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Profit Distribution Method for Innovative Customer Based on Linguistic Consistency

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Abstract

Rewarding the innovative customers in collaborative innovation can increase the initiative of customer involvement and improve the performance of product innovation. Therefore, a method of customer profit distribution based on contribution degree was proposed. Firstly, customer contribution evaluation index system was established from knowledge perspective. Secondly, customer contribution evaluation method based on group linguistic consistency was put forward to determine the contribution degree, and customer profit was distributed according to the contribution degree. Two-tuple linguistic consistency was used to integrate the multi-attribute evaluation information. Finally, the feasibility and effectiveness of the proposed method was verified.

Keywords*: innovative customer; contribution degree; profit distribution; two-tuple linguistic consistency.*

1. Introduction

Customer Collaborative Product Innovation (CCPI) is a new way of collaborative innovation. It can effectively meet the individual needs of customers and improve the competitiveness of enterprises. Customer's knowledge and creativity are regarded as the most valuable resource for innovation [1]. Customer contribution, the efforts made by customer, has a significant influence on product innovation performance. Meanwhile, customers not only want to meet their requirements by using innovative product, but also expect to get economic returns for their creative work [2]. In this way, customers are willing to make more efforts on product innovation. Therefore, customer contribution in product innovation needs be reasonably evaluated and economic incentive should be given according to their contribution. It can improve the engagement enthusiasm and stability of innovative customer, and has a positive impact on improving innovation performance.

Recently, many research achievements have been gotten on CCPI, including the identification of innovative customer, organization structure of customer collaborative innovation, conflict resolution and the improvement of innovation efficiency. For example, based on complex networks theory, F. Li established an undirected weighted network model of customer collaborative proudct innovation, and proposed an important degree evaluation method for innovative customer to identify important customer [3]. Y. Yang analyzed the features of innovative agent, put forward the measure method of interactive function metric between creative agents. On this basis, Y. Yang built organization coordination efficiency model and applied an improved colonel agent self-learning algorithm to simulate the model[4]. Q. S. Xing classified the attribute

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characteristics of design agent, defined the task attribute, and constructed efficiency model with the aim of the shortest duration to improve the efficiency of product collaborative design[5]. However, these studies did not consider the incentive mechanism for innovative customer. There are some studies on customer contribution, but they mainly focused on the areas of finance and electric power. For example, J. Mazumdar used artificial neural network to predict customer's contribution in power system [6]. P. Zou analyzed customer historical data by data mining technique, concluded the classification rules between customer property features and customer's profit contribution based on classification decision-tree, and established customer profit contribution evaluation model [7]; W. He analyzed customer contribution based on curve fitting and least square method, considering the income customer bring to enterprise and the enterprise investment, established a customer prospective profit calculation model [8]. In these literatures, customer was regarded as a user or purchaser of product/service from the perspective of Customer Relationship Management (CRM), his or her contributions were evaluated by the impacts of his or her consumption or investment behavior on enterprise business performance. Our research considers this question: taking customer as a participant in product design and collaborative innovation, how to evaluate the customer contribution and establish the customer incentive mechanism.

Motivated by the above observations, an innovative customer profit distribution method in collaborative innovation is proposed. Combined with the process of CCPI, from the perspective of knowledge creation, innovative customer contribution evaluation index system is constructed. Then, innovative customer profit distribution method based on Contribution Degree (CD) is proposed. In which, the importance of index is evaluated by triangular fuzzy numbers, and multi-attribute and multi-granularity evaluation information is integrated based on Two-tuple Linguistic Consistency (TLC). The profits are distributed according to the size of CD. Finally, a case is used to illustrate the proposed method.

2. Innovative Customer Contribution Evaluation Index System

Being different from customized design, CCPI not only emphasizes on acquiring customer personalized need, but pays more attention to using knowledge, experiences and innovation skills of lead users [9]. So, in the process of CCPI, innovative customers provide their own demand information and innovation programs, but communicate with professional designers timely and effectively as well [10]. They share their valuable innovation knowledge, experiences and innovation technologies that acquired by using and improving products. In this way, the innovative customers make up for the lack of professional designers in terms of product using knowledge and creativity, so that stimulate organization creativity and prompt innovation team to develop highly innovative and market-driven product. The innovative customers apply and share knowledge, and the most important is knowledge creation. CCPI is a process of knowledge share and knowledge creation essentially. Thus, on the basis of literature research and case study [1-3,9-14], combined with the characteristics of knowledge creation and the process of CCPI, innovative customer contribution evaluation index system is established, as shown in Figure 1.

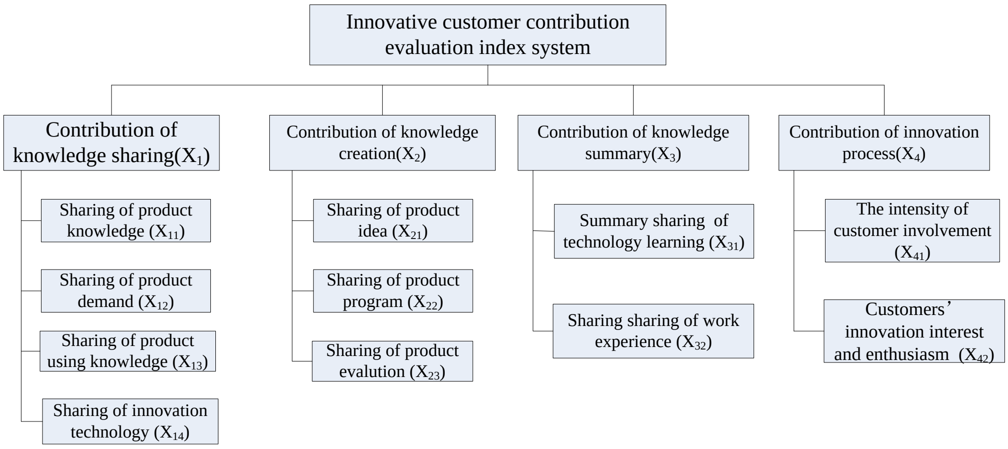

Figure 1. Innovative Customer Contribution Evaluation Index System

In the process of CCPI, customers mainly participate in the phases of demand analysis, conceptual design, detailed design and prototype testing.

(1) The phase of demand analysis. Innovative customers make their comments on product function, product structure and appearance, and clearly express their need information as well. At the same time, they share their own accumulated experiences during using product, as well as information about the current development trend and frontier technology. Through communicating with the staff of marketing department and other innovative customers, customers express their need and share their explicit knowledge and tacit knowledge. Therefore, the indexes X_{11}-X_{14} are established.

(2) The phase of conceptual design. According to their needs, customers describe product idea, search for creative ideas program and put it specific, then complete the product conceptual design. Therefore, the indexes X_{21}-X_{22} are established.

(3) The phase of detailed design. In support of a variety of computer-aided design tools, professional designers and innovative customers complete product detailed design together. They solve the conflicts by using case data and innovation tools. Further, through product program evaluation and optimization, the final product program is determined. Product design specifications, such as product performance requirements and key technical parameters, are formatted.

(4) The phase of prototype testing. Virtual prototype testing is conducted on innovation platform and testing result is evaluated. The main contribution of innovative customer is putting forward reasonable suggestion for prototype product.

Furthermore, in the process of product innovative design, innovative customers often publish their work experience, learning report and summary about product and technology through professional forum and enterprise website. Thus, the indexes X_{23}, X_{31}-X_{32} are established.

From the above analysis, customer contribution for product innovation is mainly reflected in knowledge sharing, knowledge creation and knowledge summary. In addition, based on the principle of index system completeness, customer process contribution need be considered. L. Wang pointed out that the intensity of customer involvement had a positive influence on product innovation performance, the deeper customer involvement, the higher frequency of involvement, the more time customer allocate, the more information provided by customer[15]. Furthermore, L. Wang also pointed out that the higher innovation interest and enthusiasm customers had, the more contribution customer made [16]. Thus, the indexes X_{41}-X_{42} are established.

3. Determine the Weight of Evaluation Index Based on Triangular Fuzzy Numbers

From Figure 1, it can be seen that index itself has a characteristic of fuzziness. Experts usually cannot evaluate the importance of each index quantitatively. They usually express their preference information by natural language. Triangular fuzzy numbers can converter fuzzy and uncertain linguistic variables into determined value [17]. Therefore, triangular fuzzy numbers is adopted to describe the importance of evaluation index.

Definition 1 Define the expectation of a triangular fuzzy numbers $p_1=(l_1, m_1, u_1)$ as

$$E(\mathrm{p}_1)=\frac{l_1+m_1+u_1}{3} \tag{1}$$

Definition 2 The distance d_{ij} between triangular fuzzy number $p_i=(l_i, m_i, u_i)$ and $p_j=(l_j, m_j, u_j)$ is defined as:

$$d_{ij}=\sqrt{\frac{1}{3}[(l_i-l_j)^2+(m_i-m_j)^2+(u_i-u_j)^2]} \tag{2}$$

Let $A_i^k=((A_i^k)^l, (A_i^k)^m, (A_i^k)^u)$ is the importance evaluation result of index $X_i(i=1, 2, \ldots, n)$ given by expert $Exp_k(k=1, 2, \ldots, t)$, $A_{ix}^k= ((A_{ix}^k)^l, (A_{ix}^k)^m, (A_{ix}^k)^u)$ is the importance evaluation result of index $X_{ix}(x=1, 2, \ldots, g)$ given by expert Exp_k. Then, $A_i^k=((A_i^k)^l, (A_i^k)^m, (A_i^k)^u)$ is converted into standardization evaluation information $As_i^k=((As_i^k)^l, (As_i^k)^m, (As_i^k)^u)$ as follows:

$$(As_i^k)^l=\frac{(A_i^k)^l}{\sqrt{\sum_{k=1}^{t}[(A_i^k)^u]^2}},\ (As_i^k)^m=\frac{(A_i^k)^m}{\sqrt{\sum_{k=1}^{t}[(A_i^k)^m]^2}},\ (As_i^k)^u=\frac{(A_i^k)^u}{\sqrt{\sum_{k=1}^{t}[(A_i^k)^l]^2}} \tag{3}$$

Accordingly, $A_{ix}^k=((A_{ix}^k)^l, (A_{ix}^k)^m, (A_{ix}^k)^u)$ is converted into standardization evaluation information $As_{ix}^k=((As_{ix}^k)^l, (As_{ix}^k)^m, (As_{ix}^k)^u)$ according to Eq. (4).

$$(As_{ix}^k)^l=\frac{(A_{ix}^k)^l}{\sqrt{\sum_{k=1}^{t}[(A_{ix}^k)^u]^2}},\ (As_{ix}^k)^m=\frac{(A_{ix}^k)^m}{\sqrt{\sum_{k=1}^{t}[(A_{ix}^k)^m]^2}},\ (As_{ix}^k)^u=\frac{(A_{ix}^k)^u}{\sqrt{\sum_{k=1}^{t}[(A_{ix}^k)^l]^2}} \tag{4}$$

Then, the steps of determining the weight of each index are as follows：

Step1 Integrate the fuzzy evaluation information of t experts. The comprehensive evaluation result $As_i=((As_i)^l, (As_i)^m, (As_i)^u)$ of index X_i is given by

$$As_i=\frac{1}{t}\sum_{k=1}^{t}As_i^k=(\frac{1}{t}\sum_{k=1}^{t}(As_i^k)^l,\frac{1}{t}\sum_{k=1}^{t}(As_i^k)^m,\frac{1}{t}\sum_{k=1}^{t}(As_i^k)^u) \tag{5}$$

Step2 Calculate the expectation of As_i, denoted as $E(A_i)$, according to definition 1.

Step3 Determine the weight W_i of index X_i, as follows:

$$W_i=\frac{E_i}{\sum_{i=1}^{4}E_i} \tag{6}$$

Step4 In the same way, get the comprehensive evaluation result $As_{ix}=((As_{ix})^l, (As_{xi})^m, (As_{ix})^u)$ of index X_{ix}, calculate the expectation $E(A_{ix})$, and determine the weight W_{ix} of index X_{ix}.

$$As_{ix}=\frac{1}{t}\sum_{k=1}^{t}As_{ix}^k=(\frac{1}{t}\sum_{k=1}^{t}(As_{ix}^k)^l,\frac{1}{t}\sum_{k=1}^{t}(As_{ix}^k)^m,\frac{1}{t}\sum_{k=1}^{t}(As_{ix}^k)^u) \tag{7}$$

4. Innovative Customer Profit Distribution

4.1. The Consistency Transformation of Evaluation Information

In the process of innovative customer contribution evaluation, for the different characteristics of indexes, experts give their evaluation results in different forms. Such as, for quantifiable evaluation index, expert can give an accurate number. But for non-quantitative ones, they often use interval value or semantics variable to express their preference information. Therefore, in order to get reasonable evaluation result, multi-attribute evaluation information must be integrated. Two-tuple linguistic method can effectively aggregate evaluation information of different granularity to avoid information loss and make the result more precise [18]. But for the integration of multi-attribute evaluation information, information consistency process should be done.

Two-tuple linguistic method represents the linguistic evaluation information by means of a two-tuple (s_i, α_i), where s_i is a linguistic label from predefined linguistic term set $S=\{s_0, s_1, \ldots, s_g\}$ and α_i is the value of symbolic translation, $\alpha_i \in [-0.5,0.5)$, and g+1 is the granularity of the set S . In other words, s_i denotes the central value of the ith linguistic term, and α_i represents the distance to the central value of the ith linguistic term. The linguistic term s_i can be represented by triangle fuzzy number (l_i, m_i, u_i), where l_0=0, m_0=0, u_0=1/g, u_g=1, $l_{i+1}=m_i$, $m_{i+1}=u_i$, i=0, 1, …, g.

Definition 3 A real number $\beta \in [0, g]$ is a number value representing the aggregation result of linguistic symbolic. The function Δ used to obtain the two-tuple linguistic information equivalent to β is defined as:

$$\Delta : [0, g] \rightarrow S \times [-0.5, 0.5) \quad \Delta(\beta) = \begin{cases} s_k, k = round(\beta) \\ \alpha_k = \beta - k, \alpha_k \in [-0.5, 0.5) \end{cases} \tag{8}$$

Where round() is the rounding operator, s_k has the closest index label to β, α_k is the value of the symbolic translation.

On the contrary, the 2-tuple linguistic variable can be converted into the crisp value β by the inverse function Δ^{-1}:

$$\Delta^{-1} : S \times [-0.5,0.5) \rightarrow [0, g], \quad \Delta^{-1}(s_k, \alpha_k) = k + \alpha_k = \beta \tag{9}$$

4.1.1. Consistency Transformation Between 2-Tuple Linguistic of Different Granularities

In the process of preference decision-making, in order to avoid information loss, evaluation information with smaller granularity should be transferred into the greatest granularity ones. Therefore, the linguistic term set with the greatest granularity is selected as the basic linguistic term set, marked as $S^{\#}$.

If s_j is the term not in set $S^{\#}$, according to the principle of the minimum distance, transfer s_j into the linguistic term ($s_j^{\#}$,α_i) in set $S^{\#}$ as follows:

$$s_j^{\#} = \{s_i \mid s_i \in S^{\#}, d_{ij} = min(d_{ij}), i = 0, 1, \ldots, g\}$$

$$\alpha_j = \begin{cases} d_{ij} & s_j > s_i \\ -d_{ij} & s_j < s_i \end{cases} \quad j = 0, 1, \ldots, g. \tag{10}$$

The mean of triangular fuzzy number $s_i=(l_i, m_i, u_i)$ is called $m(s_i)$, and $m(s_i)$ is equal to $1/3(l_i+m_i+u_i)$. The variance of s_i is called $\sigma^2(s_i)$, and $\sigma^2(s_i)=(l_i^2+m_i^2+u_i^2-l_im_i-l_iu_i-m_iu_i)/18$. Let s_i and s_j are triangular fuzzy number belonging to different linguistic sets, the comparison rules of s_i and s_j are as follows:

If $m_i>m_j$, then $s_i > s_j$.
If $m_i<m_j$, then $s_i < s_j$.
If $m_i=m_j$ then
  If $m(s_i)<m(s_j)$, then $s_i<s_j$.
  If $m(s_i)>m(s_j)$, then $s_i>s_j$.

If $m(s_i)=m(s_j)$, then
If $\sigma^2(s_i)=\sigma^2(s_j)$, then $s_i=s_j$.
If $\sigma^2(s_i)<\sigma^2(s_j)$, then $s_i>s_j$.
If $\sigma^2(s_i)>\sigma^2(s_j)$, then $s_i<s_j$.

4.1.2. Transform Interval Valued Into Linguistic Term of $S^{\#}$

Suppose that the evaluation result for innovative customer is shown as an interval valued I, $I=[c, d]$ in [0,1]. Its membership function is given as follows:

$$\mu_I(x)=\begin{cases}1 & c\le x\le d\\ 0 & \text{else}\end{cases}$$

Then, determine the intersection z_k of interval valued I and each term of set $S^{\#}$ [19]:

$$z_k=max\ min\{\ \mu_I(x), \mu_{Sk}(x)\ \}, k\in\{0, 1, \ldots, g\} \tag{11}$$

Where $\mu_I(x)$ and $\mu_{Sk}(x)$ are the membership functions of the interval valued I and terms s_k, respectively.

Let $\xi(I)=\{(s_k, z_k), k\in[0, g]\}=\{(s_0, z_0), \{(s_1, z_1), \ldots,\{(s_g, z_g)\}$, interval valued I is transformed into a fuzzy set by the function δ.

$$\delta: I\rightarrow f(S^{\#})$$

Where $f(S^{\#})$ is the set of fuzzy sets defined in $S^{\#}$.

$$\delta(\xi(I))=\delta\{(s_k, z_k), k=0, 1, \ldots, g\}$$
$$=\sum_{j=0}^{g} j*z_j/\sum_{j=0}^{g} z_j=\beta \tag{12}$$

Further, transform β into two-tuple linguistic information (s_i, α_i) according to definition 3.

4.2. The Aggregation of Evaluation Information

Definition 4 Let $\{(s_1, \alpha_1), (s_2, \alpha_2), \ldots, (s_m, \alpha_m)\}$ is a two-tuple linguistic variable set, the arithmetic average operator of the set is given as follows:

$$(\bar{s},\bar{\alpha})=\Delta\left[\frac{1}{m}\sum_{j=1}^{m}\Delta^{-1}(s_j,\alpha_j)\right],\quad \bar{s}\in S, \bar{\alpha}\in[-0.5,0.5) \tag{14}$$

Definition 5 Let (s_1, α_1), (s_2, α_2), …, (s_u, α_u) are the two-tuple linguistic information with different granularities that will be aggregated. u is the number of groups. The EOWA operator is defined as [20]:

$$(s, \alpha)=f((s_1, \alpha_1), (s_2, \alpha_2), \ldots, (s_u, \alpha_u))=\Delta(\sum\lambda_i c_i), s\in S^{\#}, \alpha\in[-0.5, 0.5) \tag{15}$$

Where c_i is the ith maximum number of the set $\{\Delta^{-1}(s_i, \alpha_i), i=1, 2, \ldots, u\}$, $\lambda=(\lambda_1, \lambda_2, \ldots, \lambda_u)$ is the weight of EOWA operator, it is quantified by the fuzzy operator $E(r)$:

$$\lambda_k=E(k/u)-E((k-1)/u), k=1, 2, \ldots, u$$

$$E(r)=\begin{cases}0 & r<a\\ (r-a)/(b-a) & a\le r\le b\\ 1 & r>b\end{cases} \tag{16}$$

Where a, b, $r\in[0, 1]$. Corresponding to the fuzzy linguistic quantitative principle of "half", "most" and "as much as possible", the parameters (a, b) take values (0, 0.5), (0.3, 0.8), (0.5, 1), respectively.

Considering that the evaluation information with greater granularity should have greater weight, the EOWA operator is amended and improved. Where c_i is the evaluation information with the ith maximum granularity, λ_i is the ith maximum number in array λ.

4.3. Innovative Customer Profit Distribution based on CD

Contribution Degree (CD) is defined as the effort and contribution paid out by customer in product innovative design.

In the process of innovative customer evaluation, $Cus=\{Cus_1, Cus_2, \ldots, Cus_m\}$ represents the set of evaluated customer. $Y(Cus_m^{ix})$ is a comprehensive evaluation of customer Cus_m in the index X_{ix}, and $f(Cus_m^{ix})$ is the contribution membership of Cus_m in the index X_{ix}.

If $Y(Cus_m^{ix})$ is a numerical value, its contribution membership $f(Cus_m^{ix})$ is:

$$f(Cus_m^{ix}) = \frac{Y(Cus_m^{ix}) - Y(Cus^{ix})_{\min}}{Y(Cus^{ix})_{\max} - Y(Cus^{ix})_{\min}} \quad (17)$$

If $Y(Cus_m^{ix})$ is the aggregation result of linguistic information, represented as $(s_m^{ix}, \alpha_m^{ix})$, apply the definition 3 to convert $(s_m^{ix}, \alpha_m^{ix})$ into crisp value β_m^{ix}. Therefore, obtain the contribution membership $f(Cus_m^{ix})$ as follows:

$$f(Cus_m^{ix}) = \frac{\beta_m^{ix}}{g} \quad (18)$$

Where g+1 is the granularity of the basic linguistic term set $S^{\#}$.

Then, define the contribution degree of innovative customer Cus_m as：

$$CD(Cus_m) = \sum_{i=1}^{4} W_i \left(\sum_{x=1}^{k} W_{ix} f(Cus_m^{ix})\right) \quad (19)$$

According to the principle of “the more you contribute, the more you will be rewarded”, innovative customer profit reward is distributed based on his/her CD. The rewarded amount of innovative customer Cus_m, denoted as $Pro(Cus_m)$, be calculated as follows:

$$Pro(Cus_m) = CD(Cus_m) * R_{max} \quad (20)$$

Where R_{max} is the maximum rewarded amount that enterprise pay for innovative customer.

Finally, the process of innovative customer profit distribution is shown in Figure 2.

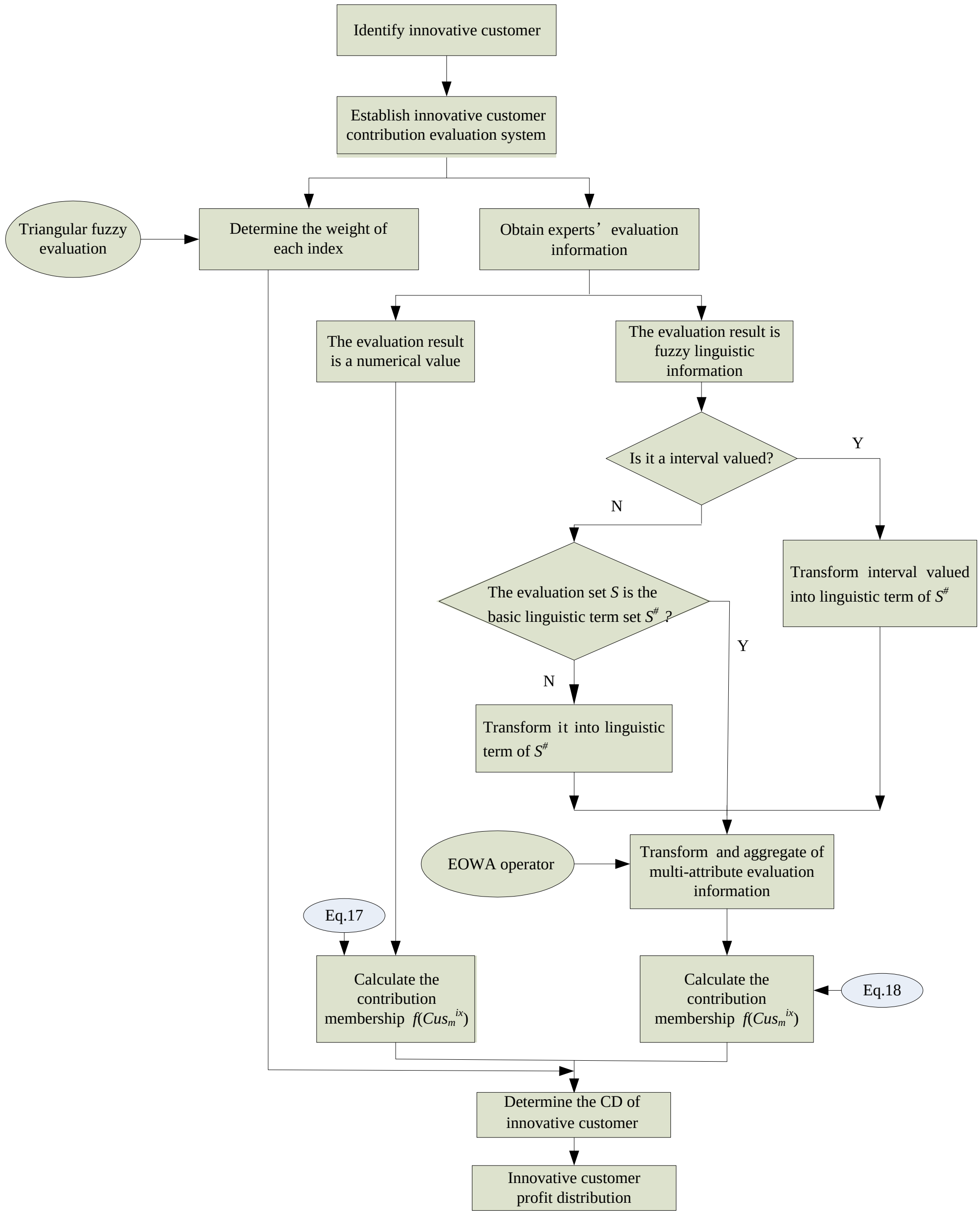

Figure 2. The Process of Innovative Customer Profit Distribution

5. Case Study

Company A is a mobile phone R&D company. It encourages customers involved in the process of product design and innovation. In a new mobile phone product design, innovative customers participated in product software design and appearance design through internet and innovation platform. In order to improve the stability and enthusiasm of customer involvement, the company decided to choose some innovative customers with greater contribution to reward them. Then, three innovative customers $\{Cus_1, Cus_2, Cus_3\}$ with higher contribution were selected.

5.1. Determine the Weight of Evaluation Index

In this product development, innovation team members were from departments of design, manufacturing, marketing and testing. Fifteen experts were chosen from these departments, Exp_1, Exp_2, Exp_3,…, Exp_{15}, respectively. They adopted triangular fuzzy number to evaluate the importance of customer contribution evaluation indexes. The evaluation results for X_i and X_{im} provided by expert Exp_k （k=1, 2, …, 15） were expressed by means of triangular fuzzy number as $\{A_i^k=((A_i^k)^l, (A_i^k)^m, (A_i^k)^u)\}$ and $\{A_{ix}^k= ((A_{ix}^k)^l, (A_{ix}^k)^m, (A_{ix}^k)^u)\}$ respectively. Then, A_i^k and A_{ix}^k were transformed into standardized form As_i^k and As_{ix}^k by Eq. (3) and Eq. (4). For example, $A_i^1= ((A_i^1)^l, (A_i^1)^m, (A_i^1)^u)$={(0.75,0.80,0.85), (0.80,0.83,0.87), (0.60,0.66,0.75), (0.68,0.72,0.76)}, after standardization, A_i^1 was transferred into As_i^1, As_i^1={(0.319,0.427, 0.504), (0.411,0.459,0.527), (0.368.0.395,0.413), (0.376,0.408,0.483)}.

Further, the comprehensive evaluation information for X_i (i=1, 2, 3, 4) were obtained according to the Eq. (5). Then, the weight W_i of index X_i was determined according to the definition 1 and Eq.(6), $W=[W_1, W_2, W_3, W_4]^T=[0.279, 0.285, 0.232, 0.204]^T$. Similarly, the weights of secondary index X_{im} were got as follows: $[W_{11},W_{12},W_{13},W_{14}]^T=[0.217, 0.281, 0.186, 0.316]^T$, $[W_{21},W_{22},W_{23}]^T=[0.361, 0.428, 0.211]^T$, $[W_{31},W_{32}]^T=[0.588, 0.412]^T$, $[W_{41},W_{42}]^T=[0.553, 0.447]^T$.

5.2. Determine the CD of Innovative Customer and Profit Distribution

On the basis of getting the weight of the indexes, the three innovative customers $\{Cus_1, Cus_2, Cus_3\}$ were evaluated by four experts{ D_1, D_2, D_3, D_4 }. Taking the secondary index X_{21}-X_{23} for example, the process of customer contribution evaluation was illustrated.

Step 1 Four experts gave their preference information, as shown in Table 1, where two-tuple linguistic evaluation information s_i^{g+1} was represented the i+1th term of the set with g+1 granularity.

Table 1. Experts' Original Evaluation Information

Innovative customer	Expert					
	D_1			D_2		
	X_{21}	X_{22}	X_{23}	X_{21}	X_{22}	X_{23}
Cus_1	[0.5,0.6]	[0.6,0.8]	[0.3,0.3]	s_3^5	s_3^5	s_4^5
Cus_2	[0.6,0.8]	[0.7,0.9]	[0.5,0.5]	s_2^5	s_4^5	s_4^5
Cus_3	[0.5,0.7]	[0.5,0.5]	[0.6,0.7]	s_3^5	s_4^5	s_3^5
Innovative customer	Expert					
	D_3			D_4		
	X_{21}	X_{22}	X_{23}	X_{21}	X_{22}	X_{23}
Cus_1	s_6^7	s_5^7	s_5^7	s_7^9	s_6^9	s_5^9
Cus_2	s_4^7	s_6^7	s_4^7	s_6^9	s_5^9	S_6^9
Cus_3	s_5^7	s_4^7	s_3^7	s_6^9	s_4^9	s_6^9

Step 2 Determined the basic linguistic term set $S^\#=\{s_0, s_1, …, s_8\}$.

Step 3 For the 2-tuple linguistic evaluation information not in set $S^\#$, consistency transformation between different granularities were achieved by applying Eq.(10).

Step 4 If the evaluation information given by experts was interval valued, transformed it into the term of set $S^\#$ according to Eq. (11) and Eq. (12).

The transformed expert evaluation information was shown in Table 2.

Table 2. The Transformed Expert Evaluation Information

Innovative customer	Expert					
	D_1			D_2		
	X_{21}	X_{22}	X_{23}	X_{21}	X_{22}	X_{23}
Cus_1	(s_4,0.444)	(s_6,-0.385)	(s_3, 0.154)	(s_6,-0.102)	(s_6,-0.102)	(s_8,-0.072)
Cus_2	(s_6,-0.385)	(s_6,0.385)	(s_4, 0)	(s_4,-0.102)	(s_8,-0.072)	(s_8,-0.072)
Cus_3	(s_5,-0.154)	(s_4, 0)	(s_5,0.222)	(s_6,-0.102)	(s_8,-0.072)	(s_6,-0.102)
Innovative customer	Expert					
	D_3			D_4		
	X_{21}	X_{22}	X_{23}	X_{21}	X_{22}	X_{23}
Cus_1	(s_8,-0.024)	(s_7,-0.054)	(s_7,-0.054)	(s_7, 0)	(s_6, 0)	(s_5, 0)
Cus_2	(s_5,0.034)	(s_8,-0.024)	(s_5,0.034)	(s_6, 0)	(s_5, 0)	(s_6, 0)
Cus_3	(s_7,-0.054)	(s_5,0.034)	(s_4,-0.034)	(s_6, 0)	(s_4, 0)	(s_6, 0)

Step 5 On this basis, adopted the principle of "most", used improved EOWA operator to aggregate two-tuple linguistic information with different granularities. The aggregation results were shown in Table 3. In this case, the expert D_1 used interval valued information, different from other three experts, so his weight was equal to 0.25, the weights of other three experts was determined by improved EOWA operator.

Table 3. The Aggregation Results of Evaluation Information

Innovative customer	X_{21}	X_{22}	X_{23}
Cus_1	(s_6,0.500)	(s_6,0.087)	(s_5,0.074)
Cus_2	(s_6,-0.395)	(s_6,0.087)	(s_5,0.404)
Cus_3	(s_6,-0.105)	(s_4,0.404)	(s_5,0.395)

Step 6 According to Eq. (17-18), calculated the contribution membership of innovation customer {Cus_1, Cus_2, Cus_3} in the indexes X_{21}-X_{23}, respectively.

Table 4. The Contribution Membership of Innovation Customer

Innovative customer	X_{21}	X_{22}	X_{23}
Cus_1	0.813	0.761	0.634
Cus_2	0.701	0.761	0.676
Cus_3	0.737	0.550	0.674

Further, obtained the contribution degree of innovation customer {Cus_1, Cus_2, Cus_3} in index X_2. The contribution degree of Cus_1, Cus_2 and Cus_3 were 0.753, 0.721 and 0.644, respectively.

Repeat steps 1-6, the contribution degree of Cus_1, Cus_2 and Cus_3 in other indexes were got.

Table 5. The Contribution Degree of Innovative Customer

Innovative customer	X_1	X_2	X_3	X_4
Cus_1	0.677	0.753	0.681	0.626
Cus_2	0.814	0.721	0.782	0.827
Cus_3	0.752	0.644	0.735	0.787

Finally, the comprehensive contribution degree of Cus_1, Cus_2 and Cus_3 we obtained were 0.689, 0.783 and 0.724, respectively. It can be seen the Cus_2 work harder and his contribution degree was maximum. In this project, the maximum award amount company A provided was 20,000 RMB. Thus, Cus_2 got the highest bonus, 15,660 RMB. The profit Cus_1 and Cus_3 obtained were 13780 RMB and 14480 RMB respectively. Form Table 5, we also can see that Cus_1 had good performance in sharing of product idea and product program, so his technology was in higher level. But his involvement enthusiasm was lower than Cus_2 and Cus_3, and he did not participate in deeply. For such customers like Cus_1, company should make some incentive strategies to enhance his/her enthusiasm, guide them to share their knowledge, experience and innovation skill.

6. Concluding

It is important to evaluate the effort and contribution of innovative customer reasonably and rewarding them according to their contribution. It plays an important role in improving the enthusiasm of innovative customer and accelerating the speed of product innovation. This paper puts forward the concept of customer contribution degree and customer profit distribution method based on his/her contribution. In this method, contribution membership is defined, and linguistic evaluation information is aggregated based on two-tuple linguistic consistency. Through case study of a mobile phone company, the feasibility and efficiency of the proposed method are verified. This method can provide decision support for companies to select important innovative customer and innovation resource allocation. In the future, we shall focus on innovative customer management and innovation resource optimal allocation.

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