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A Customer Satisfaction Based Approach for New Product Development Method

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Abstract

In this study, we suggest a product development methodology from the view of customer satisfaction. By identifying the importance level of each quality element of a product and providing the functional relation of the quality model. In the analysis process, we calculate the weight of importance of each quality element. Then, we apply a method using utility functions as a functional expression of quality model. By combining the weight of importance and these utility functions, it is possible to identify the degree of importance and the quality model. In the synthesis process, we apply group decision making stress method to synthesize the view of each evaluator because each evaluator's view differs that is realistically difficult to conform to each person. To verify the effectiveness of the proposed method, we conducted a case study regarding the choice of cars and confirmed the effectiveness of the proposed method.

Keywords: Customer; Satisfaction; New product development

Introduction

To consider a future corporate strategy, pricing and sales competition are important. But to grow the corporation's future permanently, product development is an important factor to survive. As new product's life cycle becomes shorter and shorter, it is imperative to provide a new product successfully to the market. However, the market is saturated with a lot of kinds of things and goods these days, customers would not be satisfied even a product merely satisfies their needs. Since a shift from product-out to market-in has been emphasized, there is need to conduct product development by capturing the customer's requirement.

In product development tactics, classifying quality elements is an important process. In this classification, there are attractive quality elements, one-dimensional and must-be quality element. This is Kano's quality model and is depicted by the level of functionality and the level of satisfaction towards the level of it. However, this model is only represented the correspondence relationship conceptually, representing its functional relationship has not been represented yet.

In this research, we represent Kano's quality model in functional expression, and then propose a product development method that leads to high customer satisfaction (CS) considering the quality model.

Background for the Research

Target planning V-model

For one of the way of product development, there is target planning V-model [1]. This is used for the target achievement of customer satisfaction through improvement in the process of product development and used as the framework of product development. Target planning V-model is a process model represented analysis process and synthesis process as depicted in Figure 1. The target planning level starts at the product level (left up in Figure 1), and then passes down to system, subsystem level and optimizes the design at component level. In the synthesis process, the deliverables received from the previous process by integrating and verifies whether the target of the corresponding analysis process is achieved or not as in the opposite order to the analysis process. In this way, it is obvious at a glance that the process in analysis and synthesis are on the same level. As observed above, using target planning V-model for product development is logically comprehensible and easy to visualize.

Quality model

In product development, classifying quality element is an important process in order to analyze customer's purchase behavior on which element the customer focuses. Kano's quality model [2] represents mainly three types of relationships between functionality and satisfaction, as attractive, must-be and one-dimensional quality element, as each of them represents three different relationship as shown in Figure 2. The horizontal axis indicates the level of a functionality of a specific requirement, while the vertical axis denotes the level of satisfaction towards the level of functionality of that requirement.

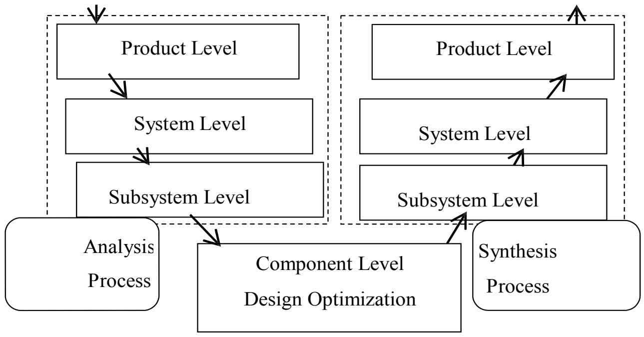

Figure 1: Target planning V-mode.

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The definition of the respective quality elements are as follows (Kano's quality model).

Attractive quality element: Fulfilment of attractive elements will lead to greater than proportional satisfaction. However, the absence of this requirement doesn't result in dissatisfaction because it is not expected.

Must-be quality element: Fulfilment of this attribute will be taken for granted. However, the absence of this requirement will result in big disaffection.

One-dimensional quality element: Fulfilment of this attribute is positively and linearly related to the level of satisfaction. The higher the level of fulfilment, the higher the degree of satisfaction.

These three are the main quality elements but the next two may occur and their definition is as follows.

Indifferent quality element: Whichever the performance is, neither satisfaction nor satisfaction would occur.

Reverse quality element: This quality element neither occurs satisfaction even performance is well or occur satisfaction even the performance is poor.

Kano et al. [2] used a questionnaire for identification for these quality models as shown in Figure 3. It examines what the evaluator feels when functionality is satisfied and not. For each question, there are five choices of answer for each pair of questions: like, must-be, neutral, live with and dislike. Based on the combination of answers of both questions, the requirement is classified as one of the six categories by checking the evaluation table as shown in Table 1.

On the other hand, Shimaguchi [3] defines two types of not being satisfaction. One is a case where satisfaction becomes negative when a customer complains or gets furious because of a trouble in using the product (dissatisfaction). The other one is a case where a customer gets angry or complains, but would not purchase because he/she is not satisfied with the product (unsatisfaction). Also, services provided by corporate can be classified into essential service and superficial service. Type of service that customers do not take for granted for the price but better to have is assumed as superficial service, while service that customers take for granted for the price is assumed as essential service. Shimaguchi demonstrated that the levels of fulfilment of these types of services are correlated with the customer satisfaction level as shown in Figure 3. The horizontal axis shows the fulfilment level and the vertical axis represents the customer satisfaction level.

Customer requiremnets		Insufficiency				
Sufficiency	Like	Q	A	A	A	O
	Must be	R	I	I	I	M
	Neutral	R	I	I	I	M
	Live with	R	I	I	I	M
	Dislike	R	R	R	R	Q

A: attractive, O: one-dimensional, M: must-be, I: indifferent, R: reverse, Q: questionable

Table 1: Evaluation duality chart

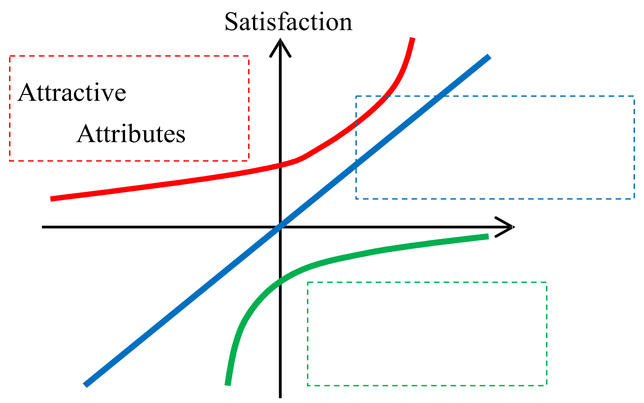

Figure 2: Kano's quality model.

From this Shimaguchi's model, the superficial service of Shimaguchi's can be relate to the attractive quality of Kano's, while the essential service is equivalent to the must-be quality. One-dimensional quality can be included in the superficial quality from its definition, however its graph is almost linier.

Bolster et al. [4] reviewed in their research the models that were obtained from the combination of the questionnaire and the answers and its result and represented all the answer patterns in Kano's quality model. Wang et al. [5] tried to represent functional relation between the fulfilment and the satisfaction and derived the function using regression analysis from the general form of the graph. But in their method, there is the possibility that the curves may cross or meet, which may cause inconsistency. As seen above, there are some studies about Kano's quality model regarding the conceptual correspondence, but it hasn't established the respectable functional relation yet.

Group decision making

Each person has different view in quality attribute, and it is realistically difficult to confirm them to each person and occurs conflict. So, there is need to apply consensus building passed through group decision making in synthesis process.

One of important problem in group decision making is how to solve diverse views. Some methods of consensus building using AHP have been developed. Nakanishi et al. [6] proposed that it can be marshalled by manipulating the individual view or not and manipulating the individual evaluator or not. Above these, group decision making stress method doesn't manipulate the individual view but manipulates evaluator. This method makes evaluators understand themselves each evaluator's measure of compromise which each evaluator has to yield for the group by understanding their own grade and the group view that minimizes the total of all evaluators' frustration (decision making stress).

Research Method

Analysis process

In this study, we denote a product development methodology conducting along target planning V- model, which has been used in product development. We assume the target planning V-model product level, and then system level consists of it, and quality attribute level consists of it. In analysis process, for each evaluator, we calculate the weight of importance of each quality attribute by Analytic Hierarchy Process (AHP) [7] and classify the quality elements leveraging Kano's quality model. Then, we proceed with the analysis down to system level and quality attribute level that realizes the quality attributes to derive the total evaluation values that grasp the customer satisfaction and the importance quantitatively on the quality attribute level. The summation of evaluator j's all degrees of importance becomes 1.0.

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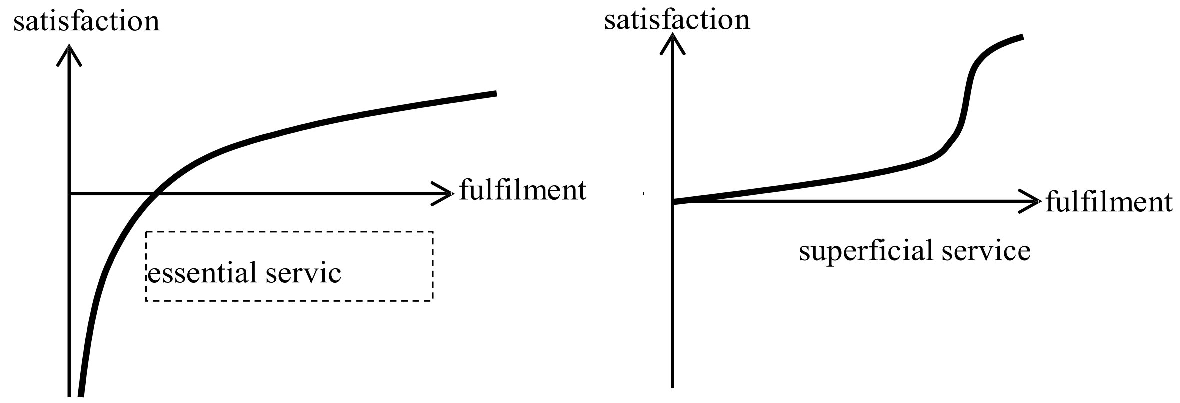

Figure 3: Shimaguchi's quality model.

Calculation of the weight: For the weight of each quality attribute, we use AHP, which is one the decision making methods. AHP is one of the way of reasonable estimating each alternative including ambiguous criterion. As a structure of decision making, there is "overall goal", and there is some "alternatives" for ultimate choice of objective. As there is "evaluation criteria" between "goal" and "alternatives", AHP figures out the structure of decision making. For comparison, using the pair comparison values provided in Table 2, we calculate the pair comparison and then calculate the weight of each evaluation criteria by using it. We define the degree of importance of evaluator's attribute as in this study, we calculate the weight against each evaluation criterion as the degree of importance.

Customer satisfaction function: Utility functions have been used for risk evaluation. There is risk aversion type, risk prone type and risk neutral type, and the definition of them is as follows respectively:

(1) Risk averse type

This type of utility function averts uncertainty and tends to return a value that meets the expected value.

(2) Risk prone type

This type of utility function returns a value even if the actual profit is below the expected value rather than returning a value that meets the expected value.

(2) Risk neutral type

This type of utility function tends to return a value regardless of the relationship between the risk and the expected value every time.

These single attribute utility functions can be expressed as follows (Figure 4).

$$u_i(x_i) = a - b\exp(cx_i) \quad (1)$$

$$x = + x \quad (2)$$

Equation (1) becomes risk aversion type when > 0, > 0, and risk prone type when < 0 , < 0 and Equation (2) is risk neutral type. Example of the graphs is shown in Figure 5. These utility functions can be related with Kano's quality model by its graph as attractive quality element−risk prone type, one-dimensional element−risk neutral type and must-be quality element−risk aversion type. To identify the utility functions, 50-50-chance lottery technique [8] has been devised. Determining the certainty equivalent using the 50-50-chance lottery technique, the utility function can be derived and we can see how the evaluators capture the quality attributes.

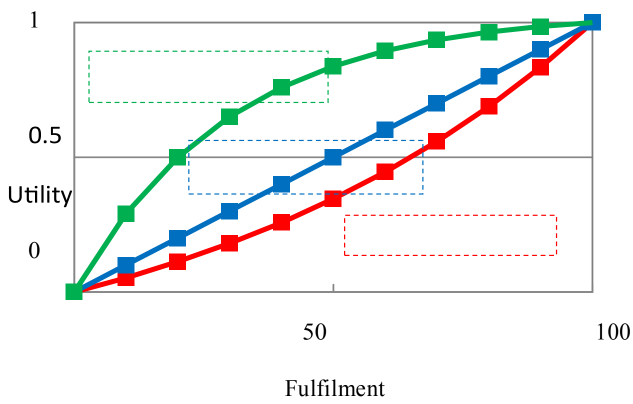

Figure 4: Three types of utility functions.

To express as Kano's quality model in function, as the range of utility function is 0 to 1, we add intercepts to the utility function and define it as customer satisfaction function. The function of each customer satisfaction function for evaluators quality attribute x is as follows when it is attractive quality, one-dimensional quality and must-be quality respectively.

$$x(x) \quad (3)$$

$$x(x) - (x) \quad (4)$$

$$x(x) - (x\ ) \quad (5)$$

Where x, x and x are utility function of risk prone type, risk neutral type and risk aversion type respectively. x is the utmost fulfilment (the best value) and x is average fulfillment in the present market. From the values of the customer satisfaction function that derived from Equations (3) to (5), we can determine the level of customer satisfaction.

By combining AHP and customer satisfaction function, which reflects the quality model that indicates the attitude to the quality attribute, we can figure out simultaneously what quality model the evaluator feels to the quality attribute and the degree of importance of it. Based on this, it will become possible to design a product aiming high customer satisfaction considering the quality model, instead of designing a product referring only to the degree of importance in the conventional product analysis.

To element, elemet is…	
1	equally important
3	slightly more important
5	more important
7	strongly more important
9	absolutely more important
2,4,6,8	for complementary

Table 2: Comparison values.

It is not always possible to obtain a high CS level even if we increase the quality attributes by utilizing only the degree of importance obtained from AHP, but it becomes possible by considering the CS level of the quality attributes at the same time. The total evaluation values for attribute of evaluator is proposed in Equation (6), which makes possible to conduct quantitative evaluation and suggests that to enhance in the descending order of the geometric average of the degree of importance and the CS level.

$$\sqrt{x} \tag{6}$$

Synthesis process

Each person has different view, degree of importance and quality model, in quality attribute, and it is realistically difficult to conform them to each person and occurs conflict. So, there is need to apply consensus building passed through group decision making in synthesis process to consider a product that can earn high customer satisfaction to many evaluators. We synthesize their views for product development in the synthesis process by conducting group decision making stress method from the data of analysis process. To achieve the group decision making with assigning a rate and not manipulating the data, the value that can manipulate is the evaluator 's assigned rate.

So to calculate the group's quality attribute 's degree of importance, group decision making stress S is defined as Equation (9) using the data of analysis process becomes big if there's somebody with similar view and becomes small when with isolated sight. The summation of all the evaluators' assigned rate will be 1 as written in Equation (7). The group's quality attribute's degree of importance will be earned when the value of group decision making stress S gets the smallest by when determined. This can be solved by method of Lagrange multiplier.

$$\sum 1 \tag{7}$$

$$\sum \tag{8}$$

$$\sum \sum (-) \tag{9}$$

This way doesn't matter to evaluators' admissible interval, and each evaluator's measure of compromise which individual evaluator has to yield for the group can be calculated by minimizing group decision making stress. By assigning a rate instead of manipulating each questionnaire result, proper weight of importance in the group can be shown to each of them. Each own sight can be understand in the group where it is, so that each evaluator can change their view for consensus building if needed. This way considers not only the weights of importance but also the individual satisfaction toward them while the single AHP isn't considered it.

While the degree of importance to each quality attribute differs by person, customer satisfaction function, which indicates the attitude to each quality attribute, also differs by person. So the customer satisfaction functions also need to synthesize. Group customer satisfaction function for quality attribute is defined in weighted geometric mean as Equation (10) and its is defined as Equation (11).

$$x(x) \tag{10}$$

$$\sum (x) \tag{11}$$

$$\sqrt{x} \tag{12}$$

Case Study

Outline of case

We conducted a case study regarding the choice of cars to know if the proposed method can be applied. To investigate whether the proposed method can be applied or not, we conducted a questionnaire survey regarding the choice of cars. Alternatives are not only gasoline (hybrid) cars but also contain electric cars and fuel cell cars. This is because if we limit only gasoline (hybrid) cars, it becomes product development of gasoline (hybrid) cars. From the point of view of product development of cars, we can obtain some perceptions of high customer satisfaction product development by containing electric cars and fuel cell cars.

Object of survey：10 people (adult male and female)

Evaluation Criterion：Price, design, functionality, range, fuel cost, carbon dioxide reduction rate

Alternatives：PRIUS, CAROLLA axio, LEAF, Fit EV, MIRAI, FCX Clarity

The definition of each evaluation is as Table 3, and the value conducted to each alternative is as Table 4. Hierarchy chart of cars can be provided in Figure 6 from these. As for upper limit and the lower limit of each evaluation criterion, the maximum and the minimum values are set as in Table 5 in reference to the catalogues and other documents as of November 2014. The average values in this table represent the maximum fulfilment x_best in the current market and the maximum value means the average fulfilment x_ave in the current market.

There may be some people who put more importance on other attributes than the evaluation mentioned above. In this case study, some are an either-or choice for the user to select or not. Consequently, such evaluation criteria are excluded because they cannot be reflected on the method used in this case study. The evaluators replied without considering them when they want to "purchase a new cars". Since most people in family have car today, the evaluators were advised to answer the questionnaire assuming that they "purchase or renew a car".

Evaluation criteria	Definition
Price	The price when the grade is worst (yen)
Design	Exterior appearance (point)
Functionality	Value-added delivering (point)
Range	Possible driving distance when fuel is full (km)
Fuel Cost	Cost of fuel to drive 1000 km (yen)
Carbon dioxide reduction rate	Rate of carbon dioxide reduction when running 1000 km and refuelling for it (%)

Table 3: Each evaluation's definition.

	Price	Range	Fuel cost	Carbondioxide reduction rate
PRIUS	2,232,000(yen)	1,467(km)	5,000(yen)	33.33(%)
CAROLLA axio	1,980,000(yen)	1,188(km)	4,340(yen)	34.27(%)
LEAF	2,797,200(yen)	228(km)	1,280(yen)	48.11(%)
Fit EV	4,000,000(yen)	225(km)	1,289(yen)	47.72(%)
MIRAI	7,236,000(yen)	650(km)	15,818(yen)	100(%)
FCX Clarity	7,000,000(yen)	620(km)	11,284(yen)	100(%)

Table 4: Each alternative's detail.

Results and consideration from the questionnaire

First we show a result in analysis process. The result is from one evaluator and is indicated as Table 6. The degree of importance calculated by AHP, the quality model, the value of customer satisfaction function x when , and quantitative evaluation are compiled in it.

When a quality attribute's degree of importance is high and the quality model is attractive quality, the value of quantitative evaluation becomes high. The value of quantitative evaluation of quality attributes with degree of importance that are not so high become higher when it makes evaluator feel higher satisfaction when its fulfilment becomes more. Referring only to the weight, enhancing the quality attributes in the descending order of the degree of importance may be proper. When quality model is also considered, the quality attributes should be enhanced in the order of price, fuel cost, carbon dioxide reduction rate from the value of when x x. When this is achieved, a higher customer satisfaction level can be gained.

Next we show a result in synthesis process. The result is of group and is indicated in Table 7. Three evaluators assign fuel cost the most important, two people assign it the second most important, and 6 people assign it attractive model. So the degree of importance in group of fuel cost became the most important too. Carbon dioxide reduction rate is assigned as attractive quality by three people and one-dimensional quality by 4 people, but not all people assign it the most important. So the degree of importance in group of carbon dioxide reduction rate resulted in the second. Referring only to the weight, enhancing the quality attributes in the descending order of the degree of importance may be proper. But considering the quality model, the quality attributes should be enhanced in the order of fuel cost, carbon dioxide reduction rate, price is proper from the value of when x x. Comparing with when each evaluator is assigned equally, evaluator number 1, 2, 4, 6 are assigned lightly and number 5 and 7 are assigned heavily. The value of group decision making stress S decreased 0.158%. By minimizing the value of group decision making stress S, we denoted each evaluator's measure of compromise which each evaluator has to yield for the group. Also, it makes possible that where each evaluator's view is in the group so evaluators can change their view if needed.

	Lower limit	Upper limit	Average value	Best value
Price (yen)	7,000,000	1,400,000	3,000,000	1,470,000
Design (point)	0	100	65	5.5
Functionality (point)	0	100	65	7.6
Range (km)	220	2,000	1,130	96
Fuel cost (yen)	15,800	1,000	7,000	80
Carbon dioxide reduction rate(%)	0	100	57	100

Table 5: Lower and upper limit of attributes.

Criteria	Price	Design	Functionality	Range	Fuel cost	Carbon dioxide reduction rate
Value	0.329	0.034	0.121	0.054	0.248	0.102
Rank	1	6	3	5	2	4
Quality model (x)	Attractive (1.583)	One-dimensional (1.150)	Attractive (0.807)	One-dimensional (0.687)	Attractive (1.445)	Attractive (1.178)
Value	0.722	0.198	0.312	0.193	0.599	0.347
Rank	1	5	4	6	2	3

Table 6: Combination of degree of importance and quality model.

Criteria	Price	Design	Functionality	Range	Fuel cost	Carbon dioxide reduction rate
Value	0.143	0.126	0.124	0.155	0.282	0.169
Rank	4	5	6	3	1	2
(x)	1.771	1.686	1.185	1.206	1.752	1.701
Value	0.503	0.461	0.383	0.432	0.703	0.536
Rank	3	4	6	5	1	2

Table 7: Combination of degree of importance and quality model.

Conclusion

We proposed a methodology of product development conducting along target planning V-model having conscious of customer satisfaction in this study. In analysis process, we suggested customer satisfaction function reflecting Kano's quality model which is only conceptually represented. In synthesis process, we synthesize the degree of importance, but we also synthesized the customer satisfaction function. We verified the validity of proposed methodology by conducting case study using cars. By this, we made it clear what kind of attitude evaluators have to quality attribute, which cannot understand only by degree of importance. We made it possible to conduct the quantitative evaluation considering not only the degree of importance but also the quality model. Thus, it is possible to conduct product development considering customer satisfaction. For future study, there is need to consider quality attributes that interact other, and quality attributes that have constrains.

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