Quality Initiative Resource Allocation To Maximize Customer Satisfaction In QFD – Kano Model

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Abstract

Among the quality initiative targets, customer satisfaction becomes company main focus. Unfortunately the customer satisfaction is a moving and invisible target that is very hard to realize. Traditional QFD integrated with Kano Model is one of the attempt devoted to overcome these problems and has been extensively used. This paper considers resource allocation aspects into the QFD and Kano Model. Kano Model divides customer's requirements into three group requirements: must be, one dimensional, and excitement. Generally those requirements are fulfilled by using strategy of : maintain, improve, and innovate respectively. Resource needed for these programs are different and will be modeled as an optimization problem in order to maximize the customer satisfaction with regard to operational resources and also improvement strategy chosen by the company.

Keywords**:** Quality initiative, Resource allocation, QFD, Kano

1. Introduction

To be successful, companies in today's global market have to initiate some quality programs. One of the quality initiatives have to focus on satisfying customers. It means that companies have to be able to design, develop, and manufacture products that will be preferred by their customers. Unfortunately the customer satisfaction is a moving and invisible target that is very hard to realize [1]. Customer satisfaction is defined as a condition where customer perception about products or services they received is equal to or more than those they expected. Naturally customer expectation is dynamic that moves over times. Besides that, customer expectation is in the form of an invisible and abstract needs. It is very difficult to accurately get the customer expectation even either to fulfill it.

A methodology that aids in the effort to get the customer expectation and its deployment into the technical respond is quality function deployment (QFD) [2], [3]. The QFD methodology provides a structured framework for ensuring that the customer needs are properly identified and then are translated into product design requirements, production processes requirements, manufacturing system requirements, and control of operation requirements sequentially. Unlike many quality methodologies that usually were developed in the West and transferred to other country, QFD was originated in Japan and has been adopted by many companies in the world. At the beginning of QFD development, it is applied primary in product design processes. Only a few years later the application has grown very vast expanded to broader field including design, planning, management, engineering, decision making, etc.

The success of the QFD methodology application much depends on the correct customer needs priority [4]. Customer requirement priority will strongly affect the level of technical responds. Many papers have published reporting methods to be used in an effort to rank customer requirements. The earliest method is to use a point scoring scale (Likert scale). The score is often obtained from customer survey or expert opinion. However, different customers or experts have different perceptions toward the same requirement. To cope with this situation it is proposed to use a group decision making technique to obtain the importance weights for customer requirements. In facts, this method cannot always work effectively because many customers and experts tend to rate every requirements more importance than those supposed to be. Then, AHP is proposed to be used in rating customer requirements and analyzed the sensitivity of the customer voice in QFD. From the other perspectives, customers' opinions are often containing ambiguity and multiple meanings. Other methods are also used a conjoint analysis method to determine the relative importance of the customer requirements. From the customer perspective, all the above methods have the same characteristics. They are customer-driven design. However companies must consider competitors' positions to make sure that their own products would not lag behind their competitors' products. In the current literature, there are some existing methods that incorporate competitors' information to prioritize customer requirements. The first widely used method is the sales point method. The second is the entropy method [4].

This paper considers resource allocation aspects into the QFD and Kano Model. It is difference from the previous methods in deciding the fulfillment of the technical responds level. The previous methods only take the customer and the competitor perspective into consideration. The most importance part, management of the company that has its own strategy, was neglected. Company's complaint data that is usually kept by marketing department was not used as a valuable input of the QFD. Kano Model divides customer's requirements into three group requirements: must be, one dimensional, and excitement. Generally those requirements are fulfilled by using strategy of: maintain, improve, and innovate respectively and it is aligned with quality initiatives programs. Quality initiative programs could be in the form of maintenance, improvement or innovation. All program activities will need some resources. How many Resources needed to perform these activities are different and will be modeled as an optimization problem in order to maximize the customer satisfaction with regard to operational resources and also improvement strategy chosen by the company.

2. Literature Reviews

2.1. QFD Initiation

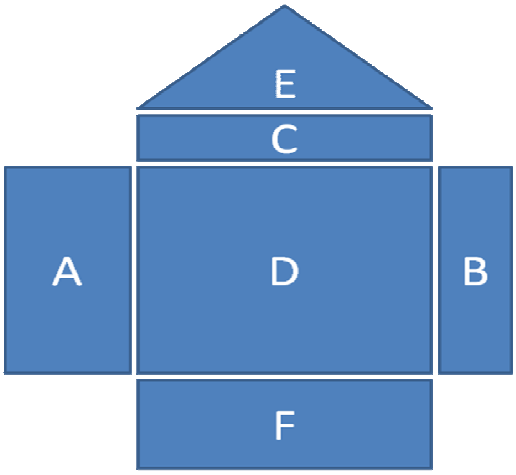

Figure 1. The generic House of Quality

Quality Function Deployment (QFD) was introduced by Yoji Akao from Japan in the late 1960's. it is a practical and effective method for developing products or services. QFD systematically deploys customer requirements into technical attribute of products / services. The QFD method includes building matrices known as quality tables. The first matrix is named the Voice of Customer (VoC) on the left hand side, and the technical response to meeting those needs along the top. Figure 1 shows each of the sections contained in the HoQ. Every section holds importance data specific to a part of the QFD analysis. The matrix is usually completed by a specially formed team, who follow the logical sequence suggested bythe letter A to F, but the process is flexible and order in which HOQ is completed depend on the team.

Section A has a list of customer needs. Section B contains market data, strategic goal setting for the new product and computations for prioritizing the customer need. Section C includes information to translate the customer needs into the organization's technical language. Section D contains the relationship between each customer need and each tec hnical response. Section E (the "roof") assesses the correlations between elements of the technical response. Section F contains the prioritization of the technical response, information on the competitors and technical targets. Moving on from the HoQ, QFD comprises the building of other matrices that help to make detailed decisions throughout the product development process.

2.2. QFD Implementation and Development

QFD's popularity has been becoming worldwide. It is reported many applications and studies in many countries such as Australia, Germany, Hong Kong, India, Netherlands, the UK and the United States (US) and may be more countries. QFD was exercised to develop some kinds of products such manufacturing products, beauty products, textiles, and also foods and health products. QFD also had been applied to develop products in the Small Medium Enterprise (SME). In addition, QFD facilitated the development of improve their ergonomic design. One major producer of remanufactured diesel engine components exploited QFD because one of its plants was receiving complaints from marketing concerning a single part package used for certain fuel system' s products. At the end of the QFD process, the customer's voice was successfully translated into satisfactory packages

Lu et al (1994) integrated the Analytical Hierarchy Process (AHP) and Benchmarking into the House of Quality, used them for marketing policy analysis [5]. According to the authors, long-range market planning is essential in order to change corporate culture, and to meet or exceed customers' needs while making a profit. They support that this can be achieved using their model, which is based on the QFD process.

Aspinwall et al., (1988), constructed a QFD matrix from the framework of quality dimensions in higher education. The authors took into account issues such as: design of programs of study, delivery and management of programs of study, assessment of students service support of programs of study. Guidance and support of students, admissions, recruitment, appraisal and development of staff. In this case, the customers were students, staff and employees. Once QFD was utilized, the measurement framework developed could be used as a basis for process improvement in an education setting. Jia,GZ, et al., (2011) used QFD in developing manufacturing strategy[6] to manufacturing strategy and corporate strategy.

3. Responding Customer Requirement Category

The Kano model has been implemented in many fields. Number of papers reported the Kano model was used and evaluated as a very useful mean. This study criticizes the way on defining the requirements and treating the Technical Responds of the previous methods. Most of the papers mentioned that survey using questionnaire have revealed customer requirement categories. It is fine, but it contains a little contradiction to the essence of Kano's category. By definition, must be requirement is a requirement that customer takes it for granted. It is not stated (un-spoken) by the customer but expected. So, it does not need to ask the customers. The must be requirement refers to basic performance of a product. That is why, it is better to take customer's complaint on the basic product performance as the must be requirement. The must be requirements could come from complaint data collected by the company and should be treated by maintaining the basic functions of the products/ services.

It is also happened to the excitement requirements. According to the initiator, this category is needed to accommodate the un- expected but appreciated requirements [7]. It should be in the form of extra features purposefully inserted into the product by the company management. Steve Jobs, the principal owner of Mackintosh company, told that customers should have no idea about these requirements at the design stage of a product [8]. So, why it is asked to the customers? Basically it depends on the product designer initiatives. It is more about company management demands or strategy than customer needs. It does not need to do survey for this customer requirements category. Instead, company management should decide whether attaining the current level operations or taking new challenges.

It is always going to be, doing survey for defining one dimensional customer requirements. One dimensional customer requirements are expected and formally stated. Asking them to the customer is definitely correct. From the above explanation, it can be concluded that product design requirements do not always come from customers, the other stake holders such as company management, community, and government may raise the other requirements.

After getting all requirements then product developer team should choose technical respond appropriately. It is

importance to ensure that all technical responds accurately solve all requirements. Respond on must be requirements should difference to those of one dimensional or excitement requirements [6]. It is reported that must be requirement should be responded using strategy of maintain. Furthermore, one dimensional and excitement requirements should be responded by means of improve and innovate strategy respectively. In term of cost needed to operate the three strategies, maintain program is easier and less cost. Improve program will consume more funding than maintain program but could be less than innovate program.

4. Optimization Model

The optimization model objective is to figurate the case of maximizing customer satisfaction. This paper assumes that customer will be fully satisfied when all their requirements are totally given. Company should realize all technical responds needed to generate products or services which are suited to the customer requirements. It means that all required resources should be prepared and allocated. Specific form of the required resources will much depend on kinds of the technical responds to develop. It may be easier to take financial form to represent all kinds of resources. Unfortunately, in general situation financial budgets are limited [9]. So, the company has to choose which technical responds should be prioritized and how much resource should be allocated.

Before choosing the technical respond, it should be emphasized that customer requirements are divided into 3 categories: must be, one dimensional, and excitement [1], [4], [10], [11]. Generally those requirements are fulfilled by using strategy of: maintain, improve, and innovate respectively. Strategy of maintain means that if management feels comfortable with current performance of the basic function of the product, they should hold the current system without any changing. Too much trying on the must-be-requirements are meaningless. Customers will be not perceived them as a big deal. Customers take them for granted. [12], [13]. A Changing is needed only if the current product basic function performance is poor. Though, Quality cost is needed to maintain the operation of current system. Characteristic of maintain strategy differs from strategy of improve. Strategy of improve means that management have to change the current system into a better manner. Cost of quality is needed to perform quality improvement projects. The last, Strategy of innovate means that management should provide something new (original) to be better performance and delight customers. Number of innovation program usually is small but it could be involved a large cost.

A company usually allocates budget for all departments in order to operate all company programs including the quality department programs. The quality department will receive a certain budget portion needed to maintain, improve, and innovate quality. This budget will become constraints for the quality department operation. From the above explanation, it can be translated as an optimization model below :

Maximize

$$Z = \sum_{j=1}^{n} (\text{LTRN})_j . N_j + \sum_{j=1}^{m} (\text{LTRM})_j . M_j . + \sum_{j=1}^{l} (\text{LTRT})_j . T_j . \quad \ldots\ldots\ldots (1)$$

Subject to :

Budget limit for all Innovation Programs

$$\sum_{j=1}^{n} (\text{LTRN})_j . cN_j \le BN \quad \ldots\ldots\ldots (2)$$

Budget limit for all Improvement Programs

$$\sum_{j=1}^{m} (\text{LTRM})_j . cM_j . \le BM \quad \ldots\ldots\ldots (3)$$

Budget limit for all Maintain Programs

$$\sum_{j=1}^{l} (\text{LTRT})_j . cT_j . \le MT \quad \ldots\ldots\ldots (4)$$

Total budget for all Quality Programs

$$BN + BM + BT \le BQ \quad \ldots\ldots\ldots (5)$$

Non-negative constraints

$$0 \le (LTRN)_j , (LTRM)_j , (LTRT)_j , \le 1 \quad \ldots\ldots\ldots (6)$$

Threshold budget constraints :

$$\begin{aligned} (LTRN)_j cN_j - cNt_j &\ge 0 \\ (LTRM)_j cM_j - cMt_j &\ge 0 \\ (LTRT)_j cT_j - cTt_j , &\ge 0 \end{aligned} \quad \ldots\ldots\ldots (7)$$

5. Illustration

For illustration purposes, this paper adapt a case on developing a pencil, adopted from Wasserman, (1993) [9] with some modification to accommodate issues of maintain, improve and innovate strategy. In the application, initially, the HOQ is constructed to represent the information gathered about the product development problems, see figure 2. Results of author's customer survey are defined as the one dimensional requirements. Technical Respond for the one dimensional requirements, as written on figure 2, are treated as Improvement Programs.

To get the must be requirements, it is proposed to use the company complaint report. Supposed that there were many complaints collected by the company and one complaint was chosen, that is product attribute of **good for writing**, according to a certain reason. After evaluating the root cause of lacking the **good for writing** attribute, the product development team has taken 2 technical responds: **color blackness** and **carbon strength**. These 2 Technical Responds are treated as the Maintain Programs.

Considering some aspects, such as current performance of the company and the competitors, sales point, future trend, etc., management of the company has decided to provide more feature as the excitement requirement. This requirement has been discussed among the product development team members and then the team decided to respond the requirement by plugging **plastic mould features** likes animal, plants, statue, etc., on the top of the pencil.

Secondly, Importance weight of all requirements and the relationship with their Technical Responds are given (see figure 2 relationship matrix and technical respond matrix). Importance of the Technical Respond were calculated from the accumulation of the relationship matrix value times the importance of the requirements. Normalized Technical Importance is also calculated to adjust the Technical Importance value so that the total is 100 %. In this session the role of correlation coefficient among the Technical Responds was assumed to be neglected. According section 3 above the value of the Normalized Technical Respond represents the maximum customer satisfaction that could be achieved if management gave all required budget to operate all the technical responds al full level. So if all the Technical Responds are set at the maximum value, means that 100 % the required resources are given, customer satisfaction value will be 100 %. But it is not allways the case. It is assumed that total required budget is 200 unit of money and only 150 units are available. That is why the available budget should be used in optimal manner.

The thirst step is using the proposed optimization Model. Required Resources for the Technical Responds are represented by financial budget. Total required budget for each Technical responds are assumed have to be calculated. Then the study tried to determine each Level of Technical Respond (LTR) by optimizing total budget limit to the Technical Responds. It means that a certain level of the customer satisfaction will need a certain amount of Technical Respond resources.

The Four-th step, computing, is used to determine a combination of optimal values of TR of the pencil. Using the Excel Solver, the optimal solution is given at tabel 1. Since the total available budget less than total required budget, it is not surprised when the predicted customer satisfaction resulted from the software is not 100 %. It is only 65,26 % (see table 1, line2). Innovation program of giving '**plastic mould features**' is planned at level of 55 %. Some Improvement programs are excluded. Only two of them have to be taken ; improve '**time between sharpening'** and '**minimize material residue** '. The total available budget is not totally utilized. 117 out of 150 unit of available budget will be allocated.

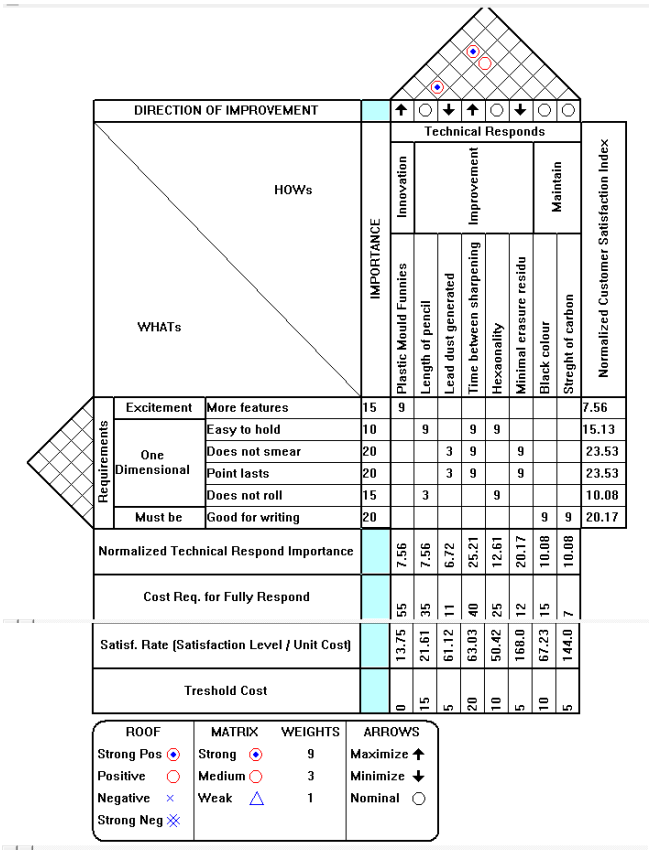

Figure 2. HoQ of a pencil development using QFD Designer Software (demo version)

Tabel 1:Optimization Report (using Microsoft Excel Solver)

Target Cell (Max)

Cell	Name	Original Value	Final Value
D25	Target P M Features	0.00	65.26

Adjustable Cells

Cell	Name	Original Value	Final Value
D20	Level of Technical Respond P M Features	0%	55%
E20	Level of Technical Respond Length	0%	0%
F20	Level of Technical Respond Lead	0%	0%
G20	Level of Technical Respond Time	0%	83%
H20	Level of Technical Respond Hexag.	0%	0%
I20	Level of Technical Respond Min Erase	0%	100%
J20	Level of Technical Respond Blackness	0%	100%
#	100%	100%	100%	100%

6. Conclusions and Research Agenda

To conclude, the Kano model divides customer requirements in the QFD into three categories that is aligned with category of quality initiative programs: maintain, improve, and innovate. Companies usually have their own strategy in order to respond all requirements by selecting programs of maintain, improve or innovate in a certain level. To obtain the must be requirements, it is suggested to utilize customer complaint rather than conducting a customer survey. Furthermore the company management's initiatives to delight his customers should be regarded as the excitement requirements category and responded using the innovative programs.

Additionally, this report presents a case study on developing a pencil. Before solving the problem of allocating resource to the all proposed Technical Responds, the Normalized Technical Respond Importance (in the bottom row of HOQ matrix) is assumed to be the maximum contribution of the Technical Respond to the customer satisfaction. The report also introduces the Threshold Budget besides the required budget to conduct all development programs. It should be understood since the budget is still needed to maintain company performance at the current level when the program is canceled out.

Output of the Solver Problem for this case study shows that not all of available budget is utilized. Only 117 out of 150 unit of money is allocated into innovation, improvement, and maintenance programs. It is also reported that the predicted customer satisfaction level is 65,26 % using the above scenario. For further research it may be useful to conduct another scenario to see how sensitive among the involved variables. Considering the correlation matrix among the technical responds is also interesting to explore

Appendix A

(LTRN)j = Level of Innovate Technical Respond j
(LTRM)j = Level of Improve Technical Respond j
(LTRT)j = Level of Maintain Technical Respond j
Nj = Max. customer satisfaction contribution of the Innovate j program
Mj = Max. customer satisfaction contribution of the Improve j program
Tj = Max. customer satisfaction contribution of the Maintain j program j
cNj = Required budget to fully operate Innovate j program
cMj = Required budget to fully operate Improve j program
cTj = Required budget to fully operate Maintain j program
cNtj = Threshold budget if Innovate j program is not selected
cMtj = Threshold budget if Improve j program is not selected
cTtj = Threshold budget if Maintain j program is not selected
BN = Budgeted cost for all Innovate programs
BM = Budgeted cost for all Improve programs
BT = Budgeted cost for all Maintain programs
BQ = Budgeted cost for all Quality Initiative programs

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