

Research on the Evaluation of Customer requirement Importance of Smart Products Based on Online Comments and Improved Quantitative Kano Model

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Abstract

With the development and popularization of smart products, the technological differences of products are decreasing, and the phenomenon of product homogeneity is becoming more and more obvious. It is necessary for the smart product manufacturing firms have the capability to analyze customer requirement deeply and adapt to the dynamically changing market quickly. Therefore, the traditional technology-oriented product development model is no longer suitable for manufacturers to obtain a competitive advantage. Based on this, this paper proposed a method to evaluate the importance of customer demands based on online comments and quantitative Kano model. First, the Python crawler tool is used to obtain online customer reviews of relevant products and the word segmentation processing is performed to obtain the product features and frequency that customers are mainly concerned about, and then the initial importance of demand can be calculated. Furthermore, use the quantitative Kano model to determine the customer satisfaction and revise the initial importance of the requirements to obtain a more reasonable ranking of the importance of user needs. Finally, a case study is carried out with the smart bracelet as an example to verify the effectiveness and feasibility of the model proposed in this paper.

Keywords: *online comments, improved quantitative Kano model, requirement importance*

I. Introduction

Traditional product development is technology-oriented [1]. With the development and popularization of smart products, the technological differences of products are decreasing, and the phenomenon of homogeneity is becoming more and more obvious. In-depth understanding and analysis of the individual needs of users, and quickly adapting to the dynamic market have become a key path for modern manufacturing companies, especially smart product manufacturers, to gain competitive advantage. Therefore, accurate customer demand analysis has become more important in the product development process, and has become a core factor to enhance the company's core competitiveness [2, 3]. Customer demand analysis, usually conducted at the early stage of product development, is the basis of the future detailed design and a crucial step to determine whether the product can have an excellent performance in the future market or not. Based on the demand-oriented design concept, this paper proposes a method for determining the importance of customer demand that uses the quantitative Kano model to modify the initial importance of demand.

Domestic and foreign scholars have conducted certain researches on the field of determining the importance of customer requirements [4-7], such as network analysis, Kano model, rough set and information entropy processing. Zhu and Yang [8] proposed the DEMATEL method and entropy to deal with the autocorrelation and market competitiveness of customer needs, and combined the results of these two aspects to get the final importance ranking. Liu and Wang et al [9] used the combination method of AHP and fuzzy comprehensive evaluation to construct analysis models of different demand elements, and quantified customer requirements through ranking scale. Geng and Qiu [10] combined hesitating fuzzy sets and decision-making experiments with evaluation experiments to analyze customer requirements, and proposed an improved A-Kano model to modify the customer requirements. Ji [11] analyzed the relationship between customer needs and satisfaction, quantitatively integrated the Kano model with QFD, and formulated a mixed nonlinear integer programming model.

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Summarizing the existing literature review, it can be found that in the customer requirements acquisition and identification stage, most of the literatures [12-14] use Fuzzy Comprehensive Evaluation, Analytic Hierarchy Process and other expert scoring methods, which are highly subjective and lack the Voice of Customer. Therefore, based on the customer-centered concept, this article obtains the real needs of users through direct acquisition and analysis of online customer comments, ensuring the accuracy and reliability of the data.

The framework is shown in Figure 1 below. After collecting and identifying customer requirements, the initial importance of customer requirements can be calculated. Then, quantifying the demands classification of Kano model, and customer satisfaction can be calculated by using the processed model. Finally, comparing and revising it with the initial importance, the final importance ranking can then be obtained.

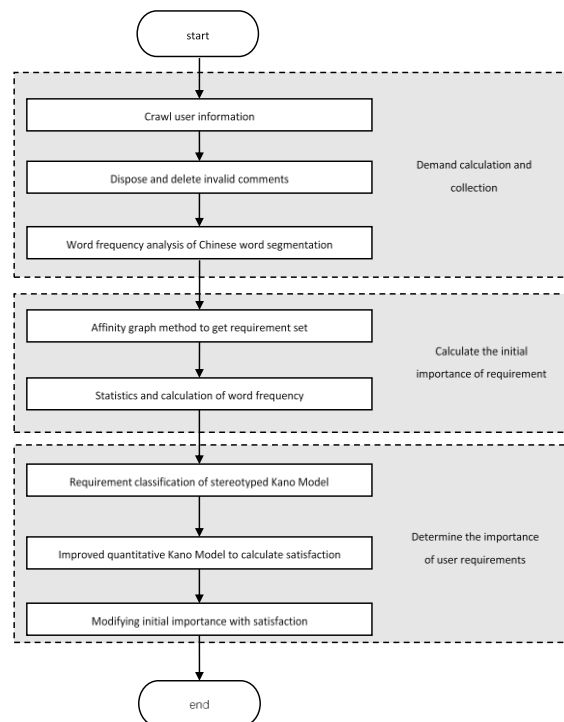


Figure1. The framework

II. Customer Requirements Collection and Initial Importance Identification

Traditional customer requirements acquisition methods mainly include questionnaire surveys and user interviews, which have obvious disadvantages such as high research costs and difficulty in obtaining sufficient samples. In order to ensure the objectivity and diversity of the data, this article uses Python crawler tools to crawl customer comments data of related smart products from the e-commerce platform. Through analyzing and processing of the comment data, the characteristics of smart products that customers concern can be obtained directly. These characteristics will be transformed into customer requirements in next step.

When collecting customer requirements, the first step is to de-duplicate the data obtained with Python, and use the word frequency analysis method to obtain the needs concerned by customers [14]. Some words such as "not bad", "ok" and "good" can often be seen in product reviews. These words can be used to describe various types of products, rather than a specific characteristic of a certain product. These words make it difficult to identify specific user needs accurately. Therefore, the word frequency analysis needs to be filtered. The specific words that can reflect customer demands are selected after filtering out some common fuzzy expression, and then a word map can be drawn to calculate the frequency.

The high-frequency vocabulary selected based on the results of word frequency analysis is fuzzy, which cannot be used in product design directly. For example, the high-frequency description of the size requirement is "long", "very short", "too wide", etc. These words need to be further abstracted and turned into the length characteristic of "size", which can indicate whether it is suitable for carrying.

This paper uses KJ method to summarize and organize high-frequency words. The main steps includes: (1) determine the theme; (2) collect the corpus; (3) cardize the corpus; (4) group the cards; (5) collect the cards; (6) make the cards; (7) arrange the cards; (8)) Complete the KJ map. The specific operation will be carried out in the case study.

Through the observation of real customer reviews, it can be found that the more frequently a certain demand characteristic appears, the demand is more concerned by customers. In other words, the demand frequency can intuitively express the importance of the relative demand characteristic. Therefore, this paper calculates the initial importance of customer requirements according to the frequency of each demand.

The customer demand set obtained through the KJ method is recorded as $C = \{c_1, c_2, c_3, \dots, c_n\}$, the demand frequency set is recorded as $CV = \{cv_1, cv_2, cv_3, \dots, cv_n\}$. Set the initial importance of the demand as cp^α , then the frequency of the requirement characteristic C_i can be calculated as:

$$cp_i^\alpha = \frac{cv_i}{\sum_{i=1}^n cv_i} (3)$$

After acquiring the frequency of each demand characteristic, the initial customer requirement importance set can be obtained as:

$$CP^\alpha = \{cp_1^\alpha, cp_2^\alpha, cp_3^\alpha, \dots, cp_n^\alpha\} (4)$$

III. Modification of the Initial Importance of Customer Requirements

3.1 Improved Quantitative Kano Model

The Kano model is a well-known model in the research field of customer requirements analysis and product design. For a certain customer demand or the corresponding quality attribute C_i , use A, O, M, I and R to represent charm requirements, expectation requirements, basic requirements, indifference requirements and opposite requirements respectively, and Q represents invalid answers.

Collect the survey results of all customers, summarize for a certain fixed requirements, record its frequency, use V_A , V_O , V_M , V_I , V_R to represent the frequency of charm requirements, expectation requirements, basic requirements, indifference requirements and opposite requirements respectively. V_Q represents the frequency of invalid answers, let the total frequency be V :

$$V = V_A + V_O + V_M + V_R + V_I + V_Q (1)$$

Kano classification is the requirements classification corresponding to the maximum frequency, denoted as MC:

$$MC = \max(V_A + V_Q + V_O + V_M + V_R + V_I) (2)$$

Table 1.Requirement Classification Table

Requirement	A	M	O	R	Q	I	Total	Kano Classification
C_1	V_A^1	V_M^1	V_O^1	V_R^1	V_Q^1	V_I^1	V^1	MC^1
....								
C_i	V_A^1	V_M^1	V_O^1	V_R^1	V_Q^1	V_I^1	V^i	MC^i

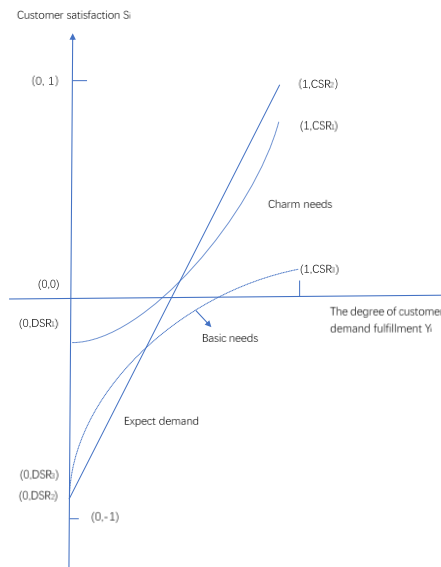


Figure 2. Improved quantitative Kano model

The current quantitative Kano model [6] is shown in Figure 2. The expressions of the three curves are shown in formula (5):

$$S_i = \begin{cases} \frac{CSR_i - DSR_i}{e-1} e^{y_i} - \frac{CSR_i - eDSR_i}{e-1}, & \text{Charm needs} \\ (CSR_i - DSR_i) y_i + DSR_i, & \text{Expect demand} \\ -\frac{e(CSR_i - DSR_i)}{e-1} e^{-y_i} + \frac{eCSR_i - DSR_i}{e-1}, & \text{Basic needs} \end{cases} \quad (5)$$

The quantitative Kano model in Figure 2 has two important parameters: the customer satisfaction index CSR , and the customer dissatisfaction index DSR . This parameter can be calculated by the formula (6) and (7).

$$CSR_i = \frac{V_A^i + V_O^i}{V_A^i + V_O^i + V_M^i + V_I^i} \quad (6)$$

$$DSR_i = \frac{-(V_O^i + V_M^i)}{V_A^i + V_O^i + V_M^i + V_I^i} \quad (7)$$

The quantitative Kano model is the quantitative expression of the traditional Kano model, which should not change the demand classification and characteristics. However, the current quantitative Kano model has the following shortcomings:

(1) The traditional Kano model describes the demand for charm requirement as: the presence or absence of this demand will not reduce customer satisfaction. Combining the quantitative model curve and equation (5), the charm demand curve crosses the point $(0, DSR_i)$, and according to equation (6), $DSR_i < 0$. The point $(0, DSR_i)$ represents that the user's dissatisfaction is negative when the objective performance of the product is zero, which contradicts the concept of charm requirement.

(2) The traditional Kano model describes the basic requirement as: the requirement should be realized, but the degree of customer satisfaction will not change with the realization of the requirement. However, according to Figure 2 and equation (5), the curve of basic requirement passes the point $(1, CSR_i)$, which means that when the objective performance of the product is fully satisfied, the customer's satisfaction is CSR_i . In accordance with equation (6), CSR_i is greater than 0, which does not match the concept of basic requirement.

Based on the above analysis, the current quantitative Kano model should be revised to make it consistent with the demand planning. Let A, O, and M respectively represent the set of charm requirement, expectation requirement and basic requirement, the mathematical expression of customer satisfaction is as follows:

$$s_i = \begin{cases} \ln((1 - e^{DSR_i})y_i + e^{DSR_i}), & \text{If } i \in M \\ (CSR_i - DSR_i)y_i + DSR_i, & \text{If } i \in O \\ \frac{CSR_i}{e-1}e^{y_i} - \frac{CSR_i}{e-1}, & \text{If } i \in A \end{cases} \quad (8)$$

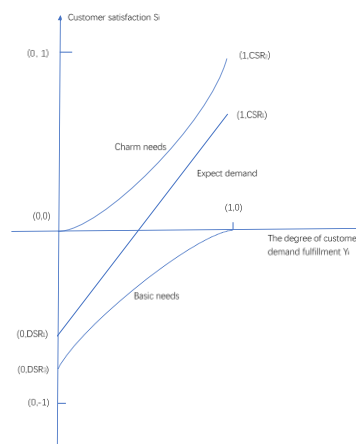


Figure 3. The quantitative Kano model is improved

From the above figure 3, it is clear that the customer satisfaction will not show negative when the charm demand cannot be met, the user satisfaction index will not be positive when all the basic requirements are fulfilled.

3.2 Modification of initial importance of requirements

Through the improved Kano model, all requirements are represented by a mathematical model to quantify the impact of different types of demands on customer satisfaction. The ranking of initial importance of users can then be revised according to the degree of customer satisfaction.

The initial importance of requirements should follow the principle that customer satisfaction is inversely proportional to the importance of product improvement demands. Higher the customer satisfaction means less improvement is needed. Therefore, the higher the customer satisfaction, the lower the importance of product improvement demands.

Set the customer satisfaction of a certain product requirement is $CS = \{s_1, s_2, \dots, s_n\}$. The modified importance degree set of demand is denoted as $CP^\beta = \{cp_1^\beta, cp_2^\beta, \dots, cp_n^\beta\}$. According to Equation (3), the initial importance degree and satisfaction degree of customer demand are both valued as (0, 1). In accordance with the above principle and the basic properties of power function, CP^β can be calculated by Equation (7).

$$cp_i^\beta = \frac{(cp_i^\alpha)^{s_i}}{\sum_{i=1}^n (cp_i^\alpha)^{s_i}} \quad (9)$$

Where s_i is the user satisfaction, according to $y = a^x$, when $a \in (0,1)$, y and x are inversely proportional.

IV. Case Study

This paper takes the smart bracelet as an example. In order to make the products comparable, the following constraint conditions are set when selecting the relevant products: similar price, well-known brands and multi-functional. Based on the above conditions, three smart bracelets were selected: Huawei Band 4, Xiaomi Band 6, and Joy Band 5s, which are respectively denoted as Z_1 , Z_2 , Z_3 .

4.1 collection and identification of customer requirements

A total of 29,937 customer comment records were crawled by using Pycharm. After extracting the evaluation information, the text should be processed to eliminate duplicate and invalid evaluations to ensure the validity of the information. Word segmentation is performed on the comment information, word frequency is counted, and customer requirements are extracted. This step is processed with a word cloud generation tool.

The top 100 vocabularies is extracted by the word cloud generation tool and a word cloud diagram can then be obtained as shown in Figure 4. According to the principle of word cloud image generation, the more frequently a word appears, the more prominent the display specification. The main concerns of customers can be seen intuitively.



Figure 4. User evaluation word cloud chart

4.2 Customer requirement identification

When users comment on a certain product, they rarely put forward professional words and cannot be directly used

as the user's demand characteristics [15]. Therefore, the KJ method is conducted to collect and organize the frequent vocabulary. For example, words such as "heart rate", "exercise", "steps", "blood oxygen", "powerful function", "alarm clock", "fitness", "running" can all be attributed to the functional characteristics KJ card, as shown in Figure 5.

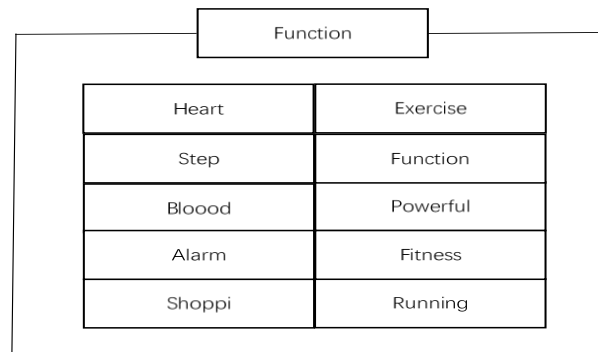


Figure 5. User requirements for "functional" affinity cards

By using the KJ graph to sort out the high-frequency vocabulary, six customer requirements: function(C_1), appearance(C_2), comfort of wearable(C_3), cost performance(C_4), time of endurance(C_5), and packaging(C_6). The KJ diagram of customer requirements can be acquired when putting all the KJ cards together. The result is shown in Figure 6 below.

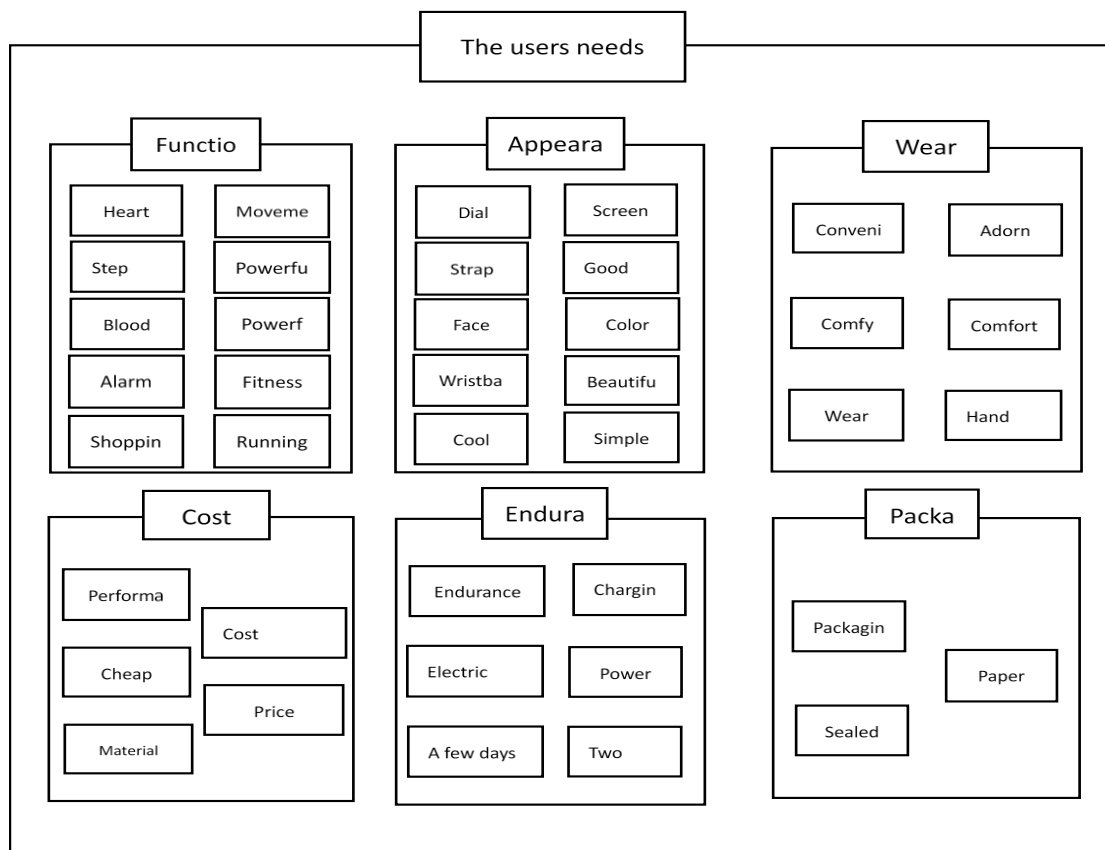


Figure 6. User Requirement Affinity Diagram

4.3 Calculation of initial requirement importance

Through the process of demand identification, the customer requirement set $C = \{C_1, C_2, C_3, C_4, C_5, C_6\}$ is obtained, and the frequency set of customer demand is recorded as $CV = \{cv_1, cv_2, cv_3, cv_4, cv_5, cv_6\}$, the frequency of each demand needs to be calculated. The customer demand frequency set is $CV = \{14828, 11907, 6408, 4097, 5707, 2905\}$, and the total frequency is 45852 times. According to formula (3), the initial value of the importance of each demand characteristic can be calculated. Taking C_1 as an example:

$$cp_1^\alpha = \frac{cf_1}{\sum_{i=1}^6 cf_i} = \frac{14828}{45852} = 0.3234$$

Similarly, the initial importance of each requirement can be obtained, and the initial importance set is:

$$CP^\alpha = \{0.3234, 0.2597, 0.1398, 0.0894, 0.1245, 0.0634\}$$

4.4 Modification of importance of customer requirement

A Kano questionnaire was designed for the six identified customer needs. The smart bracelet users were surveyed to obtain the attributes of each need.

Table 2. Kano classification of customer requirement

Requirement	A	O	M	I	Total	Kano category
C_1	14	58	29	8	109	O
C_2	57	28	19	5	109	A
C_3	18	26	58	7	109	M
C_4	16	62	26	5	109	O
C_5	28	60	14	7	109	O
C_6	58	30	11	10	109	A

The questionnaire is distributed to customers who are using or have used smart bracelets. A total of 650 paper questionnaires were issued and 620 questionnaires were returned. After removing invalid questionnaires and questionnaires, there were 609 valid questionnaires, with an effective rate of 93%.

Through the statistical analysis of the results of the questionnaire, the classification of user needs is obtained and summarized in table 2. According to these data, function, cost performance, time of endurance are expected requirements O, comfort of wearable is basic requirements A, appearance requirements, and packaging requirements are glamour requirements M.

4.5 Calculation of customer satisfaction

The customer satisfaction index CSR_i and customer dissatisfaction index DSR_i can be obtained by formulas (6) and (7).

$$CSR_i = \frac{V_A^i + V_O^i}{V_A^i + V_O^i + V_M^i + V_I^i} = \frac{14 + 58}{109} = 0.66$$

$$DSR_i = \frac{-(V_O^i + V_M^i)}{V_A^i + V_O^i + V_M^i + V_I^i} = \frac{-(58 + 29)}{109} = -0.80$$

Because the requirement C_1 is the expected demand O, according to formula (5), the values of CSI_i and DSI_i are substituted, so there is a satisfaction expression for C_1 :

$$s_1 = (CSR_i - DSR_i)y_1 + DSR_i = 1.46y_1 - 0.8 \quad (10)$$

Table 3. Customer satisfaction of S_1

Requirement	Kano Category	CSR	DSR	Expression	y_i	s_i
C_1	O	0.66	-0.80	$1.46y_1 - 0.8$	0.74	0.28
C_2	A	0.77	-0.43	$0.44e^{y_2} - 0.44$	0.67	0.42
C_3	M	0.41	-0.77	$\ln(0.54y_3 - 0.46)$	0.65	-0.2
C_4	O	0.71	-0.81	$1.52y_4 - 0.81$	0.72	0.28
C_5	O	0.81	-0.69	$1.50y_5 - 0.69$	0.69	0.35
C_6	A	0.81	-0.38	$0.48e^{y_2} - 0.48$	0.71	0.50

Where y_1 represents the objective performance of the product. In Kano classification, C_1 is considered to be an expected demand, but there are still 29 results that classified C_1 as a basic demand, which cannot be ignored. According to the nature of Kano model, even if the meet of basic demand has little impact on customer satisfaction. Therefore, when the degree of demand realization is 1, customer satisfaction may not be equal to 1, and the same as other demand classifications. after statistical calculation, the quality level of C_1 is 0.74. Substituting into equation (10), it can be obtained that customer satisfaction is 0.28. In the same way, the other results can be obtained, as shown in Table 3.

Taking C_1 as an example to modify the initial importance set by using formula (9) and the result in Table 3. The result is:

$$cp_1^\beta = \frac{(cp_1^\alpha)^{s_1}}{\sum_{i=1}^6 (cp_i^\alpha)^{s_i}} = \frac{0.3234^{0.28}}{4.0215} = 0.1813$$

Using the data in Table 3 to modify the importance of other requirements, the new importance set is obtained as follows:

$$CP^\beta = \{0.1813, 0.1411, 0.3686, 0.1265, 0.1199, 0.0626\}$$

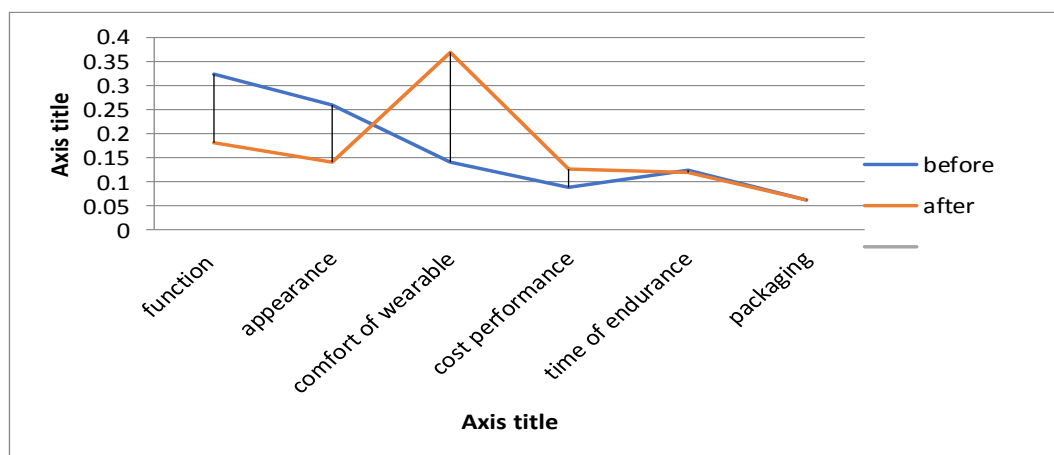


Figure 7. Comparison before and after the revision of user demand importance

The figure 7 illustrates that after using the modified quantitative Kano model, the importance of the basic needs "comfortofwearable" has changed from the third to the first. Therefore, if the manufacturers just rely on the initial importance of requirements, the importanceof the basic requirement of"comfortofwearable" will be ignored. The result shows the modification is necessary.

V. Conclusion

With the advances of information technologies, many computer-based systems have been developed and employed to improve product design quality. In recent years, manufacturers are moving towards strategies to take the customers part in the design process. To address the problem mention above, this paper studies a method for evaluating the importance of customer requirements for smart products. The Python crawler tools and word frequency analysis methods are applied to obtain more objective customer demands from online comment data. Besides, the improved quantitative Kano model is developed to calculate the final importance index of customer requirements.

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