A NEW ASSIGNING METHOD OF MANUFACTURING COST TARGET TO PRODUCT COMPONENTS BY USING THE FUNCTION EVALUATION OF CUSTOMERS

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ABSTRACT

This paper presents a proposal of a new method for assigning manufacturing cost target to main components during the product concept design phase, based on the function evaluation values of customers. The main object products in applying this method are those products in their mature stage using existing technology about to enter an existing market. Furthermore, the products are those in which the use/convenient functions play important roles as the distinguishing strategy for the product.

INTRODUCTION

In the development and design phase of a new mature product, the evaluation values frequently obtained after benchmarking competitive products is utilized as standard reference in assigning manufacturing cost target to product components.

However, in many cases, these values are those evaluated from the standpoint of the producer and cannot be said to be those from the customers' standpoint. It will be necessary, therefore, to make the assignments based on values evaluated from functions and their components as seen from customers, in order to increase customer satisfaction.

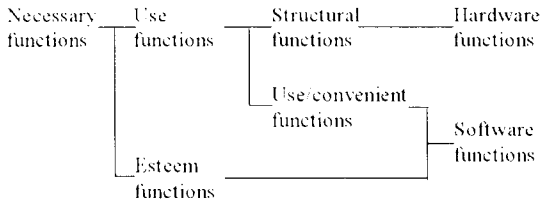
So, preference studies were made in this study on major functions and their main components of a new product to be developed and designed, and a new method is proposed for assigning manufacturing cost target based on the evaluated values obtained as a result.

THE OBJECT PRODUCTS IN THIS STUDY AND THE APPLIED METHOD

The Object Products

The main object products in this study were those products using existing technology about to enter an existing market, especially those in which the use/convenient functions play important roles as the distinguishing strategy for the product.

Those functions of such products which customers can evaluate from the purpose viewpoint are software functions according to the following function classification.



Products with comparatively small esteem function weights were taken up among the software functions in this study, so the objects for evaluation were mainly use/convenient functions and their components. A system kitchen (a type of kitchen ware) was taken up as an application case, and conjoint analysis has been used as the method of analysis in this study.

Steps of this Method

Step1: Making functional family tree of the main functions and their function evaluation

The main use/convenient functions of the object product are defined and a functional family tree is made based on them. The functions shown on this functional family tree are evaluated by

such methods as questionnaires to customers.

Step2: Decision of the main structural blocks, main components, and alternative methods

The main structural blocks (e.g., door, counter, cabinets, etc.) and their main components (material and pattern, shape, width of the door for doors) are decided. Next, alternative methods for materializing the components (natural wood or a plastic patterned board for "material and pattern" of a door) are decided.

Step3: Making multiple new product alternatives and their evaluation

Multiple new product alternatives are made from combinations of alternative methods decided in Step 2. Next, a study for ordering the preference of customers is carried out. Conjoint analysis is applied to the result to evaluate the individual new product alternatives.

Step4: Assignment of manufacturing cost target to individual components

Manufacturing cost target which have already been decided are assigned to individual components based on the evaluation values obtained in Step 3. Thus, manufacturing cost target are assigned to individual components based on the evaluation values decided from the customers' viewpoint.

Step5: Adjustment and decision of the assigned manufacturing cost target

The manufacturing cost target assigned to the product's individual components are compared with rough cost estimation obtained for the individual components, and overall adjustments are made by adding strategic elements to decide the final manufacturing cost target for the individual components.

MAKING A MATRIX TABLE OF FUNCTIONAL CHARACTERISTICS AND MAJOR STRUCTURES AND THEIR MAIN COMPONENTS

Functional Definition and Functional Evaluation of the Object Product

First, the use/convenient functions of a system kitchen were defined as in Figure 1, which were systematically arranged into the 6 functional clusters of cleanness, comfortableness, safety, durability, maintainability, and convenience.

Next, a study was made on the customers' degree of importance of these functional clusters. A similar study was made on the individual functions within the clusters. finally, the evaluation values of each convenient function are determined by calculating importance degree of functional clusters multiply importance degree of individual use/convenient functions in the clusters.

Deciding the Major Structural Blocks and Their Main Components

Detailed structural blocks are necessary to actually achieve the use/convenient functions. Furthermore, individual structural blocks are composed of several components, so the main ones were selected and decided as the objects for evaluation of structural components.

The decided components were as follows. For example, the main components of the structural block "door" were material & pattern, shape, and door width; and the main components of the structural block "counter" were material,

width, and height, while those of the "sink" were material, sink width and depth, and the shape of the drain.

Similarly, those for the "cooking equipment" were heating method, structure of the equipment, output power adjustment, and safety device, while those for the "cabinet" were method of storage, width, depth and height.

Next, a matrix diagram is made from combinations of the use/convenient functions and their components related to their achievement (See Table 1).

Table 1 Matrix Table for Use/Convenient Functions and Their Components

Functions \ Structual blocks				Door			···	Cabinet			
Functinal clusters	Degree of imp.	use/covenient functions	Degree of contri. / Degree of imp	material and pattern	Shape	Door width	···	Method of storage	Width	Depth	Height
				37.2	16.3	15.2	···	30.0	18.0	15.3	26.0
Cleanness	8.6	Difficult to get dirty	2.0	◎	○		···				
		Stains are imperceptible	1.8	○			···				
		Easy to clean	2.0	◎	◎		···	△	△	○	
		Don't smell	2.8				···				
Comfortable -ness	9.6	Easy to cook	2.2				···	○			◎
		Don't get tired even after long work	1.9			△	···	○		△	◎
		Drains well	1.4				···				
		Water doesn't scatter	1.2				···				
		Prevents bad smell	1.0				···				
		Fits well physically	1.1				···				◎
		Don't get in way	0.8			◎	···	○			
Safety	6.2	Water doesn't leak	0.8				···				
		Gas doesn't leak	1.2				···				
		Doesn't flame up	1.0				···				
		Sufficient ventilation	1.0				···				
		Automatic fire extinguishment	0.7				···				
		No shape edges	0.6		○		···				
		Strong against earthquake	0.9				···				
Durability	7.1	Difficult to get scratched	1.6	◎	○		···				
		Sufficient strength	1.7	◎			···		△		
		Doesn't get rickety	1.9			◎	···	△	△		
		Heat-resistant	2.0				···				
Maintain -ability	5.1	Easy to maintain	2.3	○			···				
		Easy to exchange parts	2.8				···	○			
Convenience	10.0	Easy to cook	2.1				···				
		Silent operation	0.6				···				
		Easy to open and close doors and drawers	1.7			○	···	◎	○		
		Large storage capacity	1.3				···	△	◎	○	◎
		Easy to store and take out	1.5				···	◎	○	◎	
		Substantial equipment	0.8				···				
		Easy to adjust heating power	0.8				···				
		Has many functions	1.2				···				

Association of Use/Convenient Functions and Their Components

(1) Clarification the degree of association

Analyze the degrees of association between the use/convenient functions and their individual components, and evaluate them according to the degrees of contribution of the components to the individual functions as ◎, ○, and △. This is the same method used for evaluation in quality function deployment(QFD).

(2) Calculation the contribution degrees of the components and decide the most important component

Quantify the result of (1). ◎ was assigned 4 points, ○ 2 points, and △ 1 point for the case here, and the degrees of contribution were obtained by multiplying these values by the degrees of importance of the use/convenient functions.

For example, the degree of contribution of one of the components of the door "material and pattern" was calculated as follows:(See Table 1)

$$(4\times2.0)+(2\times1.8)+(4\times2.0)+(4\times1.6)+(4\times1.7)+(2\times2.3)=37.2$$

also, contribution degree of "shape" was calculated as follows:

$$(2\times2.0)+(4\times2.0)+(2\times0.6)+(2\times1.6)=16.3$$

The component with the highest degree of contribution will become clear for individual structural blocks from such calculations. The result will be called the most important component.

In the case of component blocks "door", it was a component of "material and pattern".

CUSTOMER PREFERENCE STUDY AND ANALYSIS

Devising New Product Alternatives

There are several alternatives for obtaining a detailed shape and structure for the most important component, so the acceptable alternative method must be decided. It was decided as in Table 2 for this case study after comprehensive discussions and studies.

Table 2 Alternative Methods for Most Important Components in Main Structural Blocks

Structural blocks	Most important component	Alternative methods
Door	Material and pattern	Natural wood , plastic board with stone-like pattern , plastic board with abstract pattern , plastic board with wood-like pattern
Counter	Material	Artificial marble , stainless steel
Sink	Width	70cm, 110cm
Cooking equipment	Heating method	Gas , electric
Cabinet	Storage method	Set of folding doors with hinges , drawer type

Next, new product alternatives were made for studying customer preference by combining the various alternative methods for the most important components. Numerous new product alternatives can be thought of if we consider every possible combination of the most important component alternatives, the following 8 new product alternatives were made by utilizing the L_8 orthogonal array used in the design of experiments to cut down the quantity in this study. (See Table 3)

Table 3 New Product Alternatives

New product alternative	Material & pattern in door	Material in counter	Width in sink	Heating method in cooking equipment	Storage method in cabinet
1	P.B. with stone-like pattern	Artificial marble	70cm	Gas	Set of folding doors with hinges
2	P.B. with abstract pattern	Stainless steel	110cm	Electric	Set of folding doors with hinges
3	Natural wood	Stainless steel	70cm	Gas	Drawer type
4	P.B. with wood-like pattern	Stainless steel	70cm	Electric	Drawer type
5	P.B. with stone-like pattern	Stainless steel	110cm	Electric	Drawer type
6	P.B. with abstract pattern	Artificial marble	70cm	Electric	Set of folding doors with hinges
7	Natural wood	Artificial marble	110cm	Gas	Set of folding doors with hinges
8	P.B. with wood-like pattern	Artificial marble	110cm	Gas	Drawer type

CARRYING OUT ACTUAL PREFERENCE STUDY AND ANALYSIS OF ITS RESULT

Calculation of weights for individual alternatives

The order of preference for the above new product alternatives was decided from an actual study of customers. The effective number of answers was 399. The weights for individual alternatives were calculated by using conjoint analysis to the result of this study.

Part of the weights for the individual alternatives of the 399 customers thus obtained from the calculation are shown in Table 4.

Table 4 Weights for Individual Alternatives

	Door material & pattern				Counter material		Sink width		Heating method of cooking equipment		Storage method of cabinet	
Custom-er studied	Natural wood	P.B. with wood-like pattern	P.B. with stone-like pattern	P.B. with abstract pattern	Artificial marble	Stainless steel	70 [cm]	110 [cm]	Gas	Electric	Set of folding doors with hinges	Drawer type
1	0.32	1.06	1.00	1.62	0.44	0.55	-4.56	2.45	-0.27	1.27	0.23	0.76
2	1.33	1.64	0.44	0.58	-0.24	1.24	-0.13	2.13	0.61	0.38	-0.17	1.17
3	1.41	1.47	0.83	0.26	-0.29	1.29	-0.27	2.27	0.84	0.15	0.62	0.37
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
398	0.78	1.76	1.40	0.036	1.43	-0.43	2.44	-0.44	1.07	-0.072	0.48	0.51
399	2.33	0.84	-0.65	1.47	0.21	0.78	1.23	0.76	1.02	-0.024	0.61	0.93
Avg.	0.93	0.52	1.20	1.35	0.13	0.86	0.40	1.59	0.57	0.44	0.56	0.43

Calculation of the degree of importance of individual most important components

After the weights of the individual alternatives become clear, the degrees of importance of the individual most important components can be calculated based on the obtained weights.

The method of calculation was done according to the method of conjoint analysis from the following equation by considering that the component with the largest difference among the weights for the individual alternatives within the most important components was considered as the most important by the customer.

$$\alpha_i = \left| \max(\beta_j) - \min(\beta_j) \right| \qquad \cdots (1)$$

Here, α_i is the importance score for individual most important components for customer i, and β is the weight for the j-th alternative of a component.

The importance for individual most important components are calculated for individual customers, so their average was obtained as follows and considered this as the degree of importance for all the customers.

$$\text{Degree of importance for individual most important component} = \alpha_i / \sum \alpha_i \qquad \cdots (2)$$

For example, for the case customer No.1, the score for the degree of importance of the door's "material & pattern" can be calculated as follows (See Table 4).

$$\alpha_i = |1.62 - 0.32| = 1.30 \qquad \cdots (3)$$

The importance scores of most important components could be obtained using the procedure above mentioned for the counter, sink, cooking equipment, and cabinets.

Thus, the degrees of importance of individual most important components were obtained for individual customers, and the values for the entire customers were also obtained. And the ratios of the

individual components to the total degree of importance of the most important component were obtained and considered as the degrees of importance of the individual components.

Furthermore, when doing the above calculations, if the customers are segmented according to various viewpoints, the degrees of importance of the individual components for individual customer segments (for example, the degrees of importance of the individual components for individual age groups) can be calculated. Customer segmentation according to age groups was done in this study to obtain the degrees of importance.

Analysis of the degrees of importance for individual components

If the degrees of importance for individual components according to age groups are obtained, then we can know which components are considered important when customers evaluate a product. In the case here, it became clear that the degree of importance of the "door" was high for customers in the 20's and 60's while the degree of importance of the "sink" was low.

On the other hand, the degree of importance of the "door" became lower for customers between the 30's and 50's as their age increased, while that of the "sink" had the tendency to become higher.

In the case of system kitchens, customers in the 30's to the 50's age group compose about 80% of those purchasing them, so product concepts should be made by direct consideration of such reality. It will thus become necessary to assign manufacturing cost target to components in such and such a manner as mentioned above. For example, if new product development and design is aimed at the general public, then it will be desirable to assign manufacturing cost target according to the degree of importance of individual components based on the average values of the customer evaluations for customers in the 30's to the 50's age groups.

THE DEGREE OF IMPORTANCE OF INDIVIDUAL ALTERNATIVES AND THEIR COST ESTIMATION

The Most Desired Alternative and Its Degree of Importance

The degree of importance of individual most important components were calculated in the above calculations, but there are several alternative methods for realizing individual most important components (3～4 for the cases taken up here), so the degrees of importance of individual most important components will differ according to which alternative methods are selected.

So, it becomes necessary to calculate the degrees of importance of individual alternatives according to the above-mentioned method. Thus, these were obtained according to the above-mentioned method to decide which alternative the customers desired the most.

The alternatives desired the most by the customers and their degrees of importance thus obtained became as shown in Table 5 by segmenting by the age groups of the customers.

Table 5 Degrees of Importance by Age Groups of Most Desired Alternatives

Alternatives desired the most		20's	30's	40's	50's	60's	Avg.
Material & pattern of door	P. B. with stone-like pattern	**40%**	**33%**	**31%**	**26%**	**31%**	**32%**
Material of counter	Stainless steel	**20%**	**20%**	**17%**	**17%**	**23%**	**19%**
Width of sink	110 cm	**25%**	**27%**	**28%**	**33%**	**19%**	**27%**
Heating method of Cooking equipment	Electric	**7%**	**9%**	**15%**	**13%**	**15%**	**12%**
Storage method of cabinet	Set of folding doors with hinges	**8%**	**11%**	**10%**	**10%**	**12%**	**10%**
		100%	**100%**	**100%**	**100%**	**100%**	**100%**

Table 5 shows the degrees of importance in percentage of the most desired alternatives by age segmentation. It is considered very useful in conceptualizing customer-oriented products to assign manufacturing cost target to components based on values revised by adding strategic elements to the percentage obtained as above.

The Evaluation of the Customers' Alternatives and The Producer's Cost Estimates

It is desirable to assign the manufacturing cost target to individual alternatives by such methods as above, but it frequently do not become as such in reality. It has been found by comparing the manufacturing cost target assigned to individual alternatives by this desirable method and the estimated cost by adopting the alternatives to become as follows. That is, the electrically heated cooking equipment should reduce its cost approximately 50% of its estimated cost, and the cabinet with a set of folding doors with hinges reduce its cost about 30% of its estimated cost.

On the contrary, it was found out that the 110 cm sink could achieve a manufacturing cost 30% that of the customer evaluation value.

It becomes necessary to assign manufacturing cost target strategically by such analyses, and it will sometimes also become necessary to improve cost and/or improve functions by VE.

CONCLUSIONS

The assignment of manufacturing cost target to components has in most cases carried out from the standpoint of the producer. These methods might be useful assigning manufacturing cost target in the introductory or growth phases, but they are usually inadequate for products in their maturity phase. This is especially true in cases when the use/convenient functions play important roles in distinguishing strategy of the product.

Thus, a new proposal has been made in this paper for assigning manufacturing cost target to structural blocks and components of products to be developed and designed in a reasonable way based on the functional evaluation of customers. As a reasonable way, We used conjoint analysis to evaluate the degree of importance of structural blocks and components of product.

However, the values obtained by this method is assignments based only on the use/convenient function evaluations of the customers, and there are many cases in which the actual results do not agree to the calculated results.

Therefore, the manufacturing cost target should be assigned to structural blocks and components which are agreeable to the engineers in charge of the development and design of the products by the overall evaluation of both the evaluated values by this proposed method and those by the producers' evaluation integrated from managerial strategy.

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