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# Integrating Fuzzy Theory into Kano Model for Classification of Service Quality Elements: A Case Study of Machinery Industry in China

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***Abstract:***

***Purpose:*** The purpose of study is to propose and verify a method of service quality elements classification through integrating fuzzy theory into Kano model. The method has the merit of being more effective in processing customers' psychology of vagueness and uncertainties than traditional Kano model.

***Design/methodology/approach:*** In this study, considering the disadvantages of traditional Kano model in service quality elements classification without taking into account customers' complex consuming psychology, and combining with fuzzy theory which is effective to cope with uncertainty and ambiguity, a new framework of integrating fuzzy theory into Kano model in quality elements classification is proposed. In view of the strong subjectivity of traditional Kano questionnaires, a fuzzy Kano questionnaire considering the evaluators' multi-feelings is proposed. Furthermore, this study will also develop a mathematical calculation performance according to the classification of fuzzy Kano model. With this method, the accurate mentality can be fully reasonable reflected in some unknown circumstances. Finally, an empirical study in Xuzhou Construction Machinery Group Co., Ltd, the largest manufacturing industry in China, is showed to testify its feasibility and validity.

***Findings:*** The calculation results and the application effect show that the proposed model has good performance in classifying customer requirements. With this method, the accurate mentality can be fully reasonable reflected in unknown circumstances and it is more objective than traditional Kano model to classify the service quality elements.

***Originality/value:*** This study provides a method to integrate fuzzy theory and Kano model, and develops a framework to classify service quality elements.

***Keywords:*** Kano model, service quality elements classification, fuzzy theory

## 1. Introduction

Customer requirements have become a primary concern for companies in the highly competitive global market. Companies can no longer rely on high-volume and low-cost production to maintain growth or even survive in the market. Instead, they have to put their effort into meeting customer requirements and achieving customer satisfaction to remain competitive advantages in the market. Thus, detecting customers' requirements from customers' perspective, creating and delivering superiority value for customers have been the key points for companies to gain their competitive edges.

Analysis of customer requirements is an important task with focus on the interpretation of the voice of customers and subsequently derivation of explicit requirements that can be understood by marketing managers and engineering practitioners. Various methods and tools have been developed accordingly to help companies obtain a better understanding of customers' requirements, including market surveys, focus groups, individual interviews, creative groups' interviews, complaint analysis, natural field contacts, warranty data and affinity diagrams. Although surveys can commonly collect customer information, they may be affected by earlier experiences. Thus, direct surveys can produce biased responses, and the results may be misinterpreted. The Kano model (Kano, Seraku, Takahashi & Tsuji, 1984) has been proposed to address the limitation on assessing customers' requirements. Kano model has some advantages in customers' requirements classification, which can take into account customer perception preference and consumer motivation, emphasize the non-linear relationship between service quality elements and customer satisfaction. This model corrects for customer experience bias and computes the non-linear impact of service quality elements on customer satisfaction. Using functional and dysfunctional questionnaires and 5×5 evaluation table, Kano model categorizes service quality elements into five catalogs, including must-be, one-dimensional, attractive, indifferent, and reverse elements. Kano categories are combined with products or services performance scores to identify the most sensitive attributes for customer satisfaction to gain the competitive advantage.

Kano's model, as a customer-driven tool, has been widely used for customer requirement analysis in product or service improvement, decision making of product or service development and other management practices (Chen & Huang, 2008; Löfgren & Witell, 2008; Ronald et al, 2014). However Kano model is qualitative analysis method in nature, the classification criteria are not defined explicitly, and it fails to consider the fuzzy and uncertainty of customers' psychological elements. Customer judgments tend to be imprecise and ambiguous due to their linguistic origins, so crisp data are insufficient to capture preferences. With respect to the uncertainty involved, Berger et al. (1993) introduced the possibility of calculating averages for better and worse, these averages indicate whether customer satisfaction can be raised by fulfilling a certain customer requirement (better) or whether fulfilling this customer requirement merely prevents the customer from being dissatisfied (worse). Displaying these indicates in a better-worse diagram has proved to be very useful in providing an overview of the results. Lee and Newcomb (1997) modified the original methodology by classifying five combinations of 25 points as questionable. Yang (2005) extended Kano's model into eight categories by considering the importance of quality elements as defined by customers. Ting Wang and Ji (2010) developed a novel approach to measure and quantify the relationships between customer satisfaction and the fulfillment of customer requirements (S-CR) as depicted in Kano's model. Tontini and Dagostin Picolo (2013) analyzed how the interactions of services' attributes classified by the Kano model, affect customer satisfaction, and they suggested that companies should identify and keep 'must-be' and one-dimensional attributes on an adequate performance level. Only in this way attributes classified as 'attractive' or 'one-dimensional' can bring differentials in the market and have full effect on customer satisfaction. To improve the role of decision support in management, Some literatures discussed the issues of integrating Kano model with other tools and techniques, such as QFD (Tan & Shen, 2000; Ji, Jin, Wang & Chen, 2014), failure modes and effects analysis (FMEA)(Shahin, 2004), TRIZ theory of problem solving (Chen, Liu, Hsu & Lin, 2010) and IPA (Kuo, Chen & Deng, 2012).

Although these analytical proposals have attempted to partially resolve some problems of Kano model, there are always lack of considering the fuzzy and uncertainty of mentality and affection when devising questionnaires. Traditional questionnaires are reflecting the results from a two-valued logic world. To investigate the population, people's opinions or complexity of a subjective event more accurately, it is suggested that we had better use the fuzzy logic. According to the lack of study on the customer psychology in capturing and classifying quality elements, this paper aims to propose an integrative framework that incorporates Kano model and fuzzy theory to classify service quality elements more effectively. Meanwhile, to test the feasibility and validity of the method, an empirical study in Xuzhou Construction Machinery Group Co., Ltd, the largest manufacturing industry in China, is illustrated.

The paper is organized as follows. In the next section, the theoretical background is reviewed briefly. Section 3 introduces the proposed framework. An empirical case study in Xuzhou Construction Machinery Group Co., Ltd. (XCMG), which is one of the largest construction

machinery companies in China, is demonstrated in Section 4 to justify the validity of the method. Conclusions and discussions are summarized in Section 5.

## 2. Theoretical Background

### 2.1. Review of Kano Model

Kano et al. (1984) adapted the "motivation–hygiene theory" of Herzberg (1965) to develop a two-dimensional model, called Kano model, which widely used to classify and prioritize customer requirements of a product or service based on how they affect customer's satisfaction. Kano model illustrates the relationship between customer satisfaction and the performance of a product or a service. Kano model classified quality elements into five quality dimensions, namely, must be, one-dimensional, attractive, indifferent and reverse. In addition, there is a dimension called "questionable" that contains responses that do not make any logical sense.

- Must-be elements: Insufficiency of a must-be element results in extreme non-satisfaction, but basic service performance is enough to satisfy customer requirements. Customers take must-be elements for granted when they are fulfilled, but high element performance does not generate correspondingly high customer satisfaction.

- One-dimensional elements: A linear function relates the service quality element performance and customer satisfaction. The higher the level of fulfillment, the higher the degree of customer satisfaction; the reverse is also true. The customer expects these elements, and thus views them as basics.

- Attractive elements: Fulfillment of attractive elements will lead to greater than proportional satisfaction. However, the absence of these quality elements does not result in dissatisfaction. These elements are usually not expected and are often currently unaware by customers. They can provide a competitive advantage.

- Indifferent elements: This element will not result in satisfaction or not, whether they are sufficient or not. This type of element is simply a service characteristic and not a customer requirement.

- Reverse elements: Non-satisfaction come when reverse elements are sufficient and on the contrary satisfaction come when they are insufficient. A reverse element represents an element that behaves in reverse of the performance quality.

The Kano model employs inquiring techniques with pairs of functional and dysfunctional questions about each requirement; the functional situation considers the element sufficient,

while the dysfunctional situation supposes the element to be insufficient. In a Kano questionnaire, customer is required to choose one of the following responses to express their feelings: (a) I like it; (b) I expect it; (c) I am neutral; (d) I accept it; and (e) I dislike it. The classification is then made using an evaluation table in which service quality elements can be classified into one of five dimensions that exhibit different impacts on customer satisfaction depending on whether customer requirements are fulfilled, as is shown in Table 1. From the evaluation table, Kano model classifies service quality elements into categories that exhibit different impacts on customer satisfaction depending on whether customer requirements are fulfilled. Categories are evaluated and interpreted according to the frequency of answers.

| Service quality elements | | Dysfunctional | | | | |
|---|---|---|---|---|---|---|
| | | Like | Expect | Neutral | Accept | Dislike |
| Functional | Like | Q | A | A | A | O |
| | Expect | R | I | I | I | M |
| | Neutral | R | I | I | I | M |
| | Accept | R | I | I | I | M |
| | Dislike | R | R | R | R | Q |

(Note: A: attractive; O: one-dimensional; M: must-be; I: indifferent; R: reverse; Q: questionable.)

Table 1. Kano evaluation table

## 2.2. Review of Fuzzy Theory

Customer requirements are assessed based on multiple attributes and preferences judgments, where a lot of information is uncertain, and some data cannot be directly translated to numerical values but instead to confidence intervals. The fuzzy Theory formulated by Professor Zadeh (1965) provides a robust way to manage such vague information. To deal with vagueness of human thought, the fuzzy set theory was directed to the rationality of uncertainty through vagueness or unknown circumstance. A major contribution of fuzzy set theory is capability to represent vague data. A fuzzy set is a class of elements with a continuum or discreteness of degrees of membership. Such a set is characterized by a membership function, which takes values in a real interval [0,1]. In contrast to classical sets, where individuals either belong 0 or not belong 1, individuals in fuzzy sets have variable membership degrees between 0 and 1, reflecting the uncertainty.

Traditional mode in statistics means the opinion of majority of population. However, each individual has unclear views on universe of discourse U. As a consequence, it becomes a very important issue to obtain statistic consensus under fuzzy concept. When the item is fuzzy and the factors of universe of discourse can be cataloged into several types, it can use discrete fuzzy mode to obtain the consensus of the issue. Lee and Huang (2009) has addressed the fuzzy mode. The definition of discrete fuzzy mode is as follows:

Let U be the universal set (a discussion domain), K={$k_1$, $k_2$,... $k_m$} be a set of m-linguistic variables on U, and {$FS_i$, i=1, 2,..., n} be a sequence of random fuzzy sample on U. For each sample $FS_i$, assign a linguistic variable $L_j$ a normalized membership $m_{ij}$( $\sum_{j=1}^{m} m_{ij}=1$ ), let $S_j=\sum_{i=1}^{n} m_{ij}$ , j=1,2,…m. Then, the maximum value of $S_j$ (with respect to $K_j$) is called the fuzzy mode (FM) of this sample. The traditional statistic is random sampling, and gain singular numerical data or definite equidistance scale. However, it cannot reflect the ideas of each individual. If the respondents can express the extent of real feeling by utilizing membership and interval numeric out of their feelings, the questionnaire will fully show the mentality of human. Therefore, it is more reasonable to apply fuzzy mode in social science research.

## 3. Methodology

The fuzzy Kano model can assist decision-making in the process of prioritizing the service quality elements according to their impacts on customer satisfaction. The methodology of integration fuzzy theory into Kano model for classification of service quality elements will be illustrate in this section, and the general roadmap is shown in Figure 1.

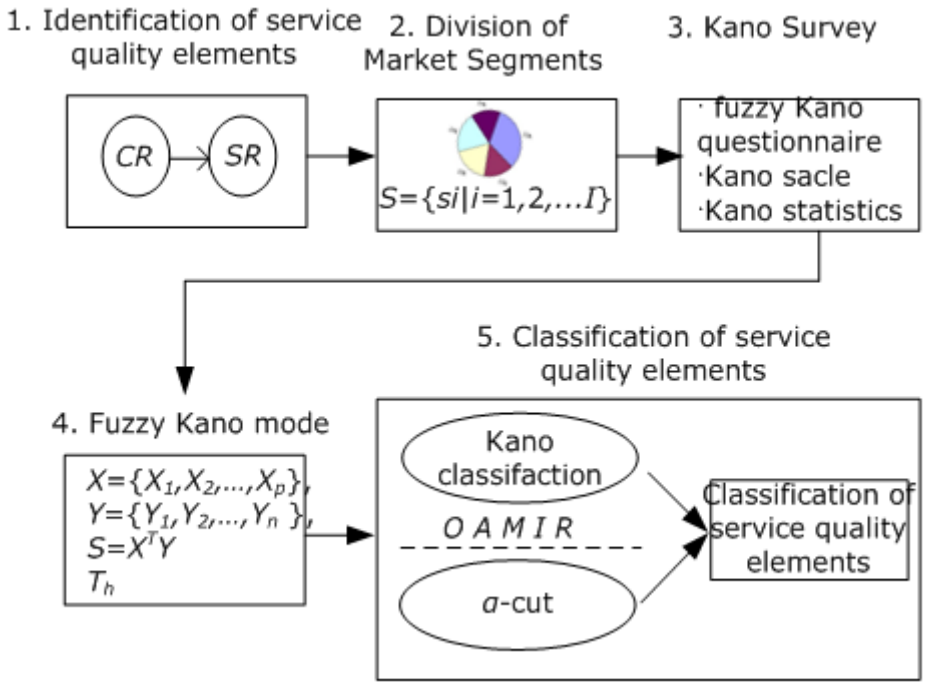


Figure 1. The classification process of service quality elements based on fuzzy Kano model

### 3.1. Identification of Service Quality Elements

The fuzzy Kano model requires the survey results of customers' satisfaction using the fuzzy Kano questionnaire. In general, the questionnaire is designed according to a set of customers' requirements. However, the customers' requirements tend to be imprecise and ambiguous due to their linguistic origins. And hence it is necessary to apply some effective analytical tools for customer requirements analysis accurately. To allow for unambiguous understanding, the customers' requirements (CR) can be translated into a set of service quality elements, i.e. $SR=\{sr_i|i\text{-}1,2,\ldots,I\}$. The distinction between customers' requirements and service quality elements is in line with the domain mapping principle. Essentially, while providing customer perceived diversities in customers' requirements, the product or service producer must seek for an economic scale in product or service fulfillment (Sukwadi & Yang, 2014). Surveys are carried out to collect the customers' evaluation of sri according to the functional and dysfunctional forms of Kano questions. The preliminary category of SR is determined using the Kano evaluation table.

### 3.2. Division of Market Segments

Very few products or services can be all needed to all people; hence, it is important to analyze a market accurately, and then choose the appropriate segment to be the target. Customers can be grouped into different market segments based on their demographic and psychographic information as well as estimates of consumer purchasing power. In this research, we determine the most commonly used metrics include age, gender and income to segment market. If the division of market segments is not evident, it becomes necessary to carry out market investigations to differentiate the customer groups. Many methods and tools are available to assist the process, such as conjoint analysis, perceptual mapping, and data mining. In this research, the classification results of only one market segment are presented for purpose of brevity.

### 3.3. Fuzzy Kano Questionnaires Survey

Fuzzy Kano questionnaires survey is carried out within specific market segments that consist of customers with similar demographic information. With respect to service quality elements, the Kano questionnaires are fabricated and the surveys are conducted to acquire the customers' assessment of the service quality elements according to the functional and dysfunctional forms of questions. However, the Kano model has identified a single category for each attribute, even if fuzzy assessments have been considered. In practice, classifying elements into Kano categories is dynamic and affected by the complex customers' thoughts. And the information

itself is characteristics with some uncertainty and ambiguity. It is necessary for us to integrate the principle of fuzzy theory into traditional Kano model.

Basically, we should design a fuzzy Kano questionnaire to acquire service quality elements. Both traditional Kano questionnaire and fuzzy Kano questionnaire use the form of functional and dysfunctional question to capture the customers' response to a certain product or service element. The largest difference is that traditional Kano questionnaire considering the single answer with ignoring the partial existed feelings from interviewees (see Table 2). Meanwhile, the fuzzy Kano questionnaire makes usage of flexible way to allow customers answer questions with their personalized standards. Therefore, it is more reasonably for customers to express their real ideas in the survey. And the fuzzy Kano questionnaire is shown as Table 3.

| **Service quality elements** | **Like** | **Expect** | **Neutral** | **Accept** | **Dislike** |
|---|---|---|---|---|---|
| **Functional** | √ | | | | |
| **Dysfunctional** | | | | √ | |

Table 2. Traditional Kano questionnaire

| Service quality elements | Like | Expect | Neutral | Accept | Dislike |
|---|---|---|---|---|---|
| Functional | 0.3 | 0.6 | 0.1 | | |
| Dysfunctional | | | | 0.2 | 0.8 |

Table 3. Fuzzy Kano questionnaire

Based on fuzzy Kano questionnaire, we will see a more detailed representation of customers' thoughts about a service quality element. In addition, the evaluation process of service quality elements classification will become robust and consistent by reducing the degree of subjectivity from the evaluator. While the drawback is that the calculating process will be more complex than the traditional one.

### 3.4. Fuzzy Kano Mode

Afterwards, based on relative information of service quality elements obtained above, the fuzzy Kano mode is defined as follows. Let $U$ and $V$ be the universal set of functional and dysfunctional questions, $X=\{X_1,X_2,\ldots,X_p\}$ and $Y=\{Y_1,Y_2,\ldots,Y_n\}$ be the sets of $p$ and $n$ linguistic variables on $U$ and $V$, respectively, which jointly construct a $p\times n$ matrix of two-dimensional quality model, and $\{FS_k,k=1,2,\ldots r\}$ be a sequence of random fuzzy sample on $U$ and $V$. For each sample $FS_k$, assign linguistic variables $X_i$ and $Y_j$ normalized membership $m(X)_{ki}(\sum m(X)_{ki}=1)$ and $m(Y)_{kj}(\sum m(Y)_{kj}=1)$, let $S=X^TY$.

After S being obtained, the classification of service quality elements will be obtained based on Kano evaluation table as shown in Table 1. $T_h$ is the sum of $S_{xy}$ which $(x, y)$ cell belonged to the hth service quality elements in the evaluation sheet.

### 3.5. Classification of Service Quality Elements

Being repeated above-mentioned steps, the classification of service quality elements will be obtained. In order to find more satisfactory and identification, the $a$-cut common consensus standard concept is used to get $\{T_h\}a$. The maximum value of $\{T_h\}a$ is called the fuzzy Kano mode of this quality element and $a$ is a significant classification level. When total service quality element level is larger than $a$, "1" will be represented; otherwise, "0" will be represented.

Finally, the largest identification frequency of service quality element using fuzzy Kano mode is the result agreed by majority. If there are more than two sets of Kano fuzzy quality element classification with the same value Th, then this set of data is called with multi-fuzzy mode. If the final scoring are equal, the greatest impact on the service quality element using the following ordering: M>O>A>I, which suggested by Kano et al. (1984).

Through adjustment of $a$-cut standard, different quality element classifications can be obtained. Different $a$ values lead to different classification results, which in turn influence the design of a product or service. This research adopts a strategy in the empirical study where $a$ changes from 0.1 to 0.7 with an increment of 0.3. A full-factorial adjustment requires 3 runs of adjustment. In each run, the service quality element are classified into different categories.

Based on the analysis above, the classification of service quality elements based on fuzzy Kano model is summarized as the following stepwise representation.

- Step1. Identify service quality elements from customers' functional requirements perspective.
- Step2. Determine the market segments.
- Step3. Design the fuzzy Kano questionnaire to acquire service quality elements.
- Step4. Construct the fuzzy Kano mode.
- Step5. Classify service quality elements by fuzzy Kano model.

## 4. The Case Study

To demonstrate the feasibility and validity of the method of fuzzy Kano model, an empirical study in Xuzhou Construction Machinery Group Co., Ltd. (XCMG) is given in this section. XCMG is the largest manufacturing industries in China, which has also been chosen as one of the premier groups of the selected 120 National Enterprises in China. Its products cover road building machinery, compaction machinery, loading machinery and cranes which include 75 series and 330 varieties. The scale of its production and market share of its primary products is the No.1 in China. Its market and service network spread all over China with 31 offices, 8

regional fittings logistics centers and more the 200 distributors and dedicated service stations. With the scale enlargement of products and markets, XCMG feels the larger and larger tension on its service quality improvement to gain competitive advantage.

The fuzzy Kano questionnaire used in this survey is shown in Table 3, including both the functional and dysfunctional forms. The questionnaire focuses on a set of 12 items of service quality elements, and the form of each item presented is shown in Table 4. A total of 250 customers from XCMG constituted the Kano survey respondent set. Each customer was required to answer the fuzzy Kano questions of each service quality element. The questionnaire is distributed in the way of face-to-face. From July 10 to September 15, 2013, 250 copies have been issued and 196 copies of effective retrieved, and the effective response rate is 78.4%.

| Service quality elements | Description of service elements | Benefits provided for customers |
|---|---|---|
| *f*1 | Fulfill service commitments | Reliability, Safety |
| *f*2 | Quick response to service requirements and complaints | Speediness |
| *f*3 | Personalized solutions | Added value |
| *f*4 | Wide maintenance service | Reliability, Safety |
| *f*5 | Monitor vehicle state | Safety |
| *f*6 | Value-added services | Added value |
| *f*7 | Network and online services | Convenience |
| *f*8 | Resale business | Convenience |
| *f*9 | High quality staffs | Pleasure |
| *f*10 | Delay compensation | Reliability, Safety |
| *f*11 | Active services regularly | Convenience |
| *f*12 | Customer participation | Added value |

Table 4. Service quality elements in XCMG

In this paper, the respondents were divided into three groups based on their age, gender, and income levels. And the three market segments are shown in Table 5. Based on the market segments, XCMG identifies its target customers, and finally selects market segment 2 as the focused market. Of course, the other market segments can be carried out following the sample procedures.

| Market segment | Age | Gender | Income($10^4$¥/year) |
|---|---|---|---|
| Segment 1 | 46+ | M/F | 12 |
| Segment 2 | 31-45 | M/F | 6-11.9 |
| Segment 3 | 21-30 | M/F | 3-5.9 |

Table 5. Customer groups in the survey

Based on the service quality elements extracted from customers' questionnaires perspective, the fuzzy Kano model will be used to illustrate the classification of service quality elements in XCMG.

The effective samples of 196 copies means the fuzzy sample FS={1,2,…196}. According to the Kao model, the service quality elements can be classified into six categories, namely, must be,

one-dimensional, attractive, indifferent, reverse and questionable service quality elements. Being repeated the above-mentioned steps in section 3, different classifications of service quality elements under different α-cut standards can be obtained. As is shown from Table 6 to Table 8.

| Service quality elements | M | A | I | O | R | Q | Classification |
|---|---|---|---|---|---|---|---|
| $f_1$ | 111 | 45 | 21 | 59 | 0 | 0 | M |
| $f_2$ | 108 | 51 | 24 | 58 | 0 | 0 | M |
| $f_3$ | 55 | 47 | 29 | 103 | 0 | 0 | O |
| $f_4$ | 102 | 66 | 20 | 48 | 0 | 0 | M |
| $f_5$ | 54 | 101 | 33 | 57 | 0 | 0 | A |
| $f_6$ | 62 | 103 | 24 | 54 | 0 | 0 | A |
| $f_7$ | 104 | 61 | 29 | 45 | 0 | 0 | M |
| $f_8$ | 36 | 53 | 23 | 109 | 0 | 0 | O |
| $f_9$ | 63 | 54 | 33 | 105 | 0 | 0 | O |
| $f_{10}$ | 106 | 58 | 18 | 56 | 0 | 0 | M |
| $f_{11}$ | 53 | 70 | 29 | 96 | 0 | 0 | O |
| $f_{12}$ | 65 | 56 | 86 | 28 | 0 | 0 | I |

Table 6. Classification of service quality elements when α=0.1

| Service quality elements | M | A | I | O | R | Q | Classification |
|---|---|---|---|---|---|---|---|
| $f_1$ | 106 | 38 | 18 | 44 | 0 | 0 | M |
| $f_2$ | 98 | 42 | 20 | 51 | 0 | 0 | M |
| $f_3$ | 51 | 43 | 25 | 99 | 0 | 0 | O |
| $f_4$ | 95 | 56 | 15 | 37 | 0 | 0 | M |
| $f_5$ | 46 | 88 | 27 | 53 | 0 | 0 | A |
| $f_6$ | 49 | 92 | 18 | 48 | 0 | 0 | A |
| $f_7$ | 95 | 52 | 24 | 38 | 0 | 0 | M |
| $f_8$ | 34 | 38 | 19 | 107 | 0 | 0 | O |
| $f_9$ | 39 | 46 | 24 | 110 | 0 | 0 | O |
| $f_{10}$ | 84 | 56 | 13 | 47 | 0 | 0 | M |
| $f_{11}$ | 43 | 64 | 25 | 86 | 0 | 0 | O |
| $f_{12}$ | 56 | 48 | 78 | 22 | 0 | 0 | I |

Table 7. Classification of service quality elements when α=0.4

| Service quality elements | M | A | I | O | R | Q | Classification |
|---|---|---|---|---|---|---|---|
| f1 | 100 | 34 | 14 | 39 | 0 | 0 | M |
| f2 | 96 | 39 | 16 | 45 | 0 | 0 | M |
| f3 | 46 | 38 | 21 | 92 | 0 | 0 | O |
| f4 | 90 | 52 | 12 | 31 | 0 | 0 | M |
| f5 | 40 | 83 | 21 | 46 | 0 | 0 | A |
| f6 | 43 | 84 | 14 | 45 | 0 | 0 | A |
| f7 | 89 | 48 | 18 | 33 | 0 | 0 | M |
| f8 | 40 | 46 | 15 | 85 | 0 | 0 | O |
| f9 | 47 | 41 | 19 | 91 | 0 | 0 | O |
| f10 | 78 | 53 | 10 | 39 | 0 | 0 | M |
| f11 | 38 | 59 | 22 | 78 | 0 | 0 | O |
| f12 | 52 | 44 | 74 | 19 | 0 | 0 | I |

Table 8. Classification of service quality elements when α=0.7

According to the classification results from Table 6 to Table 8, it is found that over large $\alpha$-cut will be easy to cause the issue of less samples of inference population. On the other hand, when $\alpha$-cut is over small, lower sample subordination and over happy threshold will be formed. Therefore, based on the comparison results and the managerial experience, we take the value of $\alpha$ as 0.4 in the empirical study.

In order to confer the difference of traditional Kano model and fuzzy Kano model, the results in XCMG is shown in Table 9. It is found that when interviewees' ideas appeared multi-feelings, traditional Kano questionnaires with single answer will lead to the ignorance of partial existed feelings. Fuzzy Kano questionnaire enables interviewees to present ideas more completely, even with little different feelings or perceptions. Therefore, Fuzzy Kano model are more objective than traditional Kano model to classify service quality elements. What's more, traditional Kano model is convenient to calculate but it is too simple. Take f8 as an example, the service quality element of traditional Kano model is "attractive", only 85 agreed (43%=85/96). However, making usage of fuzzy Kano model with $\alpha$=0.4, the largest service quality element classification is "one-dimensional" and 107 agreed (55%=107/196). Therefore, with $\alpha$=0.4, results will be agreed by the majority. According to the comparison results, it is known that classification of service quality elements of $f_8$ (Resale business), $f_9$ (High quality staffs) and $f_{10}$ (Delay compensation) are different between traditional Kano model and fuzzy Kano model.

| Service quality elements | Traditional Kano model | | | | | Fuzzy Kano model α=0.4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | M | A | I | O | Classification | M | A | I | O | Classification |
| $f_1$ | 88 | 32 | 25 | 51 | M | 106 | 38 | 18 | 44 | M |
| $f_2$ | 78 | 45 | 23 | 50 | M | 98 | 42 | 20 | 51 | M |
| $f_3$ | 45 | 38 | 20 | 93 | O | 51 | 43 | 25 | 99 | O |
| $f_4$ | 89 | 51 | 11 | 45 | M | 95 | 56 | 15 | 37 | M |
| $f_5$ | 40 | 82 | 24 | 50 | A | 46 | 88 | 27 | 53 | A |
| $f_6$ | 45 | 90 | 16 | 45 | A | 49 | 92 | 18 | 48 | A |
| $f_7$ | 84 | 39 | 26 | 47 | M | 95 | 52 | 24 | 38 | M |
| $f_8$ | 39 | 85 | 21 | 51 | A | 34 | 38 | 19 | 107 | O |
| $f_9$ | 49 | 90 | 19 | 38 | A | 39 | 46 | 24 | 110 | O |
| $f_{10}$ | 51 | 80 | 15 | 50 | A | 84 | 56 | 13 | 47 | M |
| $f_{11}$ | 38 | 59 | 19 | 80 | O | 43 | 64 | 25 | 86 | O |
| $f_{12}$ | 55 | 47 | 73 | 21 | I | 56 | 48 | 78 | 22 | I |

Table 9. Comparison of classification results of service quality elements

## 5. Conclusion and Discussions

Service quality has become a critical issue on which enterprises to gain competitive advantages, especially for machinery industries transforming into the product-service system providers. And more importantly, service quality is crucial to gain customer satisfaction and then customer loyalty. By analyzing the nonlinear relationship between customer satisfaction

and performance of a product or service, Kano model can obtain the classification of service quality elements. However, the questionnaires and classification evaluation table conducted by Kano model are criticized. This paper provides an integrated framework to classify service quality elements based on fuzzy theory and Kano model and the main contributions are as follows:

- Since traditional Kano model is deficient in processing human vagueness and uncertainties, the concept of fuzzy set theory is incorporated into Kano model to accommodate linguistic properties of subjective and vague human perception. And a mathematical calculation performance is developed according to fuzzy Kano model.

- An integrated framework of fuzzy theory and Kano model is set up in service quality elements, which involves some sub-process: identification of service quality elements from customers' requirements perspective, division of market segmentation, fuzzy Kano survey, fuzzy Kano model developing and service quality elements classification.

- The empirical study results in XCMG showed that with the fuzzy Kano model, the quality elements classification can be more objective and fully reasonable reflected customers' multi-feelings of consuming motivation in unknown circumstances.

Nevertheless, it is noted in this paper that some limitations are listed below, which are worth highlighting for the improvement of the existing approach. First, the timer interval for obtaining the data is too short, which may affect the classification results. Second, this study does not consider customer's actual perception importance level, which is significant to the decision of improving service quality. These shortcomings will be further studied in the future. Finally, in the empirical research, the perception of diversities in service quality elements classification based on deferent customer segments are not considered, which may be significant to decision-making for the enterprises with different customer orientation. Future work can be done more specifically and clearly.

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