Customer Satisfaction Measurement Model Based on QFD

Yumin Liu[*], **Jichao Xu**[**]

[*]Business School, Zhengzhou Univ., Zhengzhou 450052, Henan, P.R.China
Doctor, International Business School, Nankai Univ.,
E-mail: yuminliu@zzu.edu.cn
[**]Zhengzhou Institute of Aeronautics
Zhengzhou Henan, 450052, P.R. China
E-mail: ryan2000_cn@371.net

Abstract

With the development of the American Customer satisfaction index (ACSI), research on customer satisfaction measurement or evaluation methods have become significant in the last decade. Most of international customer satisfaction barometers or indices are evolved based on the cause and effect relationship model of ACSI. Of critical importance to validity of customer satisfaction indices is how to construct a measurement attribute or indicator model and provide an effective implementation method effectively. Quality Function Deployment (QFD) is a very useful tool for translating the customer voice into product design through quality engineering. In fact, this is a methodology for measuring and analyzing evaluation indicators by their relationship matrix. In this paper, we will make an effort to integrate the framework of QFD into the measurement problem of customer satisfaction, and also develop a new multi-phase QFD model for evaluation of Customer Satisfaction Index (CSI). From the houses of quality in this model, the evaluation indicators impacting on customer's global satisfaction are identified by means of their relationship matrix. Then the evaluation indicator hierarchy and its measurement method for the customer satisfaction index are presented graphically. Furthermore, survey data from the Chinese automobile maintenance sector and a relevant case study are utilized to show the implementation method of the QFD model used to measure and analyze of customer satisfaction.

Key Words: Customer Satisfaction Index; Customer Satisfaction Barometer; Quality Function Deployment; The house of quality

1. Introduction

Customer satisfaction measurement or evaluation has played a more important role in the business organizations with the development of national satisfaction barometers or indices. Since the Swedish Customer Satisfaction Barometer (SCSB) was first introduced in 1989 (Fornell, 1992), a number of national satisfaction indices have been established, such as, in the US (Fornell, Johnson, Anderson, Cha, and Bryant, 1996), and Norway (Andreassen and Lervik, 1999; Andreassen and Lindestad, 1998). Indices have also been pilot tested in New Zealand, Austria, Korea and the European Union (Johnson, Gustafsson, Andreassen, Lervik, and Cha, 2001; Eklof, 2000; Hackl, Scharitzer and Zuba, 1996).

In reviewing of these national satisfaction indices, we pay particular attention to Fornell's satisfaction model (Anderson, Fornell and Lehmann 1994; Fornell, 1995), which constitutes the basic measurement and analysis tool that is used in both the American Customer Satisfaction Index (ACSI) and the Swedish Customer Satisfaction Barometer (SCSB).This particular approach is based on an econometrics model that links different customer satisfaction measures (e.g. expectations, loyalty, complaints, etc.) with specific and predefined formulas. Given these defined relationships between included variables, the model produces a system of cause and effect relationships (Grigoroudis and Siskos, 2003). Partial Least Squares (PLS) are used to estimate this causal model. PLS estimates weights for the variable measures that maximize their ability to explain customer loyalty (Fornell et al., 1996). Furthermore, confirmatory factor analysis and linear equation modeling have been conducted to validate the relationships depicted in the model and the overall framework (Vavra, 1997). For the most part, the national satisfaction barometers and indices are developed and modified by Fornell's econometrics model, which satisfaction variables or indicators are embedded within the system of cause and effect relationships or satisfaction model (Spreng, Mackenzie, and Olshavsky, 1996; Fornell et al., 1996; Johnson et al., 2001).

A wide variety of differently oriented measurement approaches deal with the customer satisfaction evaluation problem, besides Fornell's satisfaction model. These techniques focus on the evaluation of an overall satisfaction measure, the analysis of associations between several satisfaction norms, and the classification of customers into different distinctive segments. According to Grigoroudis and Siskos (2002), the most important measurement approaches can be categorized into: 1. statistical and data analysis techniques, which consist of several traditional statistical methods, like multiple regression analysis; 2. quality approaches, integrated with national quality awards, like the Malcolm Baldrige Award; 3. consumer behavioral analysis approaches, which explain and analyze the consumers' behavior rather than evaluate a satisfaction measurement (Oliver,1996); 4. other methodological approaches, including the Kano's model (Shen, Tan, Xie, 2000), multi-criteria preference desegregation approach and other quantitative methods (Grigoroudis and Siskos, 2003).

Of critical importance to the validity and reliability of CSI is how to construct a measurement attribute or indicator model and provide an effective implementation method effectively. Quality Function Deployment (QFD) is a very useful tool for translating the customer's voice into product design through quality engineering (Akao, 1990). In fact, it is a methodology for measuring and analyzing evaluation indicators by their relationship matrix. This paper first attempts to integrate QFD into the customer satisfaction measurement problem, and develop a new QFD model for evaluation of customer satisfaction index (CSI). This is a meaningful but difficult work that seems having not been done before.

The paper is organized into six sections. Section 2 briefly presents an overview of the methodologies and applications of QFD. It draws a comparison to its functions between the manufacture and service sector, and emphasize on its research results from decision-making and customer needs analysis. By means of the framework of generic QFD, the house of quality for customer satisfaction measurement is set up in Section 3. This helps to divide customer satisfaction indicators or evaluation variables into their influence factors. It also analyzes their importance degrees of impacting on overall customer satisfaction in terms of their relationship matrix. Further, section 3 establishes the QFD model for customer satisfaction index measurement by the multi-phase process of quality function deployment. Here we form a measurable indicator hierarchy of customer satisfaction, step by step, by making use of a set of relationship matrices. In Section 4, the evaluation method for CSI is provided based on the multi-phase QFD model. It presents the procedure of implementation by means of two-phase quality function deployment, such as, determining the relationship matrices, computing the importance weights, constructing the judgement matrices, and calculating customer satisfaction index. Using survey data from Chinese automobile maintenance sector, a case, which shows the implementation method of QFD model for measure and analysis of customer satisfaction, is given in Section 5. Finally, some brief conclusions and remarks are made.

2. Overview of QFD Model

Quality Function Deployment (QFD) is "an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production" (Sullivan, 1987). QFD was originally proposed in Japan in the late 1960s and early 1970s (Terninko, 1997; Cohen, 1995; Akao,1972). QFD outcomes are achieved through collecting and analyzing the Voice Of the Customer(VOC), to develop products with higher quality to meet or surpass customer's needs. QFD was first brought to the attention of U.S. companies by Akao, who is universally known as the Father of QFD), and Kogure (1983). Further, it rapidly spread throughout the US in the 1980s and later to many industries in many other nations.

QFD is a customer-oriented quality management and product development technique originally used by manufactures, but its ideas and methods are gradually being introduced into the service sector (Xie, Tan, and Goh, 2003). The primary functions of QFD have been expanded from product development (Crow, 1999; Tsuda, 1997; Akao,1997), quality management (Hassan et al., 2000; Ho et al., 2001), customer needs analysis to wider fields such as product design (Nibbelke et al., 2001; Reich ,2000), planning, management, and costing (Chan and Wu, 2002), especially, decision-making (Wang, Xie, and Goh, 1998). QFD has been widely applied to the major aspects of decision-making, included measuring customer satisfaction (Motwani et al., 1996), performance measurement (Kochhar and Eguia, 1998; Kutucuoglu et al., 2001), evaluating company's current status (Kumar and Midha, 2001), service delivery priorities (Curry, 1999), and environmental decision-making (Berglund, 1993).

Quality management and product development are achieved in QFD through customer needs analysis that, in fact, is always the very first step of a QFD process and is thus an important functional field of QFD. There are a lot of QFD applications addressing some specific aspects of customer needs analysis, such as customer involvement (Huovila and Seren, 1998; Kaulio, 1998; Tottie and Lager, 1995), customer preference (Lai et al., 1998), customer responsiveness (Atkinson, 1990), customer services (Graessel and Zeidler, 1993), processing client requirements (Kamara and Anumba, 2000), and prioritizing customer needs (Persson et al., 2000).

The basic methodology of QFD is to translate the desires of customers into product design or engineering characteristics, and subsequently into parts characteristics, process plans and production requirements. The overall process of QFD is based on its core matrix framework, called the house of quality (Hauser and Clausing, 1988), which can help to identify customer requirements and establish priorities of design characteristics to satisfy the customer needs. The conventional house of quality is presented in a matrix form which shows: (1) the customer requirements in rows and the design characteristics in columns, (2) their relations within the relationship matrix, and (3) the correlations of the influence factors at the top of the matrix, see the first house of quality in Fig. 1.

The typical approach of quality function deployment centers around the four-phase process popularized by the American Supplier Institute (ASI) (Terninko, 1997; John et al., 2000), summarized in Fig. 1 which shows that QFD is a set of matrices that relate inputs to outputs. Each translation uses a matrix, namely the house of quality, for determining design characteristics according to priorities of customer requirements (Griffin and Hauser, 1993; Kim et al., 1998; Park and Kim, 1998).

In the first phase, qualitative customer requirements are translated into design independent, measurable, quality characteristics of the product. The quality characteristics are prioritized from the desired level of customer's perspective. By means of examining the relationship between the quality characteristics and the various components or parts of the design, the component parts of the design, in terms of their ability to meet the desired quality characteristic level, are selected out in Phase 2. Phase 3 explores the relationship between the part and the manufacturing processes utilized in the production of the part and finds out the key process parameters that are deployed to the fourth and final phase. In Phase 4, the key manufacturing processes and associated parameters are translated into work instructions, control and reaction plans, and training requirements necessary to ensure that the quality of key parts and processes is maintained. Ideally, these four phases combined provide a traceable link from the shop floor back to customer requirements that provides workers with insight into how their job function impacts customer satisfaction (John et al., 2000).

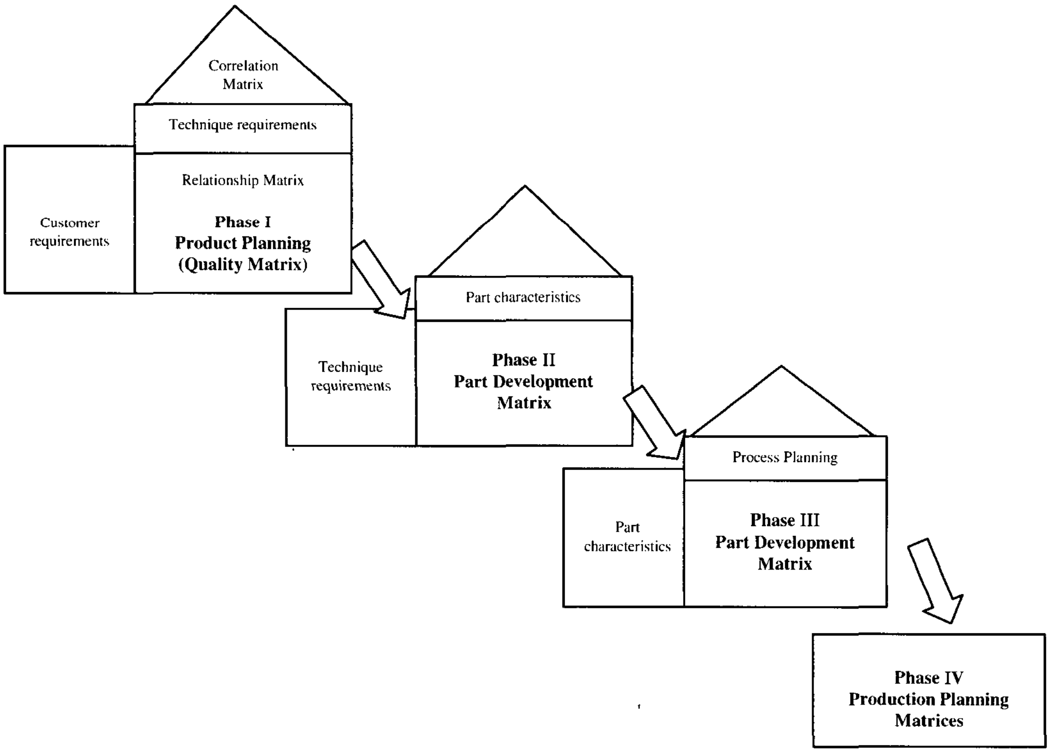


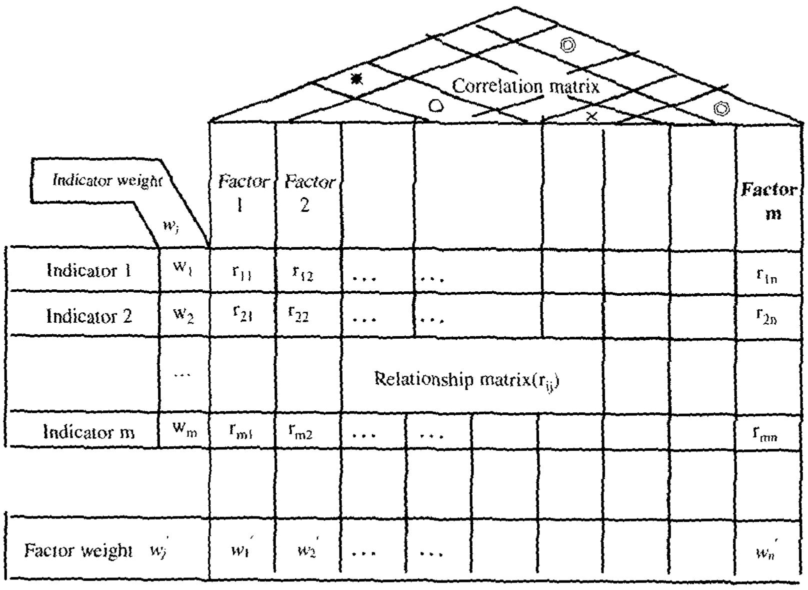
Fig. 1 Four-phase model of QFD

Making a comprehensive view of the developments of QFD, we have not yet find similar research results described in this paper that measures the customer satisfaction index with the help of the QFD model. In fact, customer satisfaction index measurement problems should be in the context of multivariable decision-making. The main idea of customer satisfaction measurement is how to design a set of measurement indicators expressing customer satisfaction, and further provide an evaluation model and its implementation method, which can be carried out by means of the framework of QFD model.

3. A Multi-phase QFD Model for CSI

3.1 The house of quality of CSI

The first step of evaluating CSI is to analyze a wide variety of factors impacting on Customer's Global Satisfaction (CGS) and then to translate them into measurable indicators in different levels, further, to form a measurable indicator hierarchy of CSI. By virtue of the framework of QFD model, we can build the house of quality for customer satisfaction measurement, presenting the relations between measurable indicators and their major influence factors in terms of the relationship matrix, and the correlativity among the factors by their correlation matrix.



◎ : Significant positive correlation ; ○ : Positive correlation ;
× : Negative correlation ; ※ : Significant negative correlation

Fig. 2 The house of quality of CSI

The house of quality for the customer satisfaction index is shown in Fig.2., in which the measurable indicators of customer satisfaction are put on the left wall and their influence factors of these indicators are hung on the ceiling. The cells in the middle of the house describe the relationship matrix (r_{ij}) where r_{ij} is denoted the relationship rating, or the degree of correlation, between the i^{th} measurable indicator and the j^{th} influence factor. The correlation matrix, presenting the correlativity among influence factors, is at the roof of quality house. The partition wall between the left wall and cells displays the degrees or weights of importance, w_i(i=1,2, ... , m), of measurable indicators for customer satisfaction. The degrees or weights of importance, w_j'(j=1,2, ... , n), of influence factors to these measurable indicators, are placed on the floor.

Based on the house of quality of CSI, we can identify various factors impacting on the measurable indicators for customer satisfaction, and assign their relation ratings, or the degrees of their correlation that consist of the relationship matrix (r_{ij}). Further, we can determine the influence factors in terms of their relation degrees, r_{ij}, to measurable indicators. It is the house of quality that the measurable indicators of customer satisfaction can be deployed to their influence factors, which can show clearly the relations between the evaluation indicators and their influence factors by their relationship matrix, and present directly the degree of correlation among influence factors according to their correlation matrix.

3.2 A multi-phase QFD model for CSI

To realize the purpose of customer satisfaction measurement, and obtain the customer satisfaction index, an evaluation system or measurable indicator hierarchy of customer's global satisfaction should be constructed and the factors related to customer satisfaction and their relationships should be determined. However, there are various factors relevant to the customer's global satisfaction in practice, and it is difficult to find out the appropriate influence factors used to evaluate and calculate customer satisfaction index in an intricate situation.

When the above house of quality in Fig.2 is integrated into the framework of a four-phase model of QFD, a new multi-phase QFD model for evaluating customer satisfaction index is presented (see Fig. 3). In phase I shown in Fig.3, there is only one indicator that is THE Customer's Global Satisfaction (CGS) on the left wall in the first house of quality. Now the critical factors impacting on CGS can be identified in terms of the relationship matrix between CGS and their influence factors. These factors are represented as the first level indicators, which are placed on the ceiling of the house. CGS is regarded as the upper level indicator of the first level indicators, that is, CGS is translated into its lower indicators through the first phase of QFD model.

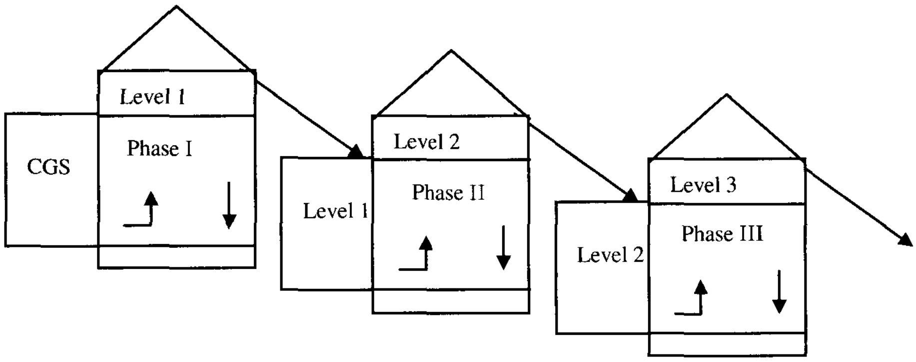


Fig. 3 A multi-phase QFD model for CSI

Similarly, by means of examining the relationship between the upper level and the lower level indicators, the upper level indicators can be deployed to its lower level indicators. According to the multi-phase quality function deployment model for CSI in Fig.3, the customer's global satisfaction can be translated into the last level indicators by a set of the relationship matrices, in which each deployment uses a relationship matrix representing the relationship ratings between the upper level and the lower level indicators. The number of phases availed in the multi-phase QFD model depends on the actual problems of evaluating CSI, usually, the more difficult it is, the bigger the number is. The last level indicators are the measurable variables, which make it easier for customers describe the degrees of their satisfactions.

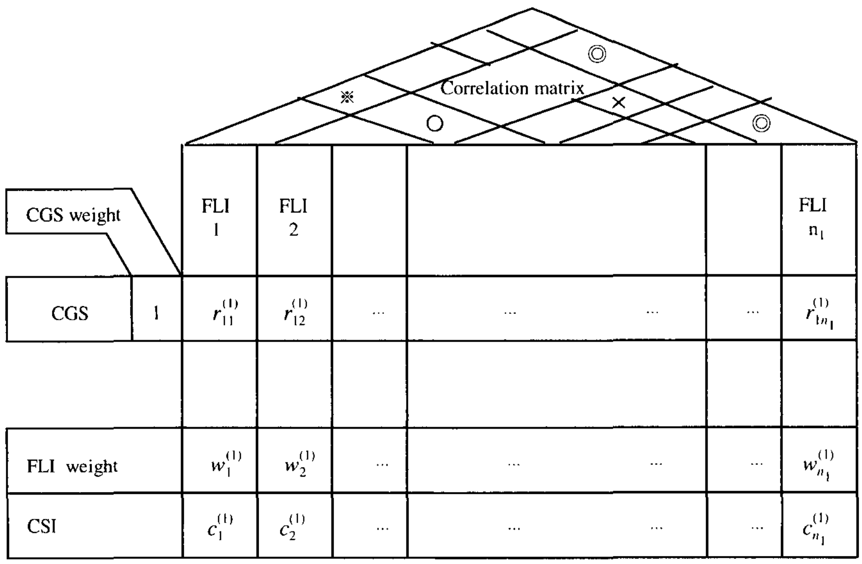
Making use of the multi-phase QFD model for CSI, customer's global satisfaction is translated into the first level indicators, and then the first level indicators are deployed to the second level indicators until the last level indicators are formed. A measurable indicator hierarchy or evaluation system is made up of the indicators from all levels, which can be shown clearly in the houses of quality in Fig.3. One of the significant characteristics of the multi-phase QFD model is that it can display intuitively the procedure of identifying, analyzing and deploying the upper level indicators to the lower level indicators from the first phase to last phase. At the same time, the lower level indicators in this phase will become the upper level indicators in next phase, and then forming an indicator hierarchy for assessing the customer satisfaction index. The multiple-phase framework provides a traceable link from customer's global satisfaction to last level indicators that are judged easily by customers.

Another advantage of this model is that we can utilize it to calculate the customer satisfaction index, which will be discussed in detail in the next section.

4. QFD Method for CSI

After constructing a measurable indicator hierarchy of CSI, the key problem of assessing a customer's global satisfaction is to explore the implementing method based on a multi-phase QFD model. A multi-phase QFD model not only presents the most important efforts for the deployment of the measurable indicators of GCS, but also takes great advantage of evaluation of the customer satisfaction index. From the above discussion, the translations of customer's global satisfaction are in the order from the first phase to last phase. On the contrary, when the measurable values of customer satisfaction are traced back from the last level indicators to customer's global satisfaction, the customer satisfaction index will be obtained.

Based on the multi-phase QFD model, customer's global satisfaction is deployed to the first level indicators, and subsequently to the last level indicators by which customers can express more easily their satisfaction. Usually, the second level indicators of CGS are enough to describe clearly any customer perceived satisfaction in practice. Now, the two-phase QFD model is used to provide the implementation method for CSI. In order to implement the QFD method smoothly, the judgment matrix presenting customer satisfaction for the indicators should be added in the basement under the floor of the house of quality, shown in the first phase and the second phase QFD methods in Fig.4 and Fig.5 respectively.



FLI: The first level indicator

Fig. 4 The house of quality in the first phase

In this section, we will devote to present: (1) the construction of the houses of quality in the first phase and the second phase QFD model, (2) the assignment of the relationship ratings between the upper level and the lower indicators, (3) the constitution of the judgment matrix composed of the customers' satisfaction for the measurable indicators, (4) the determination of the importance weights of measurable indicators and (5) the calculation of the customer satisfaction index.

4.1 Building the house of quality in the first phase

In order to explore the implementation method for the multi-phase QFD model, we employ a two-phase model to illustrate the evaluation process of customer satisfaction index. The house of quality in the first phase is built, seen in Fig.4, where only one indicator, the customer' global satisfaction, is placed on the left wall, and its weight or degree of importance for itself is just equal to 1. There are n1 indicators of the first level on the ceiling, denoted by FLI 1, FLI 2, and FLI n_1, which consist of the influence factors of CGS. The degrees of the correlation between CGS and the first level indicators, regarded as $r_{1j}^{(1)}(j=1,2,...,n_1)$, occupy the cells of the house. Below the ground, the importance weights, $w_j^{(1)}$ (j=1,2,...,n_1), representing the degrees of importance of the first level indicators for CGS are put on the floor. The customer satisfaction degrees of the first level indicators, $c_j^{(1)}$ (j=1,2,...,n_1). are displayed in the basement, where beside $c_j^{(1)}$ is the final evaluation result of the customer's global satisfaction, that is, the customer satisfaction index.

4.2 Constructing the house of quality in the second phase

Considering a two-phase QFD model for customer satisfaction measurement, the second level indicator is the last level indicator judged directly by customers. It denotes the evaluation results from customers as d_j(j=1,2,...,n_2) which will be used to construct the judgment matrix(p_{ij}). The house of quality in the second phase is constructed in Fig.5, where the first level indicators obtained in the first phase are put on the left wall, and the first level indicators are translated into the second level indicators by examining the relationship ratings, $r_{ij}^{(2)}$ (i=1,2,...,n_1; j=1,2,...,n_2).

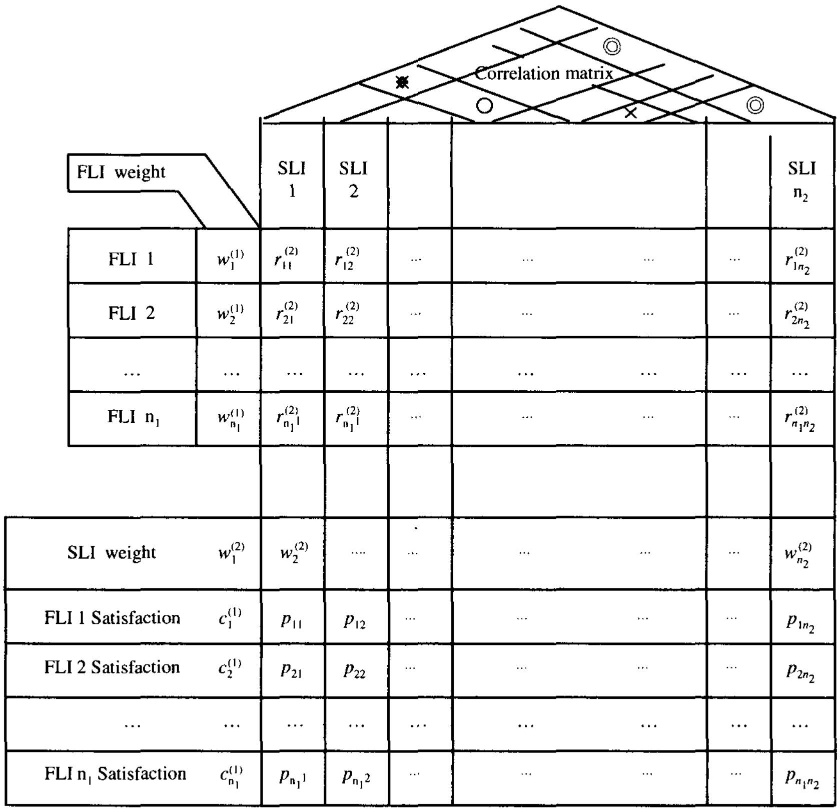


Fig. 5 The house of quality in the second phase

Similarly, the second level indicators are hung on the ceiling, and the importance weights of the second level indicators, $w_j^{(2)}$ (j=1,2,...,n_2) are placed on the floor. The cells of basement are full of the components of judgment matrix(p_{ij}), and the customer satisfaction degrees, $c_i^{(1)}$ (i=1,2,...,n_1), of the first level indicators are put on the left wall of the basement.

4.3 Assigning the relationship ratings

The relationship matrix used in the house of quality has a strong and direct impact on the customer satisfaction measurement. Thus, the choice of a relationship rating scheme is critical in implementing a suitable method of QFD model. The conventional QFD employs a rating scale, (e.g., 1-3-9, 1-5-9) to indicate the degree (i.e., weak-medium-strong) of strength between customer requirements and design characteristics. Some other relationship ratings are provided by Lu et al. (1994), Armacost et al. (1994) and Wasserman (1993).

In this paper, the relationship ratings between the upper level and the lower level indicators for customer satisfaction are measured on a 9-point scale by modifying and improving the10-point scale (Cohen, 1988). It is however necessary to select a team of 5-7 professionals or experts organized an evaluation group. Depending upon the impact of the lower level indicators for the upper level indicators, experts assign the 9-point scale. The relationship ratings of the k level to the k-1 level indicators, shown in Table 1, which form the corresponding relationship matrix ($r_{ij}^{(k)}$)(k=1, 2) in Fig. 4 and Fig. 5.

Table 1. The relationship ratings

0	1	3	5	7	9	2,4,6,8
No relation between the k level and k-1 level indicators	Possible relation between the k level and k-1 level indicators	Weak relation between the k level and k-1 level indicators	Moderate relation between the k level and k-1 level indicators	Strongish relation between the k level and k-1 level indicators	Strong relation between the k level and k-1 level indicators	Between one and next score

4.4 Determining the judgment matrix

The second level indicators in Fig.5 are easily judged by customers, denoted the evaluation results from customers as d_j (j=1,2,...,n$_2$). The second level indicators corresponding to the first level indicators can be prioritized according to the relationship ratings, $r_{ij}^{(2)}$, and then the judgment matrix of customer satisfaction, (p_{ij}), is obtained by d_j (j=1,2,...,n$_2$), that is :

$$p_{ij} = \begin{cases} p_{i_0 j} = d_j & When \quad r^{(2)}_{i_0 j} = \max\{r_{ij}\} \\ 0 & Otherwise \end{cases} \quad j = 1,\dots,n_2 \tag{1}$$

For example, when r_{11}=9=max{9,1,3} in Fig.7, one of the second level indicators, shop cleanness, corresponds to the first level indicator, maintenance environment. Then, take p_{11}=d_1=8.9 and other p_{i1} are all equal to zero.

4.5 Computing the importance weights of indicators

The importance weights or degrees of importance of indicators play a significant role in computing the customer satisfaction index. In Fig. 5, $w_i^{(1)}$ (i=1,2,...,n_1) denotes the importance weights of the first level indicators for customer's global satisfaction, and $r_{ij}^{(2)}$ (i=1,2,...,n_1; j=1, 2,⋯,n_2) describes relationship ratings of the second level indicators to the first level indicators. In order to obtain the degrees of importance, $w_j^{(2)}$ (j=1,2,...,n_2), of the second level indicators for customer's global satisfaction, we should integrate the important weights $w_i^{(1)}$ with the relation ratings $r_{ij}^{(2)}$. For each indicator in the second level, the importance weight $w_j^{(2)}$ is obtained through the normalization of $w_j^{(2)'}$, which are computed as follows:

$$w_j^{(2)'} = \sum_{i=1}^{n_1} r_{ij}^{(2)} w_i^{(1)} \quad j = 1,2,\ldots,n_2 \tag{2}$$

$$w_j^{(2)} = \frac{1}{\sum_{i=1}^{n_1} w_i^{(2)'}} w_j^{(2)'} \quad j = 1,2,\ldots,n_2 \tag{3}$$

For the same reason, the importance weights of first level indicators, $w_j^{(1)}$ (j=1,2,...,n1), can be obtained. There is only one indicator, GCS, on the left wall of the quality house in Fig.4, so, its importance weight $w_j^{(0)} = 1$. Therefore, for each indicator in the first level, its relationship rating $r_{1j}^{(1)}$ (j=1,2,...,n_1) represents exactly the degree of importance for customer's global satisfaction, and $w_j^{(1)}$ is formulated by normalizing the relationship ratings.

$$w_j^{(1)} = \frac{1}{\sum_{j=1}^{n_1} r_{1j}^{(1)}} r_{1j}^{(1)} \quad j = 1,2,\ldots,n_1 \tag{4}$$

4.6 Calculating customer satisfaction index

Before evaluating customer's global satisfaction, it is necessary to reduce the number of indicators in the same level in order to simplify the measuring process. By examining the correlation matrix on the roof in the house of quality, some indicators with high correlations in the same level can be merged into one or omitted several items from this level.

The procedure of calculating customer satisfaction index keeps in order from the last level to customer's global satisfaction. First, the customer satisfaction values for the last level indicators are obtained by a market survey, and then the customer satisfactions for next level indicator are established. Finally, the customer's global satisfaction or customer satisfaction index is calculated.

In the two-phase QFD model, for each indicator in the second level, its satisfaction can be obtained directly from customer's judgment by questionnaire, which constitutes the judgment matrix of customer satisfaction, (p_{ij}). According to the above discussion, the importance weights of the second level indicators, $w_j^{(2)}$, can be calculated. The customer satisfaction degrees, $c_i^{(1)}$ (i= 1,2,...,n_1), of the first level indicators are computed using the product of each row of the judgment matrix and their corresponding importance weights of the second level indicators, that is,

$$c_i^{(1)} = \sum_{j=1}^{n_2} p_{ij} w_j^{(2)} \quad (i = 1,2,...,n_1) \tag{5}$$

Then place the customer satisfaction degrees, $c_i^{(1)}$, of the first level indicators in all cells of the basement in the first house of quality, as shown in Fig.4. Similarly, Multiplying $c_j^{(1)}$ by the important weights, $w_j^{(1)}$ (j= 1,2,···,n_1), of the first level indicators, customer satisfaction index is calculated as,

$$CSI = \sum_{j=1}^{n_1} c_j^{(1)} w_j^{(1)}$$

5. A case study

The implementation of the multi-phase QFD model for evaluating a customer satisfaction index concerns greatly the Chinese automobile maintenance industry. With the increasing number of automobile owners in China, its automobile maintenance has become a rapid rising business sectors. However, car owners / customers seem to be less satisfied from this sector, especially in recent years. The problems caused by automobile maintenance personnel have been a new focus of consumer complaint in China. In order to improve the overall service level and solve the problems in the automobile maintenance sector, a survey of customer satisfaction for this industry was conducted in the area of Shanghai from March to June, 2003. More than 30 big automotive service/repair shops participated in this particular survey.

The investigation's objects were selected the customers that had had a service job done by the maintenance providers. The questionnaire employed 10-point scales to access each respondent's expectations, perceived quality, satisfaction and retention behaviors. The survey design included 7 factors, such as, maintenance environment, maintenance specification, maintenance quality, and 20 other items, for example, shop cleanliness, check time, repair technique etc.

The required data were collected through face-to-face interviews with customers and / or a mailing survey in which 2000 questionnaires were sent out. This resulted in 1620 feedbacks from mail responses and 500 questionnaires from personal interviews. Final input data consist of almost 1600 questionnaires with data collected that can be considered reliable and effective through a statistical test.

A two-phase QFD model has been adopted in the customer satisfaction measurement for this Chinese automobile maintenance industry survey. The working method is explained below in a step-by-step fashion.

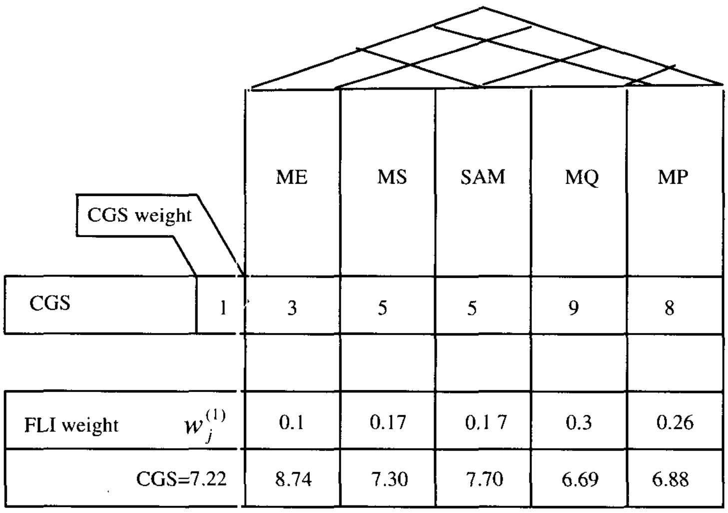


Fig. 6 The first house of quality in Chinese automobile maintenance industry

Step 1. Identifying the influence factors of CGS According to the above questionnaires used in survey research, there are 7 factors impacting on customer's global satisfaction and 20 corresponding items. By examining the corrections among factors, they can be merged into 5 factors, that is, maintenance environment (ME), maintenance specification (MS), service after maintenance (SAM), maintenance quality (MQ) and maintenance price (MP). For the same reason, only 16 indicators were selected from the 20 items in the questionnaires, shown in Fig. 7.

Step 2. Assigning the relationship ratings An evaluation group was set up, consisting of 7 professionals who were in charge of measuring the relationship ratings. Based on their expertise in and experiences with automobile maintenance processes, these experts assigned a 9-point scale (seen in Table 1.), and addressed the 5 factors and 16 indicators through extensive cooperation and strong consensus among them. The relationship matrices of 5 factors and 16 indicators were set up according to their relationship ratings, such as, maintenance quality is regarded as one of the most important indicators of CGS, and so a relationship rating of 9 is here assigned (see Fig.6.).

Step 3. Deploying the customer's global satisfaction In terms of their relationship ratings between customer's global satisfaction and their factors, CGS is translated into 5 indicators in the first level, shown in Fig.6. Similarly, the 5 indicators in the first level are deployed to 16 indicators in the second level, presented in Fig.7.

Step 4. Computing the important weights According to their relationship ratings $r_{1j}^{(1)}$ (j=1,2,...,5), the importance weights of the first level indicators for customer's global satisfaction, $w_j^{(1)}$ (j=1,2,...,5) are obtained by normalizing the relationship ratings. For each indicator in the second level, the importance weight $w_j^{(2)} j = 1,...,16$ is obtained respectively by formula (3). For example, multiplying the first column of the relationship matrix by its left column in Fig.7, and summing up these products, $w_1^{(2)}$ is given below.

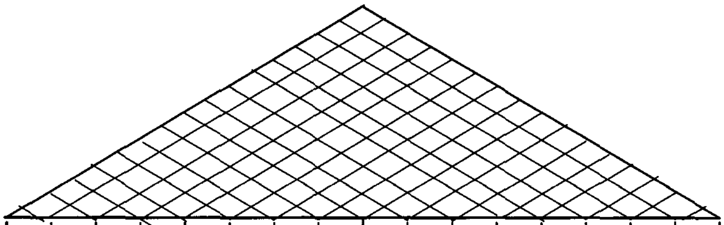
$$w_1^{(2)} = \frac{w_j^{(2)'}}{\sum_{i=1}^{5} w_i^{(2)'}} = \frac{1.98}{1.98+1.55+1.31} = \frac{1.98}{4.84} = 0.41$$

Step 5. Constructing the judgment matrix Using the data collected by the questionnaires, the customer satisfaction degrees of 16 indicators are presented by the means of their customer satisfactions, d_j(j=1,...,16), such as, for shop cleanness, its customer satisfaction degree is 8.9. By formula (1), the judgment matrix (p_{ij}) can be constructed, shown in Fig.7.

Step 6. Measuring the customer satisfaction index In this step, the degrees of customer satisfaction of every level indicators are measured from the second level indicators to CGS. It is convenient to do through the second and first houses of quality in Fig.6 and Fig.7. In the second house of quality, adding up the products of the first row in the basement and each row in the judgment matrix, the customer satisfaction values of the first level indicators, $c_i^{(1)}$ (i=1,..., 5) are obtained. Similarly, in the first house of quality, multiplying the first row by the second row in the basement and summing up these products, the average of customer's global satisfaction is 7.22, shown in Fig.5. Customer Satisfaction Index is calculated as follows:

$$CSI = \frac{7.22 - 1}{10 - 1} \times 100 = 69.1$$

This survey for the automobile maintenance sector in China shows that its overall customer satisfaction index is below 70, to be exact, only 69.1. The most worried result is that, in general, customers have lower level of satisfaction, especially where it affects them most. They appear very dissatisfied with maintenance quality and maintenance price, of which the customer satisfaction level is a low 63.2, and 65.2 respectively.



FLI weight		FLI 1	FLI 2	FLI 3	FLI 4	FLI 5	FLI 6	FLI 7	FLI 8	FLI 9	FLI 10	FLI 11	FLI 12	FLI 13	FLI 14	FLI 15	FLI 16
ME	0.10	9	7	5													
MS	0.17			3	5	9	7	3	1	3				3	3		
SAM	0.17		5						9	5	3	5	3		1		3
MQ	0.3	1		1	3	3	3		7		1	9	7	3		5	
MP	0.26	3					5			1		3			7	9	5
SLI weight		0.41	0.32	0.27	0.21	0.30	0.42	0.07	0.61	0.26	0.13	0.52	0.31	0.17	0.31	0.47	0.22
ME Satisfaction 8.74		8.9	8.7	8.4													
MS Satisfaction 7.30					7.9	7.5	6. 8	7.6									
SAM Satisfaction 7.70									7.5	8.6	6.8						
MQ Satisfaction 6.69												6.6	7.5	5.5			
MP Satisfaction 6.88															7.3	6.4	7.3

FLI 1: Shop cleanness;
FLI 2: transport facilities
FLI 3: Parking space;
FLI 4: Test time ;
FLI 5; Showing defect;
FLI 6: Part change ;
FLI 7: Repair time;
FLI 8: Repair guarantee;
FLI 9: Service attitude;
FLI 10: Cleanout car;
FLI 11: Repair technique
FLI 12: Bad repair rate;
FLI 13: Deliver on time:
FLI 14: Repair price list;
FLI 15: Reasonable price;
FLI 16: Reasonable charge

Fig. 7 The second house of quality in Chinese automobile maintenance industry

6. Conclusions

This study made an importance effort in three areas namely (1) to integrate the framework of QFD into the evaluation problem for customer satisfaction, and (2) to develop a new multi-phase QFD model and (3) to provide the implementing method for evaluating customer satisfaction index. It is necessary to explore the methodologies and applications of QFD as it has been proven in this case study to be a very useful tool for identifying and translating customer needs by a relationship matrix. It is by means of a set of relationship matrices that customer's global satisfaction is deployed to the first level indicators, and sequentially to last level indicators, which forms a measurable indicators hierarchy for a customer satisfaction index. This is found to be one of the critical aspects of the evaluation problem in any customer satisfaction process.

Another critical part of that process is to provide the measurement method for customer satisfaction based on the indicator hierarchy. There are several methodological issues resolved in this paper, namely (1) construction of the houses of quality in multi- phase QFD model, (2) assignment of the relationship ratings between the upper level and the lower indicators, (3) constitution of the judgment matrix of customer satisfaction, (4) determination of the importance weights of measurable indicators, and (5) calculation of customer satisfaction index.

The new model and its method rely on the house of quality for measuring customer satisfaction. There are mainly two functions of the houses of quality in a multi-phase QFD process. One is to deploy the customer's global satisfaction from the first phase to last phase, and another is to measure it in converse order. Although there are some comprehensive steps involved in the implementation method, it is made easier to do through the houses of quality in multiple phases. The new QFD method for customer satisfaction measurement is a very handy and useful tool for practitioners.

Acknowledgment

This research was jointly supported by National Science Funds for Distinguished Young Scholars 70125004, and NSFC Projects 9870100, 70072029 . We appreciate that Acd Lou Magritzer check the whole paper manuscript.

Reference

1. Andreassen, T. W. and Lervik, L. 1999. Perceived relative attractiveness today and tomorrow as predictors of future repurchase intention, Journal of Service Research, 2, 164-172.
2. Andreassen, T. W. and Lindestad, B. 1998. The effects of corporate image in the formation of customer loyalty. Journal of Service Marketing 1, 82-92.
3. Akao, Y. 1997. QFD: Past, present, and future. Proceedings of the International Symposium on QFD'97, Linköping.
4. Anderson, E.W., Fornell, C., and Lehmann, D.R., 1994. Customer satisfaction, market share and profitability: Findings from Sweden. Journal of Marketing 58, 53-56.
5. Atkinson, W., 1990. The customer-responsive manufacturing organization. Manufacturing Systems 8 (5), 58-61.
6. Akao, Y. 1990. Quality Function Deployment: Integrating customer requirements into product design. Cambridge, Massachussetts: Productivity Press.
7. Akao, Y. 1972. New product development and quality assurance deployment system (in Japanese). Standardization and Quality Control 25 (4), 243-246.
8. Armacost, R.L., Componation, P.J., Mullens, M.A., Swart, W.W.,1994. An AHP framework for prioritizing customer requirements in QFD: an industrialized housing application. IIE Trans. 26 (4), 72-79.
9. Berglund, R.L., 1993. QFD: A critical tool for environmental decision making. In: Transactions of the 1993 ASQC Quality Congress, Boston, MA, pp. 593-599.
10. Chan, L. K. and Wu, M. L. 2002. Quality function deployment: A literature review. European Journal of Operational Research 143, 463-497.
11. Crow, K., 2000. Performing QFD Step by Step. DRM Associates, Palos Verdes, CA.
12. Curry, A., 1999. Innovation in public service management. Managing Service Quality 9 (3), 180-190.
13. Crow, K., 1999. QFD and Target Costing Case Study. DRM Associates, Palos Verdes, CA.
14. Cohen, L., 1995. Quality Function Deployment: How to Make QFD Work for You. Addison-Wesley, Reading, MA.
15. Cohen, L., 1988. Quality Function Deployment: A application perspective from digital of equipment corporation. National Productivity Review, 197-188.
16. Eklöf, J. A. 2000. European customer satisfaction index pan-European telecommunication sector report based on the pilot studies 1999. Stockholm, Sweden: European Organization for Quality and European Foundation Quality Management.
17. Fornell, C., Johnson, M. D., Aderson, E. W., Cho, J. & Bryant, B. E. 1996. The American

customer satisfaction index: Nature, purpose and findings. Journal of Marketing 60, 7-18.
18. Fornell, C., 1995. The quality of economic output: Empirical generalizations about its distribution and relationship to market share. Marketing Science 14 (3), 203-211.
19. Fornell, C. 1992. A national customer satisfaction barometer: The Swedish experience. Journal of Marketing, 56: 6-21.
20. Grigoroudis, E. and Siskos, Y. 2003. A survey of customer satisfaction barometers: Some results from the transportation-communications sector. European Journal of Operational Research 152, 334-353.
21. Grigoroudis, E., Siskos, Y., 2002. Customer satisfaction evaluation: methods for measuring and implementingservice quality with integrated software, Kluwer Academic Publishers, Dordrecht (in preparation).
22. Graessel, B., Zeidler, P., 1993. Using quality function deployment to improve customer service. Quality Progress 26 (11), 59-63.
23. Griffin, A., Hauser, J.R. 1993. The voice of the customer. Marketing Science 12 (1) , 1-27.
24. Ho, D.C.K., Duffy, V.G., Shih, H.M. 2001. Total quality management: An empirical test for mediation effect. International Journal of Production Research 39 (3), 529-548.
25. Hassan, A., Baksh, M.S.N., Shaharoun, A.M. 2000. Issues in quality engineering research. International Journal of Quality and Reliability Management 17 (8), 858-875.
26. Huovila, P., Seren, K.J., 1998. Customer-oriented design methods for construction projects. Journal of Engineering Design 9 (3), 225-238.
27. Hackl, P., Scharitzer D. & Zuba, R. 1996. The Austrian Customer Satisfaction Barometer (ACSB): A pilot study. Der Markt 35, 86-94.
28. Hauser, J.R. and Clausing, O. 1988. The house of quality. Harvard Business Review, May. June, 63-73.
29. Johnson, M. D., Gustafsson, A., Andreassen, T. W., Lervik, L.& Cha, J. 2001. The evolution and future of national customer satisfaction index models. Journal of Economic Psychology 22, 217-245.
30. John J. Cristiano, Jeffrey K. Liker, and Chelsea C. White, III 2000. Customer-Driven Product Development Through Quality Function Deployment in the U.S. and Japan. Journal of Production Innovation Management 17, 286-308.
31. Johnson, M.D., Fornell, C., 1991. A framework for comparing customer satisfaction across individuals and product categories.Journal of Economic Psychology 12, 267-286.
32. Kumar, R., Midha, P.S., 2001. A QFD based methodology for evaluating a company's PDM requirements for collaborative product development. Industrial Management and Data Systems

101 (3), 126-131.

33. Kutucuoglu, K.Y., Hamali, J., Irani, Z., Sharp, J.M., 2001. A framework for managing maintenance using performance measurement systems. International Journal of Operations and Production Management 21 (1,2), 173-195.
34. Kamara, J.M., Anumba, C.J., 2000. Client requirements processing for concurrent life-cycle design and construction. Concurrent Engineering - Research and Applications 8 (2), 74-88.
35. Kochhar, A.K., Eguia, F.J., 1998. A quality function deployment approach to performance measurement and benchmarking in manufacturing control systems. Proceedings of the 9th IFAC Symposium, Vol. 2.,815-820.
36. Kaulio, M.A., 1998. Customer, consumer and user involvement in product development: A framework and a review of selected methods. Total Quality Management 9 (1), 141-149.
37. Kim, J. K., Han, C. H., Choi, S. H., and Kim, S. H. 1998. A knowledge-based approach to the quality function deployment. Computers & Industrial Engineering 35(1,2):, 233-236.
38. Kogure, M. and Akao, Y. 1983. Quality function deployment and CWQC in Japan. A strategy for assuring that quality is built into new products. Quality Progress October.
39. Lai, Y.J., Ho, E.S.S.A., Chang, S.I., 1998. Identifying customer preferences in quality function deployment using group decision-making techniques. New York, pp. 1-28 (Chapter 1).
40. Lu, M., Madu, C.N., Kuei, C., Winokur, D., 1994. Integrating QFD, AHP, and benchmarking in strategic marketing. J. Business Ind. Marketing 9 (1) , 41-50.
41. Motwani, J., Kumar, A., Mohamed, Z., 1996. Implementing QFD for improving quality in education: An example. Journal of Professional Services Marketing 14 (2), 149-159.
42. Nibbelke, R., Ferro, D., Hoogeboom, P., 2001. Design and evaluation with the human in mind. Air and Space Europe 3(3-4), 218-220.
43. Oliver, R.L., 1996. Satisfaction: A behavioral perspective on the customer. McGraw-Hill, New York.
44. Persson, P., Kammerlund, P., Bergman, B., Andersson, J.,2000. A methodology for multi-characteristic system improvement with active expert involvement. Quality and Reliability Engineering International 16 (5), 405-416.
45. Park , T. and Kim, K.J. 1998. Determination of an optimal set of design requirements using house of quality Journal of Operations Management 16, 569-581.
46. Reich, Y., 2000. Improving the rationale capture capability of QFD. Engineering With Computers 16 (3-4), 236-252.
47. Shen, X.X., Tan, K.C., Xie, M., 2000. An integrated approach to innovative product development using Kano's model and QFD. European Journal of Innovation Management 3

(2), 91-99.

48. Spreng, R. A., Mackenzie, S. B. and Olshavsky, R. W. 1996. A Reexamination of the Determinants of customer satisfaction. Journal of Marketing 60, 15-32.
49. Sullivan, L.P., 1987. Quality Function Deployment QFD : the beginning, the end, and the problem in-between, A collection of presentations and QFD case studies, American Supplier Institute.
50. Terninko, J., 1997. Step-by-Step QFD: Customer-Driven Product Design, second ed. St. Lucie Press, Boca Raton, FL.
51. Tsuda, Y., 1997. Concurrent engineering case studies applying QFD models. Concurrent Engineering - Research and Applications 5 (4), 337-345.
52. Vavra, T.G., 1997. Improving your measurement of customer satisfaction. ASQC Quality Press, Milwaukee.
53. Tottie, M., Lager, T., 1995. QFD - Linking the customer to the product development process as a part of the TQM concept. R&D Management 25 (3), 257-267.
54. Wang, H., Xie, M. and Goh, T. N. A. 1998. Comparative study of the prioritization matrix method and the analytic hierarchy process technique in quality function deployment. Total Quality Management 9(6): 421-430.
55. Wasserman, G.S., 1993. On how to prioritize design requirements during the QFD planning process. IIE Trans. 25 (3), 59-65.
56. Xie, M.; Tan, K.C. and Goh, T.N. (2003). Advanced QFD Applications, ASQ Quality Press, Milwaukee, WI, USA.