers (TFNs) found in Table 2.

Please Insert Table 2 Here

- Fuzzy values are averaged employing equation (1), where $A_{ave}$ is the average value of a factor upon expert opinion (Hsu *et al.*, 2010).

$$A_{ave} = (\frac{1}{n}\sum_{i=1}^{n} a_1^i , \frac{1}{n}\sum_{i=1}^{n} a_2^i , \frac{1}{n}\sum_{i=1}^{n} a_3^i) \qquad (1)$$

In eq. (1), $(a_1^i, a_2^i, a_3^i)$ denote the TFN appointed by experts and $i$ indicates the expert number (i.e., an index).

- The values obtained in the previous step are defuzzified by equation (2) (Minkowskis method), where $\gamma$ denotes the defuzzified value of the factor in question (Yang & Hsieh, 2009).

$$\gamma = a_1 + \frac{a_3 - a_2}{4} \qquad (2)$$

- The process described above is reiterated. The difference between the two phases be less than a *low threshold* (determined to be 0.1 in this research), the process is stopped, but is otherwise reiterated.
- The criteria with the defuzzified average value ($\gamma$) more than the threshold *(S)* are accepted. In this paper, *S* is considered to be 0.6.

### 3.2. Best-Worst Method

BWM is a method to extract the weights of criteria, as developed by Rezaei (Rezaei, 2015). A number of different approaches to BWM have been already introduced, e.g., linear (Rezaei, 2016), fuzzy FBWM (Guo and Zhao, 2017), Euclidean EBWM (Kocak *et al.*, 2018), intuitionistic fuzzy version IFBWM (Muo *et al.*, 2016), Z number version ZBWM (Aboutorab *et al.*, 2018) and multiplicative MBWM (Brunelli and Rezaei, 2019; Rezaei *et al.*, 2019). Fuzzy BWM is described below (Guo and Zhao, 2017).

1. A set of decision criteria is elected ($\{\mathrm{C}_1 . \mathrm{C}_2 \ldots . \mathrm{C}_\mathrm{n}\}$).
2. Experts or focus groups choose the best and the worst criteria. No comparison is implemented in this step. In this research, the authors have modified this step and used the rank of the Delphi fuzzy method to choose the best and worst criteria.
3. Experts or focus groups determine the preference of the best criteria over other criteria via a linguistic term. The linguistic term is transformed into a TFN known as$\left(\widetilde{\mathrm{A}}_{\mathrm{b1}} . \widetilde{\mathrm{A}}_{\mathrm{b1}} \ldots . \widetilde{\mathrm{A}}_{\mathrm{bn}}\right)$, as per Table 3. Note that $\widetilde{\mathrm{A}}_{\mathrm{bj}}$ denotes the fuzzy preference degree of the best criteria compared with the $\mathrm{j_{th}}$ criteria.
4. Experts or focus groups determine the preference of other criteria over the worst criteria via a linguistic term. The linguistic term is transformed into a TFN, as formed in Table 3 as $\widetilde{\mathrm{A}}_\mathrm{W} = \left(\widetilde{\mathrm{A}}_{1\mathrm{w}}, \widetilde{\mathrm{A}}_{2\mathrm{w}}, \ldots, \widetilde{\mathrm{A}}_{\mathrm{nw}}\right)$. Note that $\widetilde{\mathrm{A}}_{\mathrm{jw}}$ denotes the fuzzy preference degree of the $\mathrm{j_{th}}$ criteria compared with the worst criteria.

Please Insert Table 3 Here

5. The model expressed in Eq. (3) below is solved to attain optimal weights via the General Algebraic Modeling System (GAMS) or LINGO software packages as ($\{\mathrm{W}_1 . \mathrm{W}_2 \ldots . \mathrm{W}_\mathrm{n}\}$), where $W_j^l$ is the lower limit of a TFN, and $W_j^m$ and $W_j^u$ are the moderate and the upper limit of the TFN weights, respectively.

$$Min\ \varepsilon$$
$$\left|\frac{(W_B^l \quad W_B^m \quad W_B^u)}{(W_j^l \quad W_j^m \quad W_j^u)} - (A_{Bj}^l \quad A_{Bj}^m \quad A_{Bj}^u)\right| \le \varepsilon$$
$$\left|\frac{(W_j^l \quad W_j^m \quad W_j^u)}{(W_W^l \quad W_W^m \quad W_W^u)} - (A_{jW}^l \quad A_{jW}^m \quad A_{jW}^u)\right| \le \varepsilon \tag{3}$$
$$\sum_{1}^{j} S(W_j) = 1;$$

$$S(W_j) = \frac{1}{6}(W_j^l + 4W_j^m + W_j^u)$$

$$W_j^l \le W_j^m \le W_j^u; \qquad W_j^l \ge 0$$

6. The compatibility rate (CR) of the comparisons is calculated using Eq. (4). In this research, CR less than 0.2 are considered acceptable.

$$CR = \frac{\xi^*}{CI} \tag{4}$$

Note that *CI* is the compatibility index, which is determined based on the preference of the best criteria over the worst criteria ($A_{BW}$). *CI* values are reported in Table 4 (Guo and Zhao, 2017).

Please Insert Table 4 Here

7. Fuzzy extracted weights $(W_l, W_m, W_u)$ are defuzzified by Eq. (5) where $W_j$ is the weight of the $j_{th}$ criteria.

$$W_j = \frac{1}{6}(W_l + 4W_m + W_u) \tag{5}$$

### 3.3. K-Mean Clustering

Clustering is an unsupervised process of learning. Each cluster includes a set of data that is similar to other data in the same cluster and different from data in other clusters (Kalra *et al.*, 2018). Distance is the criteria used to compute the similarity in clustering (Jintana and Mori, 2019). There are different approaches to calculating the distance. A Euclidean method is a frequent approach, as illustrated in Eq. (6) (Gultom *et al.*, 2018).

$$\text{Distance}\,(O_i . O_j) = \sqrt{\sum_{k=1}^{n} (X_{ik} - X_{jk})^2} \tag{6}$$

K-mean is a clustering technique in data mining. However, this is a simple method but is the basis of many other clustering techniques. In the k-mean algorithm, (k) members are first picked randomly from (n) members. K is the number of clusters. Then (n-k) members are allocated to the nearest cluster. After allocating all members, cluster centres are calculated once more, and the allocation is repeated based on new centres. This procedure is continued to reach fixed centres (Jintana and Mori, 2019).

### 3.4. Fuzzy Complex Proportional Assessment of Alternatives

COPRAS is an MCDM technique developed by Zavadskas to rank alternatives placed on decision criteria (Zavadskas *et al.*, 1994). The steps to this method are expressed below. This technique has been performed according to the fuzzy theory (Zade, 1965). In the following, the FCOPRAS are demonstrated (Amoozad Mahdiraji *et al.*, 2018)

1. The fuzzy weighted normalised matrix is formed by Eq. (7) using the linguistic terms reported in Table 5.

$$\tilde{v}_{ij} = \frac{\tilde{r}_{ij}\widetilde{w}_j}{\sum_{i=1}^{m}\tilde{r}_{ij}} \quad ; i = 1, 2, \ldots, m, j = 1, 2, 3, \ldots n \tag{7}$$

Here, $\tilde{r}_{ij}$ is the value of $i_{th}$ alternative resting on the $j_{th}$ criteria where $\widetilde{w}_j$ the weight of the jth criteria resulting from the FBWM section is. $m$ is the number of alternatives and $n$ is the number of criteria (Hajiagha *et al.*, 2015a and 2015b).

Please Insert Table 5 Here

2. Fuzzy weighted normalised scores are calculated for beneficial criteria as well as cost criteria via Eq. (8).

$$\tilde{S}_{+i} = \sum_{j\in B}\tilde{v}_{ij} \; ; i = 1, 2, 3, \ldots, m$$
$$\tilde{S}_{-i} = \sum_{j\in C}\tilde{v}_{ij} \; ; i = 1, 2, 3, \ldots, m \tag{8}$$

Note that $\tilde{S}_{+i}$ is the fuzzy beneficial score and $\tilde{S}_{-i}$ is the fuzzy cost score in Eq. (8).

3. The fuzzy relative priority of alternatives ($\tilde{Q}_i$) is obtained via Eq. (9).

$$\tilde{Q}_i = \tilde{S}_{+i} + \frac{\tilde{S}_{-min} \times \sum_{i=1}^{m}\tilde{S}_{-i}}{\tilde{S}_{-i} \times \sum_{i=1}^{m}\frac{\tilde{S}_{-min}}{\tilde{S}_{-i}}} \tag{9}$$

4. To measure the absolute priority of criteria, the values of the fuzzy relative priority are defuzzified by Eq. (10).

$$Q_i = f_1 + \frac{(f_3 - f_1) + (f_2 - f_1)}{3} \tag{10}$$

5. The absolute priority of alternatives ($N_i$) is measured by applying Eq. (11) (Razavi Hajiagha *et al.*, 2015; Beheshti *et al.*, 2016).

$$N_i = \frac{Q_i}{Q_{max}} \times 100 \tag{11}$$

Four methods, including fuzzy Delphi, K-Mean, Fuzzy BWM, and Fuzzy COPRAS, were employed in this research to identify customer complaints and customer clusters to weigh determinant complaints and rank customers' needs in the Iranian automobile industry. The reason(s) why each method is employed, in conjunction with their pros and cons, is presented in Table 6.

Please Insert Table 6 Here

Considering sections 3.1 to 3.4 and Table 6, the detailed analytical steps of this research can be understood and are as illustrated in Figure 2. Adopting optimal decisions in a changing environment and with a high amount of data is challenging for any organisation; these are generally known as large-scale decision-making problems or LSDM. Many simple decision-making methods (e.g., analytical hierarchical process (AHP), simple additive weight (SAW), etc.) or non-decision-making methods (e.g., Pareto analysis) could be used for similar situations. Nevertheless, while dealing with uncertainty, big data, and qualitative and quantitative criteria, a single method does not typically present applicable findings. The authors in this research have presented a hybrid approach consisting of four data mining and decision-making methods to aid LSDM problems. In this regard, the large amount of data is first clustered by K-mean. Then, the key factors are identified and evaluated by fuzzy Delphi and fuzzy BWM under uncertain conditions. Eventually, by considering qualitative and quantitative factors, the clusters are ranked to identify the priorities for decision-makers in any organisation.

Please Insert Figure 2 Here

## 4. Case Study and Results

Iran's automotive industry is the third-most active industry in the country, after its oil and gas industry, accounting for 10% of Iranian gross domestic product (GDP) and 4% of the Iranian workforce. Since the early 2000s, automobile production in Iran has grown exponentially. According to figures from the International Organisation of Motor Vehicle Manufacturers (OICA), Iran was the 12th biggest car market on the planet in 2017, with sales in the region of 1.5 million cars. That number of cars represented an 18% growth in sales, which made Iran the fourth fastest-growing nation in the market, behind Brazil, Portugal, and Russia. Today, Iran is the 18th largest automaker in the world and one of the largest in Asia.

As of 2001, there were 13 public and privately-owned automakers in Iran, of which two IRAN KHODRO (IKCo) and SAIPA (SC) accounted for 94% of the total domestic production. Iranian manufacturers currently produce six different types of vehicles, including passenger automobiles, 4WD, trucks, buses, minibusses, and pickup trucks. The sector directly employs about 2.3% of the workforce and many more in related industries. About 75% of local output is passenger cars, with pick-ups the next largest category, accounting for around 15%. Figure 3 shows the car production statistics from 1970 in Iran.

Please Insert Figure 3 Here

Tough economic sanctions imposed by the United States have hit Iran's automobile and truck production hard, with foreign automobile companies partnering with local manufacturers leaving the country altogether. Two years ago, before the U.S. imposed sanctions, Iran produced 1,538,000 vehicles, which declined to 956,000 units last year as the sanctions kicked in. Production of private cars has since decreased by more than 47 percent, reaching 40,602 units, while production of vans has stopped and pickup truck production was only 1,916 units (Press, Radiofarda, 2019).

Considering the international sanctions, there is only the domestic market available for car manufacturers; thus, considering customer satisfaction, needs, and complaints in this new environment have become vital. Moreover, pending the duopoly market in the car industry of Iran, nearly 95% of consumers are buying their automobiles from IKCo or SC. Accordingly, analysing the voice of customers for the aforementioned companies could lead to applicable results. Hence, in this research, complaints about one of the market owners have been considered. The rest of the paper presents the results of implementing the multi-layer decision-making approach. For easy tracking, the results are presented according to the phases and steps mentioned in Figure 1.

**Phase 1. Step (1**) The customers complaints about products from the three main Iranian automobile companies (SAIPA (S.C) PARSKHODRO (P.K) and ZAMYAD (Z.K)) are gathered through the CRM unit. These data have been submitted from 03/21/2018 to 03/20/2019 (Table 7).

Please Insert Table 7 Here

**Step (2)** The complaints noted in Table 7 have been discussed by experts and academic professors, 26 of which have subsequently been elected for the next step, as elaborated in Table 9. These 26 factors include 95% of all complaints. The items that were not considered only include 5% of customer complaints.

**Step (3)** In the following electing factors chosen by experts, a linguistics questionnaire has been distributed to appropriate experts in universities, the automotive industry, and managers of automobiles leasing companies. These three groups of experts include university professors (group 1: six members), Iranian car industry authorities (group 2: three members), and car leasing company managers (group 3: six members). They expressed their opinions in the linguistic terms reported in Table 2. Thereafter, the experts' opinions were averaged and defuzzified by Eqs. (1) and (2). The Delphi fuzzy method was performed for two rounds, the results of which are reported in Table 8.

Please Insert Table 8 Here

Note that we stopped the Fuzzy Delphi process after two rounds because we received the required consistency in expert opinion by achieving the required difference between the two rounds of less than 0.1 (absolutely low threshold). As mentioned earlier, the acceptance threshold was set at 0.6. This indicates that these complaints fall in the linguistic category of 'medium significant' (0.25, 0.5, 0.75) to 'moderately significant' (0.5, 0.75, 1) as defined in Table 2. Therefore, this has enabled the researchers to reduce the total number of complaints from 26 to just 7 ($C_1$ to $C_7$) as highlighted in Table 8. This makes it much easier for the management to deal with, representing a reduced number of significant complaints at first to achieve better customer satisfaction in the short term. It is also interesting to note that there is only one complaint ($C_6$) that relates to product quality; the remaining six complaints, namely delay in automobile delivery from the manufacturer ($C_1$), delay in profit calculations by finance company ($C_2$), automobile price change ($C_3$), delivery drawbacks ($C_4$), failure to assign the license ($C_5$) and failure to supply the agreed product ($C_7$), all are about problems relating to the business processes itself.

**Step (4)** Note that the resulting weights for the seven complaints (Table 8) have weights close to 0.6. This limits the management in terms of being able to identify which of these complaints are relatively more crucial to address, which could therefore have a significant impact on their businesses in terms of retaining customers. To make a differentiation, we employed a Fuzzy Best-Worst Method (FBWM) approach. To this end, we took the outcome of the fuzzy Delphi method (Table 8) and chose $C_4$ (which has the lowest average defuzzified value out of the seven complaints) as the 'Best' or most significant (important) complaint criterion, whilst $C_6$ (which had the highest average) was chosen as the 'Worst' or least important complaint criterion. We conducted a pairwise comparison for the seven chosen complaints (criteria) using the fuzzy linguistic terms defined in Table 3. Again, we conducted the analysis using the same three groups of experts and calculated the means of the group scores, as illustrated in Table 9.

Please Insert Table 9 Here

The fuzzy weights of the complaint (criteria) obtained from each group of experts were extracted (defuzzified) using Eq. (3), as depicted in Table 10. The second to last column (Ave.) on the right-hand side of Table 10 is the simple arithmetic mean of the weights of the three groups that denote the fuzzy weights for each of the critical complaints. These averaged weights are defuzzified using Eq. (5) and the final weights for each criterion are given in the extreme right-hand side column of Table 10.

Please Insert Table 10 Here

To evaluate the quality of the assessment by the three groups of experts, the compatibility rate of the experts' opinions was computed using Eq. (4). The results indicated that all groups of experts presented had an acceptable consistency index and ratio. Therefore, the weights given in Table 10 are considered acceptable, valid and reliable. To ascertain the relative merits of the two methods, the weights obtained from the FBWM and fuzzy Delphi method are charted in a radar plot form, as given in Figure 4. Where the Fuzzy Delphi method gives very similar weights to the complaints, the relative merit of FBWM is obvious in that it gives many discriminatory values for each complaint. Complaint $C_6$ remained the most significant (critical) complaint, however, according to FBWM the least significant complaint was $C_2$, as compared with $C_4$ as determined with the Fuzzy Delphi method.

Please Insert Figure 4 Here

**Phase 2. Step (5**) Earlier analysis resorted to finding out the seven most significant (critical) complaints that car manufacturers must resolve to improve their customer satisfaction. It is imperative to find out that Iranian customers from which region of the country are facing most dissatisfaction. Also, if there is a particular problem with one or more types of the car resulting in customer complaints. Also, if the customers are facing more problems with one company on the whole. We employed K-Mean analysis to undertake this investigation. The 3342 data set related to customer complaints were clustered employing the K-Mean method, considering four features namely the province (31 provinces), automobile type (19 types), automakers (3 automakers), and the causes of the requests (53 causes). The analysis resulted in 5 main clusters as described in Table 11. The number of clusters was tested from 3 to 10 by the Elbow method and Silhouette approach and as a result of these tests, five clusters were chosen.

Please Insert Table 11 Here

**Step (6**) To rank which cluster is facing a more critical challenge from customer complaints, we employed the Fuzzy Complex Proportional Assessment of Alternatives (FCOPRAS) method. Again we used fuzzy linguistic terms as defined in Table 5 to attain the opinions of the three expert groups to rank the seven complaints against a five cluster decision-making matrix obtained from the expert opinions of the three groups, as provided in Table 12.

Please Insert Table 12 Here

The weighted normalised matrix is computed by Eq. (7). Subsequently, the results of performing FCOPRAS are detailed in Table 13 by applying Eqs. (8) to (11).

Please Insert Table 13 Here

Based on the seven identified critical complaints, the results indicate that cluster $A_5$ is the most critical, with complaints that need resolving on an immediate basis. The complaints in a cluster all belonged to one particular family of cars relating to a particular manufacturer. The total number of complaints recorded was 1027, stemming from all the provinces of the country. Also, this cluster had recorded all seven critical complaints. This requires immediate attention by the management of the company in terms of addressing their customers' issues to protect their business. Nearly 30% of the complaints were related to this specific car and factory.

## 5. Discussion and Implication

### 5.1. General Discussion

*Generally speaking,* the success of goods or services rests on customer satisfaction; thus, the main mission of every company is responding to customers' needs. This means paying attention to VoC as an integral part of modern marketing. Accordingly, identifying and ranking the key factors of the automotive industry would allow the application of VoC in an influential manner to increase their achievements and sales. Nonetheless, VoC analysis has not been performed in the automotive industry. This study thus offers a novel approach to VoC analysis in this industry. Concentrating on complaints as the voice of customers can be beneficial in terms of understanding customers' needs. In addition to hearing voices, employing a clustering method to segment complaints and an evaluative method to sort the clusters and identify the more critical voices, provides the opportunity for a deep investigation of these voices to develop suitable strategies to address their needs. The automotive industry is a vital part of Iranian economics and making appropriate decisions is crucial to companies and activists in this industry. Thence, appropriate decisions could improve the performance of this industry and reduce the current high rates of customer displeasure. Adopting optimal decisions while dealing with a large amount of data is one of the main challenges in the management era. Therefore, large-scale decision-making problems exist in companies with large parts of the market share. Adopting one optimal method or technique to deal with these kinds of problems and dilemmas has been considered by many scholars. This research proposes a hybrid novel approach to aid such situations. By considering uncertainty as fuzzy numbers, using qualitative and quantitative criteria, employing expert opinions and customer complaints, and designing a mixed data mining and decision-making approach, the authors believe that LSDM problems are solvable and applicable for managers in similar conditions.

*Theoretically speaking*, the Delphi method is an applicable way to survey the voice of customers. Indeed, the automotive industry is mutable; as a consequence, there are abundant variables in this industry that can cause uncertainty. Hence, fuzzy Delphi can enhance the reliability of investigating experts' opinions for such circumstances. Note that the weights determined from fuzzy Delphi have low discriminatory power and are not capable of distinguishing the relative importance of the various criteria. Thus, applying a more powerful evaluation method is suggested by the authors to overcome this limitation. As a result, in addition to fuzzy Delphi, BWM, as an advantageous MCDM method in terms of extracting the weight of criteria, was applied by the authors. The connection between BWM and fuzzy set theory also improves the accuracy of this method when applied to the changeable environment of the automotive industry. Therefore, the alliance of fuzzy sets with other methods brings them closer to reality. Furthermore, clustering is a powerful data mining tool that has been applied in this manner in various studies. Nevertheless, clustering has not been widely applied in VoC analysis, especially in the automotive industry. This study describes the application of this data mining tool. Although the adoption of MCDM techniques and clustering has not previously been the subject of VoC analysis, it has been popularly applied in other parts of strategy development, e.g., customer segmentation and retailer clustering. This study illustrates the usage of this integration. Note that in dealing with thousands of complaints and making decisions based on high volumes of data is known as a Large-Scale Decision-Making problem (LSDM). For LSDM problems, this research designed a novel and hybrid approach to integrating data mining and decision-making knowledge. In this regard, a combination of data mining methods (K-mean) and decision-making approaches (fuzzy Delphi, Best Worst Method-Fuzzy, and Fuzzy COPRAS) are used and presented in Figure 2. This approach is novel in this area and can be applied in any LSDM situation.

### 5.2. Managerial Implications

Surveying the list of complaints shows that paying attention to the four most voiced complaints can reduce them more than 54 percent. These complaints are delays in automobile delivery from the manufacturer, delay in paying balances to customers, and failure to withdraw a payment from customers accounts. The first complaint refers to the supply chain management issues. The three others represent financial difficulties. Concentrating on SCM and financial management is a must in this industry for future developments. These complaints are approved by experts so that 11 out of 26 finalised complaints by experts directly mention SCM and financial management problems. Additionally, experts have focused on quality issues that are specified in this industry. From the viewpoint of significance, by applying both the Fuzzy Delphi and FBWM, automobiles quality issues are the most highlighted ones. This can harm the manufacturers, notably in this developing competitive industry. Furthermore, the results of investigating the cluster state that the cluster with the most priority contains the complaints of every seven criteria and from the whole country. This shows that responding to this cluster is a complicated procedure.

According to the final ranks of the most important complaints (Table 10), it is clear that Quality, Delivery, Financial, and customer supports are the main complaints in this research. Hence, the managers should consider these four main elements in the strategies and plans. Currently, the responsibility of the delivery and transportation of the automobiles is with the manufacturing company, and logistic service providers (LSP) are not cooperating with the producer. Considering the significant role of LSPs including third-party logistic companies (3PLs) in any supply chain prosperity, it is recommended to sign long-term agreements with 3PLs to reduce the negative effects of delivery time, delivery defects, etc.

Iran's automotive industry is the third-most active industry in the country, accounting for 10% of (GDP) and 4% of the workforce. Note that 95% of Iranian society buy their cars from domestic manufacturers with a total production of 1.5 million cars per year (as measured before recent U.S. political sanctions). Iran is the fourth fastest-growing nation in the market and is the 18th largest automaker in the world. This research presents the more notable complaints of the customers of the three main car producers in Iran, with nearly 50% of market share (as the duopoly automotive market in Iran). By gathering 3342 complaints and expert opinions from industry and authorities, the results are potentially generalisable. Moreover, the validity and reliability of the results are checked by the consistency ratio and indexes. The policymakers should develop appropriate strategies and invest to build up the knowledge and skill level of the workforce and management competencies (Al-Qatawneh and Hafeez, 2015) to help to increase productivity and the economic value of the sector.

The highest-ranked complaints from customers of the car industry in Iran are those relating to delivery time, price alternations, customer service support, and quality issues (Table 8). These factors, Time (T), Quality (Q), Cost (C), and Service (S), indicate that the automotive manufacturers in the Iranian market are far behind reasonable standards of customer satisfaction. The combination of these four factors (TCQS) is known as customer value (Martin, 2005). Thus, with high and non-competitive prices, delays in the delivery of products, limited supporting services, and low quality of such, all aspects of customer value are neglected in the studied industry. Nonetheless, due to government support and the non-competitive situation in this market in Iran, the consumer is forced to buy from domestic producers. With poor performance relating to economic factors, environmental factors, and social criteria, this industry, and the relevant manufacturers have poor performance regarding sustainable manufacturing indicators and the triple bottom line (TBL) model. Policymakers should be aware of the possible negative future outcomes in case they continue to adopt noncompetitive policies. The complaints and VoC analysis of this research and studied industry indicates that the customer value and satisfaction is ignored by manufacturers and policymakers. Policymakers can make use of these findings to invest in upgrades to the associated technology, countrywide workforce and managerial skills development programmes to increase the productivity of the sector.

## 6. Conclusion

In this research, a hybrid clustering-MCDM approach is used to consider the VoC in the Iranian automotive industry. In the beginning, the key factors of the VoC are extracted by studying customer complaints. Note that 26 complaints were selected from 53, which included 95% of all factors. Consequently, seven factors were selected employing fuzzy Delphi and the weights of these criteria are assigned applying FBWM. Subsequently, the data from the 3342 customer complaints about automobile manufacturers were gathered and clustered into five classes found on four features via the K-Mean method which included the province (31 provinces), automobile type (19 types), automakers (three automakers) and the causes of the complaints (53 causes). Finally, the clusters were prioritised via FCOPRAS. The results indicated that the top cluster contained 1027 complaints of all the causes from a specific type of car (PRIDE) as made by a particular manufacturer (SAIPA Corporation) in all provinces. Although VoC encompasses not only the complaint but also suggestions and critique, this research offers a novel framework for addressing problems within the Iranian automotive industry.

The cluster of customer complaints resulted from applying the K-Mean method and was based upon real-world databases. However, evaluating and ranking the clusters resulting from the opinions of experts (constituted of three groups, namely university professors, authorities, and car industry managers) rather than being based on databases. For future studies, using database information such as the number of complaints could be considered. Furthermore, the fuzzy uncertain approach has been applied for weighting factors and ranking clusters; thus, more complex uncertain figures encompassing hesitant fuzzy (HF), intuitionistic fuzzy (IF), or interval-valued intuitionistic fuzzy (IVIF) are applicable. Moreover, in factor evaluation, besides BWM, other possible methods including the Stepwise Weight Assessment Ratio Analysis (SWARA), AHP, Simultaneous Evaluation of Criteria and Alternatives (SECA), etc., are applicable to recheck and benchmark the results. Besides, to rank the clusters, other available methods including SECA, the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), etc. should be usable. Besides, the optimal number of clusters could be analysed and properly optimised before ranking in any future studies of this kind.

Besides the methodological perspective, further applicational and practical developments are also considerable. As a case in point, the proposed approach is capable to be implemented in other automotive companies in Iran (e.g. IKCO), other middle east countries (e.g. Turkey), or other Central Asian countries (e.g. India) to identify and evaluate VoC. Afterward, the results emanated from other companies or countries could be compared and benchmarked with high-class manufacturing companies in the automobile industry such as Toyota, BMW, etc. for future planning and target setting. Furthermore, the suggested framework in this research is a multi-layer and multi-criteria decision-making approach, which is potentially applicable to other industries.

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