The Developing of Customer Product Recommendation Service System

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ABSTRACT

In recent years, the styles and functions of products have become very diverse due to the rapid advancement of new technologies. Before, customers were finding it hard to decide on what they would need although they have more product knowledge and choices. They were often unable to articulate their needs due to lack of specialized product knowledge, leading to the possibility of buying products that were not ideal. Now, enterprises should offer their assistance to match customer needs to product features, provide customer enquiry services, and create a product database from which more choices can be offered to customers. To this end, this study undertakes to build a customized product recommendation service system that parameterizes customer needs and product features, using the information axiom and the Taguchi method to create the system's search and evaluation function. In addition, the triangular fuzzy numbers of the fuzzy set theory are used to establish the evaluation algorithms to search for the ideal product for the customer. A case study on the purchase of laptops is used to demonstrate the procedures and methods that lead to the successful purchase of a desired product.
Keywords: *Triangular fuzzy number, Information axiom, Taguchi method, product recommendation service*

INTRODUCTION

With the advancement of technology and the continual increase of a customer's knowledge, companies have changed from the earlier "functional" strategy to the "customer-oriented" strategy for developing new products, and by understanding customer needs and striving to meet these needs, they are able to bring the highest satisfaction to customers and thereby maximize profits. Therefore, the application of needs-based operations can maintain customer loyalty, create new customer needs and effectively attract new customers; hence, making Customer Relationship Management a very important aspect of the corporate world.

In Customer Relationship Management, it is necessary for companies to build a learning relationship with their customers, so as to obtain customer information and news in order to meet the diverse customer needs. Consequently, merchandise with different features that can meet different needs has begun to emerge in the market, and customers can choose to purchase merchandise of different functions according to their needs. Upon understanding customer needs, manufacturers can extend a particular product to produce a variety of goods with different features, therefore enhancing the competitiveness of their products. These goods are also known as customized goods.

Generally, consumers are not perfect decision-makers and will often make irrational decisions. When purchasing a product, they are unable to articulate their personal needs and have significantly different requirements. Therefore, experts must relate product features with the functional requirements of customers, and in doing so, provide a more objective and ideal outcome. However, there is a considerable degree of fuzzy association between the functional requirements and the product features, and appropriate theories are needed to uncover these relationships and establish patterns. Therefore, in view of the above reasons, this study undertakes to use the triangular fuzzy theory, Taguchi method and fuzzy information axiom algorithms to establish a set for a customized product recommendation service system. Through a case study on the purchase of laptops, the research seeks to explore the model by which customers select their products.

LITERATURE REVIEW

Most consumer decisions are composed of many attributes. In a rational decision, decision-makers follow certain grouping rules to determine the most effective outcome according to the effectiveness of each attribute and its corresponding significance. Based on the outcome, the conjoint analysis uses certain decomposition rules to determine the different functions of each attribute and its corresponding significance. Green & Srinivasan (1978) believed that the conjoint analysis is an analytical method whereby a known subject's preference structure is determined through a decompositional approach based on the overall assessment of the known subject toward a product under a set of stimuli. This method is very much favored by researchers and enterprises. Wittink & Cattin (1989) used the conjoint analysis as a basis to assess new product designs so as to determine the best product design.

In this customer-oriented era, it is important for products and design concepts to meet customer needs and desires. Cooper & Kleinschmidt (1987) believed that if a product designer is able to understand customer needs and desires, and designs products based on that understanding, the product will certainly be successful. Hence, the pursuit of quality products is an important factor. Hauser & Clausing (1988) adopted the Quality Function Deployment method (QFD) to perform a multi-level analysis on the product requirements of customers, and the results were transformed into quality project management techniques which in turn defined product design requirements, component features, design requirements of the manufacturing process and production requirements. House of Quality is also one of the main tools for product design, and was adopted by Urban & Hauser (1992) in the development of new products.

Suh (2001) from the Massachusetts Institute of Technology further developed QFD and proposed the axiomatic design (AD) as shown in Figure 1. Suh described the design process as the mapping of the customer domain, function domain, physical domain and process domain.

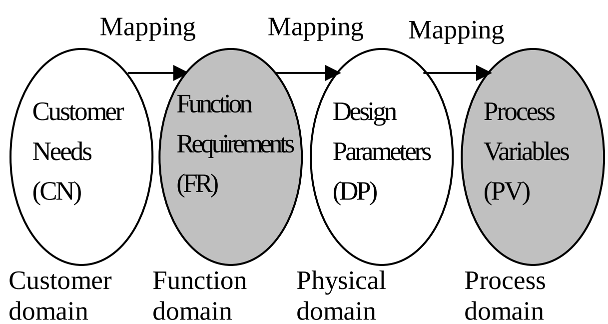

Figure 1: Four main domains of axiomatic design by Suh (2001)

To ensure the effective performance of these four domains, Suh proposed two design,axioms:Axiom 1,The independence axiom;Axiom 2: The information axiom

Axiom 1 states that: the functional requirements (FR) must be mutually independent in the design process, and a design parameter (DP) can only affect one of its related functional requirements. Therefore, there should not be any interaction or relationship between two functional requirements or two design parameters. Based on the above considerations, the design process will then become very simple, in which each functional requirement is designed for only one suitable parameter regardless of the relationships between different functional requirements.

Axiom 2 states that: among the design parameters that satisfy a particular functional requirement (FR) under the independence axiom, the design parameter with the smallest information content is the most ideal. The main purpose of this axiom is to produce a simple design. Suh defined the information content as I, and is calculated using the formula is I = log (design range / common range). A small I implies a large common range, which means that as the common range becomes larger, it is easier for the product of this design parameter to be successful. seen in Figure 2.

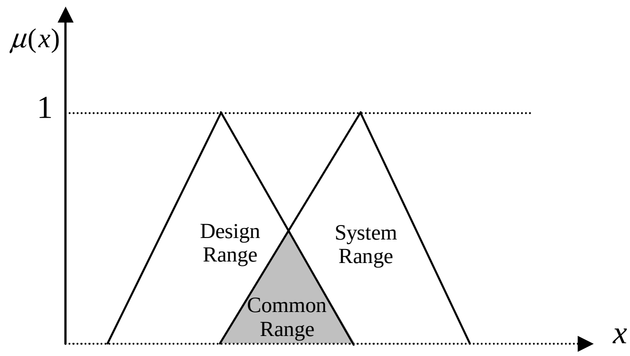

Figure 2: Graph showing the triangular fuzzy relationship

Japanese scholar Taguchi (1986) proposed the Taguchi method which classifies quality features into “the larger the better” (LTB), “the smaller the better” (STB) and “nominal the best”, which are briefly explained as follows:

While it is important to focus on customer needs, decision-makers must also determine the design proposal to transform product features based on customer needs. The overall proposal chosen by Pugh (1991) was to align the concepts with the levels of consumer satisfaction, calculation of the points of various solutions using weighted factors, and then making a comparison in order to determine the best design. The literature on the use of algorithms to evaluate and purchase products has gradually increased in recent years. Kulak *et al.* (2005a,2005b,2005c,2005d) explored multi-attribute product designs that supported decisions and systems using concepts such as the fuzzy information axiom as well as the fuzzy and gray theory, etc. Hsiao (2005)、Tsai *et al.* (2004,2006,2007,2009),explored customers’ evaluation and selection of multi-function products with the use of the analytic hierarchy process, gray theory and fuzzy theory. Hsiao *et al.* (1994,2002) attempted to help product designers with design consultation using the fuzzy theory, gray theory and artificial neural network, while Sun (2000) tried to combine the fuzzy theory and the artificial neural network to evaluate and decide product design concepts.

THEORETICAL BACKGROUND

Triangular Fuzzy Numbers (TFN)

A triangular fuzzy number is a special type of trapezoidal fuzzy number where the function $\tilde{t} = (t_1, t_2, t_3)$ represents the membership value of the distribution graph, as shown in Figure 1, and the real numbers t_1, t_2 and t_3 are the values of the three vertices of the triangular graph on the x-axis.

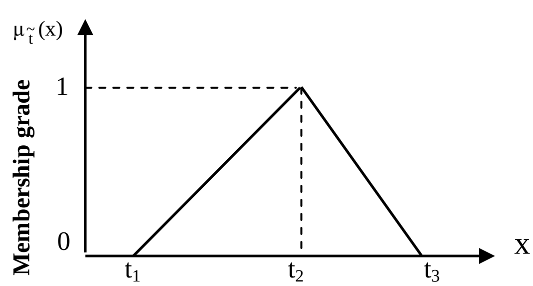

Figure 3: Schematic diagram of triangular fuzzy numbers

Therefore, the triangular fuzzy numbers can be expressed as:

$$\mu_{\tilde{t}}(x)=\begin{cases}0,\cdots\cdots\cdots\ x<t_1\\ \dfrac{x-t_1}{t_2-t_1},\cdots\ t_1\le x< t_2\\ \dfrac{x-t_3}{t_2-t_3},\cdots\ t_2\le x<t_3\\ 0,\cdots\cdots\cdots\ x\ge t_3\end{cases}\quad\cdots\cdots\cdots\cdots\cdots(1)$$

Fuzzy Information Axiom

The second axiom of the Axiomatic Design is the information axiom, which states that among those designs that satisfy the independence axiom, the one with the smallest information content is the best design. The definition of information content (I_j) expressed in terms of the triangular fuzzy numbers is as follows:

$$I_j=\log_2(1/p_j)\quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

where p_j is the ratio of the area of the common range to the area of the system range for the jth design requirement, which is also the probability of the system range meeting the design requirement.

$$p_j=\left[\frac{CommonRange}{SystemRange}\right]\quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (3)$$

As shown in Figure 2, the overlap of the "design range" set by the designer and the “system range” of the system capacity is the acceptable common range; the larger the common range, the higher the success rate will be.

Assuming that a product has m number of design requirements, the summation of all the design requirements Total Information Content (I_{total}) is defined below:

$$I_{total}=\sum_{j=1}^{m}I_j\quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (4)$$

ALGORITHMS TO CALCULATE THE RELATIONSHIP BETWEEN CUSTOMER NEEDS, PRODUCT FEATURES

In this study, an ideal product purchasing information system for the purchase of laptops is being established, and the research methodology and execution steps are explained as follows:

Determination of Customer Needs and Product Features

The basic customer needs are jointly developed by two experienced and professional computer sales staff, two laptop product planners and one of the R&D personnel,. Based on the basic customer requirements for the important features, the experts and consultants of this study selected 7 preferred features (PF), namely, CPU, RAM, Screen Size, Hard Disk Capacity, Display Card, Price and Color, as shown in Table 1.

Table 1: Designer’s selection of customers’ functional requirements and preferred product features

Designer’s selection			
Customer Needs		**Product Features**	
CN1	Word Processing	PF1	CPU
CN2	Professional Graphics	PF 2	RAM
CN3	Numerical Computation	PF 3	Screen Size
CN4	Portability	PF 4	Hard Disk Capacity
CN5	Price	PF 5	Display Card
CN6	Color	PF 6	Price
		PF 7	Color

Establishment of Rules for Evaluating the Relationship between Customer Requirement Options and Product Features

Using the concepts of the triangular fuzzy numbers and Taguchi method, the following were established: (1) triangular fuzzy numbers for the requirement levels (2) the relationship between the evaluation of functional requirement options and product features, in order to establish rules to relate the evaluations of customers and designers.

For a designer, the functional requirements do not only contain the main obvious product requirements of customers, but also their potential needs. The functional requirements of customers are often hard to express explicitly, so fuzzy numbers are used to determine customer needs, as expressed using the 7 levels listed in Table 2 and represented in Figure 4.

Table 2: Triangular fuzzy numbers showing 7 requirement levels

Vocabulary	Denotation	Triangular Fuzzy Numbers
A Very low	VL	(0,0,1)
B Low	L	(0,1,3)
C Medium low	ML	(1,3,5)
D Medium	M	(3,5,7)
E Medium high	MH	(5,7,9)
F High	H	(7 ,9,10)
G Very high	VH	(9,10,10)

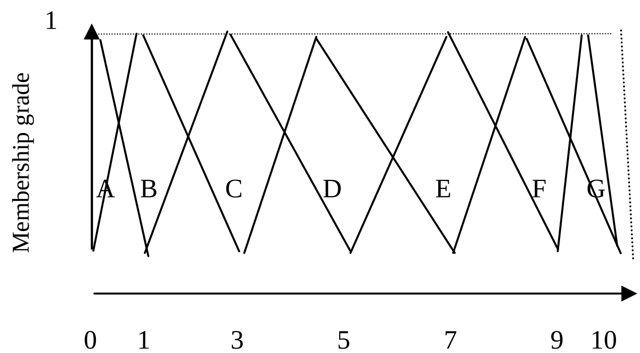

Figure 4: Triangular fuzzy numbers diagram showing 7 requirement levels

After obtaining the various independent customer needs and product features, the experts evaluated the impact of the customers' functional requirements on the product features, and brought in the concept of the Taguchi method to form 7 levels of triangular fuzzy numbers.

Table 3: Relationship between customer needs and product features

		Product Features						
		1	2	3	4	5	6	7
	Customer Needs	CPU	RAM	Screen Size	Hard Disk Capacity	Display Card	Price	Color
1	Word Processing	L+	L+	MH+	ML+	L+		
2	Professional Graphics	VH+	H+	H+	MH+	VH+		
3	Numerical Computation	VH+	H+	NR	L+	L+		
4	Portability	NR	NR	L-	NR	NR		
5	Price						V-	
6	Color							Vo

Note：+: LTB, - STB, 0 :Nominal the best

Product features are generally classified into "the larger the better", LTB (+), which means that a bigger function is better; the price and screen size (taking into consideration the need for portability) is based on "the smaller the better", STB (-); the exterior color of the laptop is based on "nominal the best" (o), where the target must be met, as shown in Figure 5.

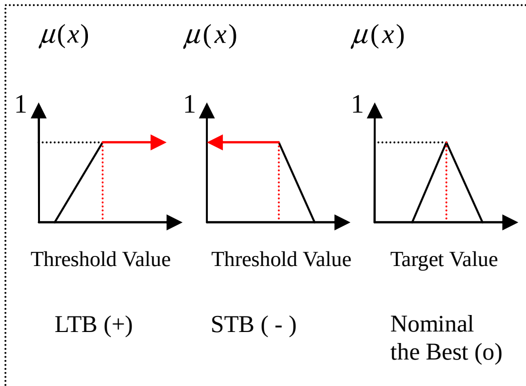

Figure 5: Graphs of LTB, STB and Nominal the best for product features

Establishment of Fuzzy Reasoning Principles

According to the fuzzy reasoning principles for feature requirements established by Tsai (2004) shown in Table 4, the vocabulary levels of product feature requirement can be obtained and used as an important tool for evaluating laptops by giving due consideration to the actual weighted product features that meet customer needs based on the relationship table between customer needs and product features in Table 3.

Table 4: Fuzzy inference rules for feature requirements

Customer Needs	Relationship between Customer Needs and Product Features						
	VH	H	MH	M	ML	L	VL
VH	VH	VH	H	M	L	VL	VL
H	VH	H	H	M	L	L	VL
MH	H	H	MH	M	ML	L	L
M	H	MH	MH	M	ML	ML	L
ML	MH	MH	M	M	M	ML	ML
L	MH	M	M	M	M	M	ML
VL	M	M	M	M	M	M	M

In this study, a total of 51 laptops, all current branded products in the market, were gathered, and a product database such as that in Table 5 was established based on experts' opinions. The triangular fuzzy levels for laptop prices such as that shown in Table 6 were established, and the prices were based on STB, "the smaller the better".

Table 5: Fuzzy product database according to experts' opinions

Product Feature	CPU	RAM	Screen Size	Hard Disk Capacity	Display Card	Price	Color
NB1	VL	VL	VL	VL	VL	VL	Black
NB2	VL	M	ML	ML	M	L	White
NB3	L	M	M	ML	M	L	Black
…							
NB51	H	M	M	L	VL	MH	Black

Table 6: Laptop prices

Laptop Price	Below 20	20~25	25~30	30~35	35~40	40~45	45~
Triangular Fuzzy Levels	VL	L	ML	M	MH	H	VH
					Unit: Thousand Dollars Yuan		

Establishment of Rules for Selection of the Best Product

The computation formula for the selection of the best product is explained as follows:

1. Assuming the customers' functional requirements to calculate the median of customers' functional requirements.

If there are n basic customer needs, they are translated into 7 levels of triangular fuzzy numbers and the median of customer needs is calculated and normalized to obtain the customer needs in the hierarchical order **w** ($w_1, w_2, \ldots, w_n$), as shown in Formula (5).

$$\sum_{i=1}^{n} w_i = 1 \qquad (5)$$

2. Computation of the level of requirement for product feature

As shown in Table 4, the triangular fuzzy numbers for the relationship matrix of customer needs and product features assessed by experts are $\tilde{A}$

$$\tilde{A} = [\tilde{a}_{ij}] \text{...(6)}$$

where i and j denote i-th customer need and j-th product feature.

The product of the relationships between the normalized customer requirement levels, weighted customer needs and product features will give rise to a j-th triangular fuzzy number for product feature $\tilde{b}_j$

$$\tilde{b}_j = \sum_{i=1}^{n} w_i \times [\tilde{a}_{ij}] \text{...................................(7)}$$

3. Computation of Information Content I_j

Based on the results in step 2 using the design range and system range of the actual product shown in Figure 2, the information content I_j of the j-th product feature is determined：

$$I_j = \log_2(1/p_j) \text{ ....(8)}$$

4. Establishment of Rules for Evaluating Products

According to the fuzzy reasoning principles of feature requirements established in Table 5, the median of various product features is calculated, and the normalized weight of the j-th product feature is w_j^{nd} , whereby $\sum_{j=1}^{m} w^{nd}{}_j = 1$

5. Finally, all the information content obtained is sequentially multiplied by the standardized level to obtain the grand total value for product information content E (STB); its formula is as follows:

$$E = \sum_{j=1}^{m} \left(I_j \times w_j^{nd.} \right) \text{...................................(9)}$$

Establishment of the Ideal Product Purchasing Interface for Customers

The above algorithms are programmed to establish the ideal product purchasing programming interface (as shown in Figure 6). Consumers can use this interface to select their personal needs and the system will suggest the most suitable merchandise, or use this interface to preview the recommended products.

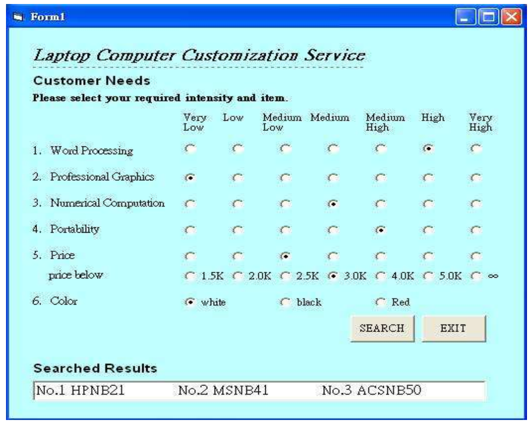

Figure 6: Product Purchasing Interface

CASE STUDY

Feigo & Tom would like to buy a laptop, but knows nothing about computer hardware. In this study, the fuzzy information axiom algorithms are used to help him search for the ideal laptop available in the market based on his actual needs, which is listed in Table 7.

Table 7: Feigo's & Tom's requirements for computers and the requirement levels

Serial Number	Functional Requirements for Computer	Feigo's Requirement Level	Tom's Requirement Level
CN1	Word Processing	H	L
CN2	Professional Graphics	VL	H
CN3	Numerical Computation	M	MH
CN4	Portability	MH	M
CN5	Price	Below TWD 30,000 ML	Below TWD 30,000 ML
CN6	Color	White	Black

Feigo's functional requirements for the computer are normalized to the triangular fuzzy numbers, and the information content of each product feature is obtained using the abovementioned formula, followed by summation to obtain I_{total} as shown in Table 8 below. using the fuzzy inference rule for feature requirements from Table 5 and customer needs, Table 9 is generated.

Table 8: Various information contents on product features obtained by the computing program

Rating	NB2	NB21	NB41		NB50
I(CPU)	∞	0.00	0.08	…	2.28
I(RAM)	0.00	1.31	1.31	…	0.00
I(Screen Size)	2.12	0.00	0.00	…	0.00
I(Hard Disk Memory)	0.00	0.00	0.00	…	0.00
I(Display Card)	0.00	0.00	0.00	…	0.00
I (Total)	∞	1.31	1.39	…	2.28

Table 9: Relationship between customer requirements and product features after computation

		Product Feature				
		1	2	3	4	5
Customer Needs		CPU	RAM	Screen Size	Hard Disk Capacity	Display Card
1	Word Processing	L	L	H	L	L
2	Professional Graphics	M	M	M	M	M
3	Numerical Computation	H	MH	NR	ML	ML
4	Portability	NR	NR	M	NR	NR

Standardizing the median of the triangular fuzzy function in Table 10, the following result is obtained as w_{ij}^{nd} (0.247253, 0.21978, 0.225275, 0.153846, 0.153846). The results for customers' assessment of the computers are shown in Table 10.

Table 10: Assessment of the computer and product features after computation

Computer	NB21	NB41	NB50	…
E(CPU)	0.00	0.02	0.56	…
E(RAM)	0.29	0.29	0.00	…
E(Screen Size)	0.00	0.00	0.00	…
E(Hard Disk)	0.00	0.00	0.00	…
E(Display Card)	0.00	0.00	0.00	…
E(Total)	0.29	0.31	0.56	…
Ranking	**1**	**2**	**3**	…

Rank-ing	Product Number	CPU	RAM	Screen Size	Hard Disk Capacity	Display Card	Price	Color
1	NB21	MH	ML	MH	M	ML	ML	White
2	NB41	M	ML	ML	ML	MH	ML	White
3	NB50	ML	M	ML	L	ML	M	White

A smaller information content indicates that the laptop is closer to the customer's requirements. Feigo's top three computers are NB21, NB41, and NB50. Looking at the laptop ranked first in the table, its price and color have satisfied Feigo's requirements, the screen size is comparable to his requirements, and it has a higher CPU and hard disk capacity. As the customer has a greater need and priority for word processing and numerical computation, therefore, even though the laptops ranked second and third may have smaller screens, their CPU and hard disk capacity are much smaller, placing them below NB21.

Again take another different demand's consumer Tom as the example, finally sees Table 7 and Table 11,According to the abovementioned computation method, the results obtained are as follows:

Table 11: Assessment of the computer and Product Features after computation

Rating	NB11	NB5	NB39	…
E(CPU)	0.00	0.00	0.00	…
E(RAM)	0.00	0.00	0.32	…
E(Screen Size)	0.07	0.07	0.00	…
E (Hard Disk Capacity)	0.00	0.00	0.23	…
E(Display Card)	0.00	0.00	0.00	…
E(Total)	0.07	0.07	0.55	…
Ranking	**1**	**2**	**3**	…

Rank-ing	Product Number	CPU	RAM	Screen Size	Hard Disk Capacity	Display Card	Price	Color
1	NB11	MH	H	M	M	MH	L	Black
2	NB5	H	H	M	M	MH	M	Black
3	NB39	MH	MH	M	ML	MH	M	Black

After computation, Tom's top three computers are NB11, NB5, and NB39. Looking at the laptop ranked first on the table, its price and color have satisfied Tom's requirements, the screen size is comparable to his requirements, and it has a higher CPU, hard disk capacity and display card, as well as a lower price. The customer has also placed professional graphics and numerical computation as his priority. The functions of the laptops ranked second and third are also satisfactory, but their prices are much higher than that of NB11.

CONCLUSION

The arrival of the customer knowledge era has captured the manufacturers' attention in today's competitive market. Therefore, it is important to integrate customer functional needs with the product features, and the information obtained can greatly benefit sales. This study, which quantifies the fuzzy customer needs using reasonable and rigorous mathematical algorithms and mapping them onto the product features, is one that cannot be overlooked.

This study combines methods such as the triangular fuzzy theory, Taguchi method and the fuzzy information axiom, and strives to logically calculate and solve the related conversions at the various stages. In order to enhance the objectivity and accuracy of the computation structure, the logic and rationality set up by various experts in the field must be emphasized to verify the objective accuracy of the results. As every individual's functional requirements are different, we are often helpless when it comes to selecting the appropriate product type when confronted with relatively unfamiliar product features or complex features. Today, as the internet and e-commerce technology progressively matures, there is an urgent need among many brand manufacturers for an internet consulting service interface that can appropriately guide them in meeting customer needs. In this study, the computation rules, established based on objective and logical computation methods, are able to transform the customer's functional requirements into suggestions based on product features, so as to guide them in product selection. In addition, an actual case study was also provided. In doing so, companies are more equipped in understanding customer needs and maintaining good customer relationships, which will in turn generate greater profits. As for the customers, their needs are fully satisfied, hence creating a win-win situation for both companies and customers.

In this study, the customer selection process does not take into consideration the customer's brand loyalty. The degree of brand preference can be considered for future research, in order to better meet customer needs.

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