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# An Approach to Dealing with Importance Weights of Customer Needs and Customer Dissatisfaction in Quality Function Deployment Optimization

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**Abstract.** This paper explains about the necessity of Quality Function Deployment (QFD) optimization model due to the absence of the formal methodology in QFD for allocating the available product development resource to determine the best possible product specifications. The proposed optimization model also deals with the improper handling of customer need's importance weight and customer's satisfaction and dissatisfaction feeling in the QFD process.QFD assumes that the customer need's importance value is equivalent with the satisfaction level perceived by the customer when the need is met. However, most of the time, a fulfillment of an extremely important customer need does not lead to any improvement in customer satisfaction.QFD also considers that customer satisfaction level will increase automatically as the customer dissatisfaction sources are eliminated. This is not always true, since the sources of customer satisfaction and dissatisfaction are not always the same. Thus, fulfilling a certain customer need to improve customer satisfaction does not automatically reduce the customer dissatisfaction, and vice versa. In order to explain the effect of the customer needs fulfillment on customer satisfaction and/or dissatisfaction, Kano's model is used. A pencil design example is also presented in the paper. Using Kano's model in QFD optimization helps to distribute the available product development resource in an effective way to increase the customer satisfaction and to reduce the customer dissatisfaction.

## Introduction

Quality Function Deployment (QFD) is a structured product design methodology that aims to maximize customer satisfaction [1], [2], [3], [4]. Despite its ability to translate the customer needs into representative product design, there are some flaws concerning the methodology. QFD does not provide a formal procedure in allocating organization's resource that is available to be used for developing product which leads to the maximum level of customer satisfaction [3].

Moreover, in the QFD, design team commonly regards the importance weights of customer needs as the impact values on customer satisfaction as those needs are fulfilled. However, some customer needs with great importance weight lead to very low satisfaction, even when those are fully met. Such those needs may only subject to customer dissatisfaction when improperly fulfilled [2], [4].In the other hand, a certain customer need with low importance weight may lead to high level of customer satisfaction, even when it is not fully met. Consequently, the impact value of customer need fulfillment to customer satisfaction and/or dissatisfaction should be considered as a different aspect from the importance weight of customer need.

Kano's model that was developed by Noriaki Kano explains that not all fulfillments of the customer needs have the same impact value on customer satisfaction and/or dissatisfaction. According to the intensity of its impact on customer satisfaction and/or dissatisfaction as those needs are fulfilled at certain level[2], Kano's model categorizes the customer needs into several main groups, those are must-be or basic, one-dimensional or satisfier, and attractive or delighter type of customer needs.

Regarding that the impacts of customer needs' fulfillments can be different; the design team should consider those impacts when meeting the customer needs in product development process. Focusing on the customer needs that have low impact on customer satisfaction does not lead to above average product design [2]. On the other hand, low product performance or capability in meeting those needs may cause customer dissatisfaction.

Furthermore, Kano's model also states that customer needs fulfillments which trigger customer satisfaction may be different with those which may cause customer dissatisfaction. Hence, fulfillment of a certain need to improve customer satisfaction does not automatically eliminating or even reducing customer dissatisfaction. Correspondingly, a successful product development project should not only consider the customer satisfaction aspects, but also customer dissatisfaction as well [4].

Considering those issues, this paper presents a formal QFD methodology for allocating the organization's available resource for product development project in order to determine the optimal target specifications as early output in QFD process. The formal methodology presented in this paper is in the form of a mathematical model. Kano's model is integrated in the model to explain about the relations of customer needs fulfillments with customer satisfaction and/or dissatisfaction. According to the proposed model, organization's resource is allocated to improve the engineering characteristics that later will affect the product performance in meeting customer needs. The priority values of the customer needs determine which customer need will become the focus of product development project. An important customer need with strong impact on customer satisfaction as it is met gets major priority value. More over, the proposed mathematical model also prevents the customer dissatisfaction to occur. The complete optimization model is presented in the next section.

## The Proposed Optimization Model

The objective of the proposed model is to emphasize the product development process in meeting important customer needs which have great impact on customer satisfaction as fulfilled. It also works intensely on driving down the customer dissatisfaction of important customer needs. The objective function is written as follows:

$$\text{Max } Z = \sum_i w_i \times (S_i + DS_i). \quad (1)$$

Where:

$w_i$ = relative importance weight for customer need $i$, $0 \le w_i \le 1$.
$S_i$ = satisfaction score that is achieved through meeting the customer need $i$, $0 \le S_i \le 1$.
$DS_i$ = dissatisfaction score that is remained as the result of customer need $i$ fulfillment, $-1 \le DS_i < 0$.

The objective function is developed to drive the satisfaction and dissatisfaction score to the bigger value. The bigger value of the satisfaction score means the higher satisfaction that is perceived by the customer, while -1 for the dissatisfaction score represents the most dissatisfaction feeling. Hence, maximizing the objective function means maximizing the customer satisfaction and minimizing the dissatisfaction that is perceived by the customer.

The constraint functions are presented by Eq. 2 to Eq. 11.

$$\forall i: P_i = \beta_{i0} + \beta_{i1} \times x_1^c + \beta_{i2} \times x_2^c + \cdots + \beta_{ik} \times x_k^c + \varepsilon_i. \quad (2)$$

$P_i$ represents functional relationship between the level of product performance in meeting customer need $i$ and the level of engineering characteristics related. $P_i$ values range from near 0 when $x_1^c, x_2^c, \cdots, x_k^c$ are in the worst level to around 1 when $x_1^c, x_2^c, \cdots, x_k^c$ are in the best level. $\beta_{i1}, \beta_{i2}, \cdots, \beta_{ik}$ are used as substitutes of subjective ratings, for example 1-3-9, and denote the relationship values between customer need $i$ and the related engineering characteristics $0,1,2,\cdots,k$.$\beta_{i0}$ expresses the regression coefficient that is associated with $P_i$.$\beta_{i1},\beta_{i2},\cdots,\beta_{ik}$ which are obtained using regression method are considered as the more appropriate judgments than subjective ratings [1]. The use of linear regression method demands the engineering characteristics should be statistically independent.

$x_j^c$ is the coded form of the value of engineering characteristic $j$. The values of engineering characteristics are converted into the coded forms which range from 0 to 1. The conversion is done by using Eq. 3.

$\forall j: \quad x_j^c = \frac{(x_j - L_j)}{(U_j - L_j)}$ for the case more is better, or

$$x_j^c = \left|\frac{(x_j - U_j)}{(U_j - L_j)}\right| \quad \text{for the case less is better, } 0 \le x_j^c \le 1. \tag{3}$$

As defined by Eq. 4, $P_i$ may have a minimum level$\gamma_i$to accommodate the competitive environment of the product market.

$$P_i \ge \gamma_i. \tag{4}$$

$$\forall j: \quad L_j \le x_j \le U_j. \tag{5}$$

$U_j$and $L_j$ represent the upper and lower value of the technically allowed values of engineering characteristic $j$ . Target value of engineering characteristic $j$ that is denoted by$x_j$ lies between $U_j$ and $L_j$.

$$B \ge \sum_j c_j \times \left|(x_j - x_j^0)\right|. \tag{6}$$

$B$ units organization's resource such as R&D budget are available for product development project. It is used for improving the engineering characteristics. $\left|(x_j - x_j^0)\right|$ denotes the amount of improvement for engineering characteristic $j$ from its origin value $x_j^0$ to its target value $x_j$ while $c_j$ denotes the cost needed to make a unit improvement of engineering characteristic $j$.

For each customer need, it should be classified into one of Kano's model's type of customer needs. This can be done by using Kano's model's questionnaire (see [2] for the details).Moreover, Tan and Shen have developed the functional representation of customer satisfaction and product performance based on Kano's model (see [5] for the details). The adjusted form of Tan and Shen's proposed function is then applied for the relevant type of customer need as presented below.

For each customer need ($\forall i$):

If customer need $i$ is a Kano's attractive type of customer need:

$$DS_i = 0. \tag{7}$$

$$S_i = min\left(\left[\left(\frac{P_i}{P_i^*}\right)^{m_i} \times S_i^*\right], 1\right), m_i > 1. \tag{8}$$

The attractive type of customer need is a category of need that customer is unaware of its existence. Therefore, it does not lead to any dissatisfaction feeling when unmet. However a considerable low product capability in fulfilling it will delight customer and trigger a nonlinear customer satisfaction level. The maximum satisfaction score is 1 that represents the highest level of satisfaction that perceived by the customer. The satisfaction score bigger than 1 is considered irrelevant, thus such score is converted to 1.

Supposed that $S_i$ can be determined by using the functional relationship of $S_i = \pi_i \times P_i^{m_i}$, $\pi_i$ is a positive constant and $S_i^*$ is the satisfaction score that is produced by product performance level $P_i^*$. Thus, $\frac{S_i}{S_i^*} = \frac{\pi_i}{\pi_i} \times \left(\frac{P_i}{P_i^*}\right)^{m_i}$. Next, $S_i$ can be defined as $\left(\frac{P_i}{P_i^*}\right)^{m_i} \times S_i^*$.

A quadratic function may be used to represent the relationship between $S_i$ and $P_i$ [5]. $S_i^*$ can be obtained by doing a survey, the respondents are asked to assess the satisfaction perceived as the consequence of $P_i^*$. Using the survey result and $m_i = 2$, $S_i$ can be computed using Eq. 8. Otherwise, the parameters of the function $S_i = \pi_i \times P_i^{m_i}$ should be identified and the complete function should be developed before $S_i$ can be computed.

If customer need $i$ is a Kano's must-be type of customer need:

$$S_i = 0. \tag{9}$$

$$DS_i = max\left(\left[\left(\frac{P_i}{P_i^*}\right)^{n_i} \times DS_i^*\right], -1\right). \tag{10}$$

Eq. 9 and Eq. 10 explain that a must-be type of customer need is a kind of need that subjects to the customer dissatisfaction when unmet. Here the maximum customer dissatisfaction is scored as -1. It is considered as maximum dissatisfaction feeling that perceived by the customer. The negative value lower than -1 for the dissatisfaction score does not have important meaning, thus it is converted to -1. Furthermore, according to Eq. 9, a must-be type of customer need does not have contribution to customer satisfaction, even when the product has maximum capability in meeting it.

It is assumed that a functional relationship of $DS_i = \mu_i \times P_i^{n_i}$ is exist, $\mu_i$ is a constant and $DS_i^*$ is the dissatisfaction score that is produced by product performance level $P_i^*$.Eq.10 is obtained in a similar way to get Eq. 8 except that $\mu_i < 0$ and $n_i < 0$. As an adjustment of Tan and Shen's satisfaction function, $-2$ can be chosen as an option of $n_i$. Similar to $S_i^*$, $DS_i^*$ can be obtained by doing a survey, and $DS_i$ can be computed using Eq. 10.

If customer need $i$ is a Kano's one-dimensional type of customer need:

$$F_i = \alpha_i \times P_i + \theta_i,$$
$$\text{if } F_i \geq 0 \text{ then } \left(DS_i = 0, S_i = min(F_i, 1)\right),$$
$$\text{if } F_i < 0 \text{ then } (DS_i = max(F_i, -1), S_i = 0). \tag{11}$$

The one-dimensional type of customer need is the one that subjects to customer satisfaction when met, but also subjects to customer dissatisfaction when it is not properly fulfilled. As stated in Eq. 11, the customer satisfaction increases in a linear manner as the product capability in meeting the respective need improves. The satisfaction or dissatisfaction that is perceived by the customer is represented by a linear function $F_i$ which its slope is denoted by $\alpha_i$ and intercept is denoted by $\theta_i$. The function $F_i$ can be constructed using the result survey, respondents are asked to measure their feeling about at least two different levels of product performance. Moreover, $F_i$ may occur in both the negative or positive value. When $F_i$ is a positive value, it is regarded as the customer satisfaction score. $F_i$ is regarded as the customer dissatisfaction score when it is a negative one.

## Numerical Example

A pencil design example is presented to show how to use the proposed model. The example was adapted from [1] and [3]. Three customer needs were collected: Easy to hold ($CN_1$), Does not smear ($CN_2$), Indicate personal identity ($CN_3$) with the related relative importance weights: 0.441 ($w_1$), 0.358 ($w_2$) and 0.200 ($w_3$). Using Kano's model's questionnaire (see [2]), it was concluded that $CN_1$ is a must-be, $CN_2$ is a one-dimensional and $CN_3$ is an attractive type of customer need. Three relevant engineering characteristics were then identified: Diameter ($EC_1$; in mm), Pencil cap ($EC_2$;

binary variables), Name space ($EC_3$; in mm). $P_1$ and $P_3$ were obtained using linear regression method. Those functions show how $CN_1$ and $CN_3$ relate to certain engineering characteristic(s). As $CN_2$ is only related to $EC_2$ which its values are binary, it was considered unnecessary to construct $P_2$. Instead, survey results were used to determine $S_2$ and $DS_2$. The survey revealed that respondents felt just about completely satisfied when a pencil was designed with a cap, but they experienced neither the dissatisfaction nor satisfaction feeling when a pencil was designed without any cap. The allowable $EC_3$ values are 0 that means there is no space; or 20 to 50 mm length space to write the personal identity on the pencil. For $EC_1$, the allowable range lies from 6 to 7.2 mm. $DS_1^*$ (-0.206) for relevant $P_1^*$ (0.66) and $S_3^*$ (0.771) for relevant $P_3^*$ (0.637) were obtained by doing a survey. IDRs 1050 were available to improve the design. IDRs 867.36 were needed to make a unit of improvement of $EC_1$, IDRs 153.41 were needed to make $EC_2$ and IDRs 9.76 were needed to make a unit of improvement of $EC_3$. The complete optimization model for pencil design example is as follows.

Max $Z = 0.441 \times (S_1 + DS_1) + 0.358 \times (S_2 + DS_2) + 0.200 \times (S_3 + DS_3)$

Subject to

$$P_1 = 0.665 + 0.341 \times x_1^c$$
$$P_3 = 0.0472 + 0.983 \times x_3^c$$
$$x_1^c = \frac{(x_1 - 6)}{(7.2 - 6)}$$
$$x_3^c = \frac{(x_3 - 0)}{(50 - 0)}$$
$$6 \le x_1 \le 7.2$$
$$x_2 \in \{0,1\}$$
$$x_3 = 0 \vee 20 \le x_3 \le 50$$
$$1050 \ge 867.36 \times (x_1 - 6) + 153.41 \times (x_2 - 0) + 9.76 \times (x_3 - 0)$$
$$S_1 = 0$$
$$DS_1 = max\left(\left[\left(\frac{P_1}{0.66}\right)^{-2} \times -0.206\right], -1\right)$$
$$x_2 = 0 \Rightarrow (S_2 = 0;\ DS_2 = -1)$$
$$x_2 = 1 \Rightarrow (S_2 = 1;\ DS_2 = 0)$$
$$DS_3 = 0$$
$$S_3 = min\left(\left[\left(\frac{P_3}{0.637}\right)^{2} \times 0.771\right], 1\right)$$

Using Lingo 13.0, the following optimal solutions were found.

| Variable | Value |
|---|---|
| Z | 0.3157950 |
| S1 | 0.000000 |
| DS1 | -0.9762265E-01 |
| S2 | 1.000000 |
| DS2 | 0.000000 |
| S3 | 0.4232896E-02 |
| DS3 | 0.000000 |
| X1 | 7.033700 |
| X2 | 1.000000 |
| X3 | 0.000000 |
| P1 | 0.9587431 |
| X1C | 0.8614166 |
| P3 | 0.4720000E-01 |
| X3C | 0.000000 |
| B | 1050.000 |

According to the optimal solutions, the customer dissatisfaction could be avoided in the design by using the target specifications obtained (the value of $DS_1$ is just about to reach 0 and the others ($DS_2$ and $DS_3$) are 0. The customer satisfaction was increased by meeting $CN_2$. It was considered more efficient to spend IDRs 867.36 of budget to make improvement of $CN_2$ and spending the rest for eliminating dissatisfaction than spending minimum IDRs 195.2 of budget to make improvement of $CN_3$ and spending the rest for eliminating dissatisfaction. By the first option, total increase of 0.316 points of Z was obtained, while the second one gained the maximum of 0.244 points of increase in Z.

## Summary

Using the proposed optimization model as a formal guidance to allocate the available product development resource, a team design will be able to determine the optimal engineering specifications that focusing on meeting the important customer need which has great impact on customer satisfaction, while also intensely working on decreasing the customer dissatisfaction that is risen from improper fulfillment of certain important customer need. The optimal solutions of the pencil design example shows that the developed model has performed as intended.

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## References

[1] Askin, R. G., Dawson D. W., Maximizing customer satisfaction by optimal specification of engineering characteristics, IIE Transactions 32 (2000) 9-20.

[2] Matzler, K., Hinterhuber, H. H., How to make product development projects more successful by integrating Kano's model of customer satisfaction into quality function deployment, Tehnovation 18(1)(1998), 25-38.

[3] Wasserman, G. S., On how to prioritize design requirements during the QFD planning process, IIE Transactions 25(3)(1993) 59-65.

[4] Rahaju, D. E. S., Dewi, D. R. S., Dealing with dissatisfaction measure in QFD model to derive target of engineering characteristics, International Journal of Industrial Engineering 18 (12) (2011), 634-644.

[5] Tan, K. C., Shen, X.X., Integrating Kano's model in the planning matrix of quality function deployment, Total Quality Management 11 (8) (2000), 1141-1151.

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