Int J Adv Manuf Technol (2009) 41:1019–1033
DOI 10.1007/s00170-008-1533-2

ORIGINAL ARTICLE

Integration of marketing research techniques into house of quality and product family design

R. B. Kazemzadeh · Majid Behzadian · Mohammad Aghdasi · Amir Albadvi

Received: 27 May 2007 / Accepted: 16 April 2008 / Published online: 3 June 2008

Abstract Quality function deployment (QFD) is a well-known technique used for designing products and services to reflect customer needs. The first phase of QFD, usually called house of quality (HOQ), is of fundamental and strategic importance in the QFD process. Although the traditional HOQ has been successfully used for several decades, it has often been faced with a number of problems in real application cases. This paper will discuss three main problems: (1) the conceptual gap between customers and designers, (2) the existence of the possible customer segments, and (3) the need for trade-off among different levels of customer needs, which tend to come up in the early stage of the HOQ process. In order to overcome these problems, a new methodology is proposed based on the integration of two marketing research techniques: conjoint analysis and two-stage cluster analysis. Conjoint analysis is used to bridge conceptual gap and to balance different levels of customer needs. A two-stage clustering method is employed to cluster customers into different segments based on the main benefits derived from the conjoint study, and to foster the development of a product family. This paper also introduces three indices, namely, the commonality percentage, the cost reduction, and the satisfaction percentage to analyze the results of developing a generic product in comparison with a product family. A case study on office chair is put forward to illustrate the performance of the proposed methodology.

R. B. Kazemzadeh · M. Behzadian (✉) · M. Aghdasi · A. Albadvi
Tarbiat Modares University,
Tehran, Iran
e-mail: behzadian_ie@yahoo.com

Keywords QFD · HOQ · Two-stage cluster analysis · Conjoint analysis · Benefit segmentation · Product family

1 Introduction

In a competitive market, it is a prerequisite for companies to design and produce products and services that respond to market changes and satisfy customer needs. In this regard, QFD is a well-structured technique and strategic tool to reflect customer needs in the product design and manufacturing processes. QFD, which was originally developed in Japan in the late 1960s [1], has been used to translate customer needs into technical requirements through the integration of marketing, design, engineering, manufacturing, and other relevant functions of a company [2]. In recent years, a variety of industries around the world have welcome QFD [3], and a number of researchers have attempted to adopt QFD to different domains. A literature review and a reference bank of 650 QFD publications were presented by Chan and Wu [4]. In this review, the QFD references were grouped according to their contents into four broad categories: general introduction, functional field, application industry, and theoretical development.

In essence, QFD utilizes four sets of matrices to establish relationships between company functions and customer needs. The four matrices include product planning, parts deployment, process planning, and production planning [5]. As depicted in Fig. 1, the QFD process begins with a matrix that links customer needs to technical requirements, along with competitive benchmarking information. The process is then followed by a sequence of matrices that integrate technical requirements into design, operation and manufacturing system.

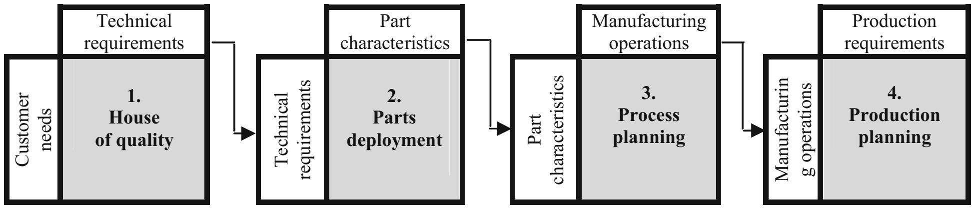


Fig. 1 Four QFD matrices

Although the traditional QFD technique has been proposed and put in use for several decades, it has been fraught with a number of problems in real application cases. In recent years, many researchers have focused on finding efficient methodologies to improve applicability of this technique. According to an in-depth review of some recent QFD publications, the main problems concerning the implementation of the traditional QFD can be categorized into the followings:

(1) It is complex and very time consuming [6–10].
(2) The size of the matrices is too big [3, 9, 11–13].
(3) It is often difficult to discriminate between diverse and conflicting customer needs [11, 14–16].
(4) It is often difficult to reach agreement on conflicting technical requirements [9, 17–19].
(5) It is difficult to prioritize customer needs and technical requirements with conventional scaling of ratings [20–23].
(6) The voice of the customer (VOC) is dynamic in nature, and listening to the current VOC is not enough [24–27].
(7) It is difficult to meet the needs of different customer groups or segments [24, 28–31].
(8) It is not possible to consider all technical requirements during product development because of many constraints in time, budget, feasible technology and so on [32–36].
(9) Customer needs, correlation among technical requirements, relationship between customer needs and technical requirements are often expressed informally in subjective and vague terms and linguistic variables [10, 37–41].

This paper aims at the following: 1) addressing the problem of the conceptual gap between customers and designers in the early stage of the HOQ process; 2) focusing on identifying the existence of the possible customer segments based on the variation among customer needs prior to utilizing the HOQ process; 3) attempting to create a reasonable balance among the different levels of customer needs in the early stage of the HOQ process.

In order to deal with these problems, this paper employs a combination of marketing research techniques. Conjoint analysis is used to bridge the conceptual gap between customers and designers and to create a reasonable balance among the different levels of customer needs. Two-stage clustering method is employed to cluster customers into different segments, and to support the development of a product family. In a further attempt, three indices are proposed to provide a basis for comparison between the development of a generic product for all customers and a customized product for each segment. The research scope is limited to HOQ, the first phase of the QFD method. In today's competitive environment, HOQ is a key strategic tool to aid companies in developing products that satisfy customer needs [42].

The rest of the paper is organized as follows. In the next section, research problems are illustrated in details. In Sect. 3, a literature review of the research problems is presented. Section 4 outlines the proposed methodology combining conjoint analysis, benefit segmentation, two-stage cluster analysis and three comparative indices. Section 5 illustrates the performance of the proposed methodology using a case study on office chair. Finally, conclusions and further research are discussed in Sect. 6.

2 Research problems

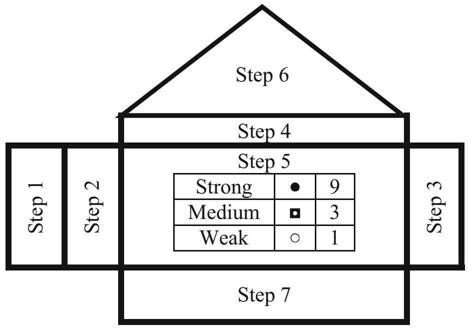
The HOQ is of fundamental and strategic importance in the QFD system [8]. The foundation of the HOQ is the belief that products should be designed to reflect customers' desires and tastes. According to Hauser and Clausing [43], the HOQ is a kind of conceptual map that provides the means for inter-functional planning and communications. The basic concept of HOQ is to translate customer needs into technical requirements, and then to rank technical requirements. As shown in Fig. 2, seven steps are required to construct a typical traditional HOQ. The final output of HOQ is the set of technical requirements, which are transferred into the second phase of QFD, parts deployment.

In spite of a considerable number of documented successes with the use of traditional HOQ, there have been some problems in the implementation process, and a large number of companies have failed in this regard [9]. In the following paragraphs, three main problems are investigated in detail:

- Need for conceptualization

In the HOQ process, customer needs determined using the customer's conception are translated into technical

Fig. 2 Representation of HOQ chart



Step 1: Identifying customer needs
Step 2: Determination of relative importance of customer needs.
Step 3: Customer competitive assessment.
Step 4: Determination of technical requirements.
Step 5: Preparation of the relationship matrix.
Step 6: Preparation of the correlation matrix.
Step 7: Ranking technical requirements and defining targets.

requirements using the designer's conception. The core principle of this process is a true and exact translation of customer needs into technical requirements. Customers have a limited knowledge of the individual functions of the product, and they express their needs, such as high quality and reliability of the product as a whole using linguistic qualifiers. In addition, several needs of customers sometimes remain unspoken, while capturing VOC using present methods. In contrast to the customer, designers have an in-depth knowledge of the functions of the product, and they usually express their information in technical and clear terms. Due to conceptual gap between customers and designers, it is often difficult for designers to translate the real needs of customers into technical requirements. Further, the company has to address the question, whether effectively represent the customer's conception when translating customer needs into technical requirement. In order to respond to this question, it is important that company looks for an effective solution to connect customer's conception with designer's conception in the early stage of the HOQ process.

- Need for segmentation

When defining the external customer in HOQ, a single customer group is often assumed [24, 31]. In this case, designers can easily find the corresponding technical requirements for the product design. If the different customer groups have similar needs for the same product and the importance of the needs is almost the same, traditional HOQ can be applied. However, different customer groups may have different sets of customer needs for the same product. In order to cope with this situation, two strategies can be considered:

(1) The first strategy is to develop a generic product for all customers or segments. This implies that company needs to uphold the traditional HOQ process. However, meeting the needs of one customer group does not mean that product can be accepted by other groups.
(2) The second strategy is to develop a uniquely customized product for each customer. This implies that company needs to fill out a unique HOQ matrix for each customer. Due to constraints in design, time, budget or feasible technology in a competitive environment [33], it is not reasonable to manage a unique HOQ matrix for each customer. As a market-oriented strategy, it is important that company recognizes the existing customer segments on the basis of the benefits they seek. The objective is to develop a product family in response to the needs of each segment. Developing product family enables a company to offer two or more products that are highly differentiated yet share a substantial fraction of their components [29].

- Need for trade-off

In the traditional HOQ, customers are usually asked to prioritize each customer need individually. They compile a list of priorities for their needs. In this regard, it is often too difficult for companies to discriminate which needs are related to each other, or cannot be satisfied simultaneously [44]. Although customers wish all their needs with high and low priorities would be satisfied at once, given cost and feasible technology constraints, a company cannot completely satisfy all its customers' needs. This understanding enables a company to strike a balance among its customers' needs by constructing the most value profiles of different levels, which are related to each other, and to ask customers to weigh each profile, rather than weigh each customer need individually.

A clear definition of three main problems is schematically presented in Fig. 3.

3 Literature review

This section of the paper presents a brief literature review on research problems. It is mainly related to the aspects of conceptual gap between customers and designers, market segmentation and trade-off among the customer needs in the literature of QFD and new product development.

In the context of product conceptualization and customer segmentation, a number of comprehensive studies can be found in Chen et al. [45, 46] and Yan et al. [47, 48]. Chen et al. [45] proposed a prototype system that comprised two

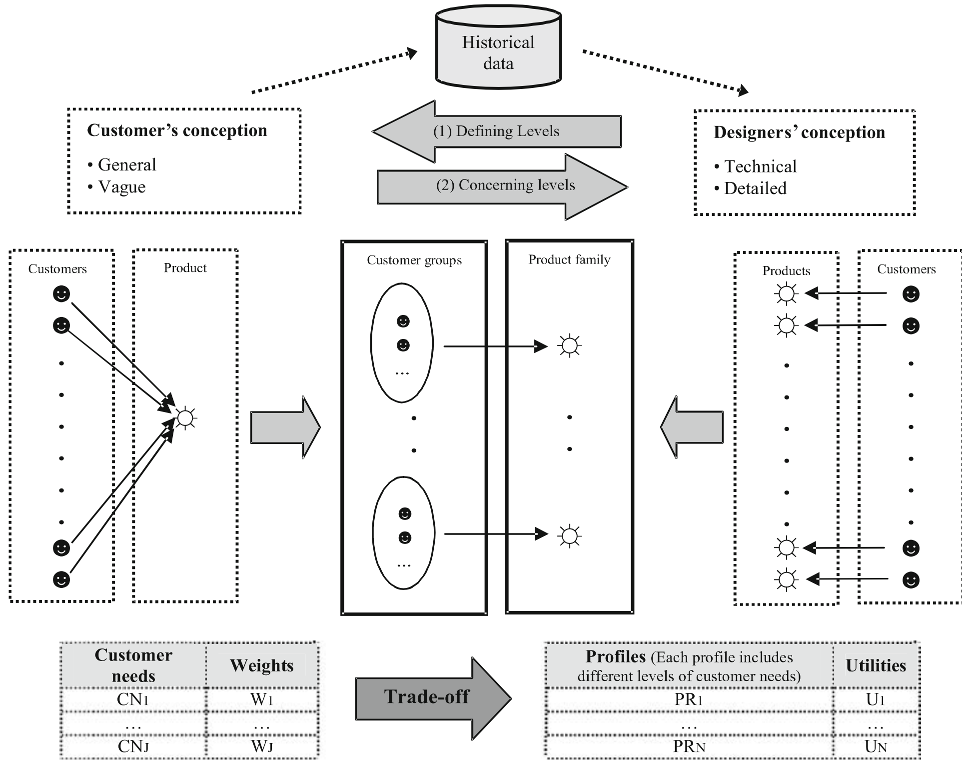


Fig. 3 Graphical representation of research problems

phases, namely product definition using laddering technique and design knowledge hierarchy, and product customization using conjoint analysis and Kohonen association techniques. Conjoint analysis was used to generate utility function representing the customer preference on design alternative, and Kohonen association technique employed to detect the cluster centers of customer ratings for soliciting the customer desirability. In order to maximize customer involvement in relation to product concept development, Chen et al. [46] also proposed a prototype system that comprises two interrelated components, namely, the customer requirements elicitation (CRE) and the customer/marketing analysis (CMA) modules. In the prototype system, the laddering technique was employed to enable CRE and adaptive resonance theory neural network was applied as a toolkit for customer segmentation and marketing analysis. The output patterns obtained from CMA module identified major customer groups according to multicultural factors.

Yan et al. [47] established a QFD-enabled product conceptualization system that consists of three cohesively interacting modules, namely, design knowledge elicitation module using laddering technique, design knowledge representation module using design knowledge hierarchy (DKH), and design knowledge organization module using restricted Coulomb energy (RCE) neural network. The novel classification strategy based on the RCE network proposed to analyze multicultural customer factors. More recently, Yan et al. [48] established a novel system based on a four-domain modelling paradigm and a three-phases process to evaluate demographic customer characteristics and to detect demographic customer differences in the product conceptualization process. In this system, a design knowledge hierarchy is postulated for product conceptualization and a Kohonen association algorithm is adopted for clustering customer rating organized in diverse demographic customer groups.

Apart from the studies mentioned above, few attempts have concentrated on the customer segmentation in the HOQ process. Using an illustrative example that is hardly supported by any market research, Xie et al. [24] divided customers into three groups and drew up three columns in HOQ for different priority ratings associated with each customer group. Sohn [49] employed a cluster analysis method based on the centroid method to group individual locations of accidents. Different HOQ matrices were proposed in this paper to meet the needs of different groups of individuals. Hsiao and Liu [29] applied two HOQ matrices for two different markets with different lunch times. Kim et al. [50] proposed to use several HOQs for several customer groups. These attempts clearly imply the need for huge expenditures of time and effort to handle several HOQs. While the current studies have proposed some useful insights for customer segmentation, there is often inadequate concentration in-depth marketing research into the HOQ matrix.

In order to address conceptual gap problem in HOQ, most recent studies have applied fuzzy set theory [9, 10, 36–40, 51–54]. Although fuzzy logic can be widely used in handling vagueness in the knowledge and other inexact information, it just quantifies the vagueness levels of the importance and relationships in HOQ. Therefore, the problem of interrelating non-technical and informal expression of customers and technical characteristics synthesized by the designers is not solved.

According to a review of literature, few researchers have been attempted to link conjoint analysis to QFD [55]. These attempts have used conjoint analysis from an engineering perspective to evaluate the relative importance of technical requirements in the eyes of the customers. Based on a comparative study of QFD and conjoint analysis, Pullman et al. [56] concluded that these two approaches are, in fact, complementary rather than substitutes. In response to Pullman, Katz [57] argued QFD and conjoint analysis are used best sequentially. However, recent research papers on the integration of QFD and conjoint analysis have focused on technical requirements and their importance levels, and there has been a lapse of concentration on the areas of interest presented in this paper.

4 The proposed methodology

This paper aims at highlighting the importance of the marketing research techniques as the premise for product conceptualization, market segmentation and trade-off among the customer needs in the early stage of the HOQ process. For this purpose, a five-step methodology is proposed in the paper, as shown in Fig. 4.

In the first step, a conjoint analysis is employed to bridge the conceptual gap between all customers and designers and to balance the different levels of customer needs. It is also applied for prioritizing the needs of all customers. The second step of the methodology employs a benefit segmentation approach and a two-stage clustering method to cluster customers into meaningful homogeneous segments. The benefits obtained from conjoint study are used as an input to two-stage clustering method. In the third step, conjoint analysis is performed for each segment by exactly the same procedure as it is done in the first step. The fourth step follows the traditional HOQ process to prioritize technical requirements for each segment and all customers. In the final step, three indices are proposed to make a point of comparison between developing a generic product for all customers and a customized product for each segment.

4.1 Conjoint steps and formulation

Conjoint analysis is a multivariate technique used specifically to understand how customers develop preferences for product [58]. In the context of design, conjoint analysis was introduced as one of the market research hard tools for creating more attractive products in future [59], and as a tool supporting the use of QFD [60]. According to Kamakura [61], conjoint analysis is especially helpful in the identification and understanding of benefit segments. The followings are the necessary steps to perform a conjoint study [58, 62]:

(1) Determination of the relevant factors and levels: For the purpose of this paper, conjoint analysis allows defining customer needs, as factors, and different levels for each customer need. These levels are understandable for customers and represent a single concept. Firstly, customer needs are listed based on the

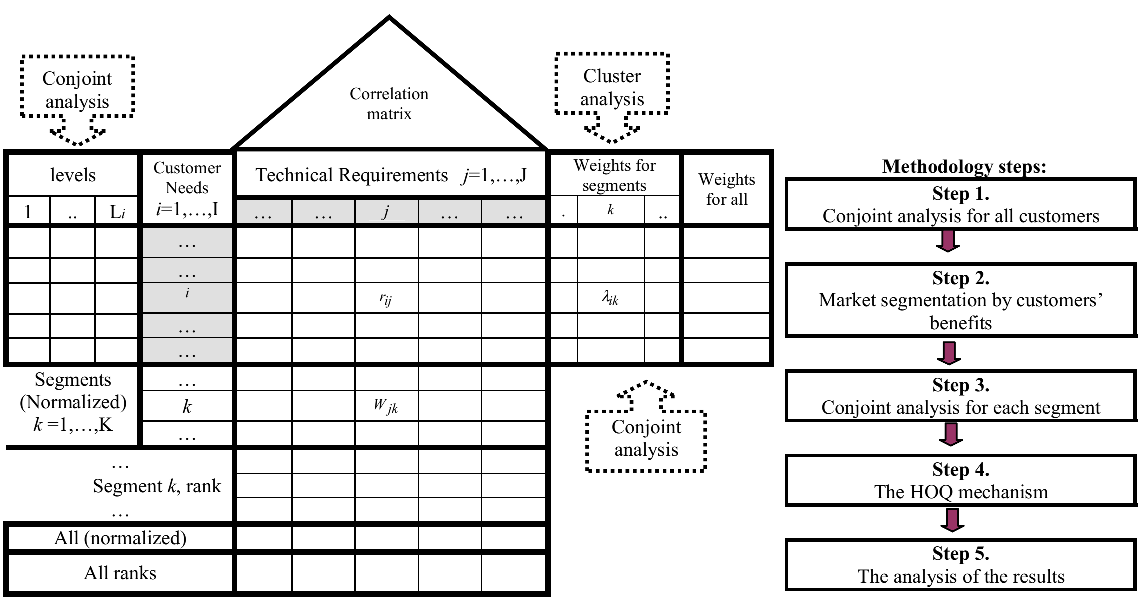


Fig. 4 Framework and steps of the proposed methodology

historical data and interviews. This list of primary customer needs is usually imprecise and very general in nature. Further definition is accomplished by defining different levels of each customer need to support the primary customer needs. The new list represents greater details than the primary list, and is often actionable and communicable by designers. Therefore, customers have to concentrate on the levels of needs that are slightly detailed, and close to the conception of designers.

Conjoint analysis is also used to create a reasonable balance among the different levels of customer needs, because customers are asked to make judgments about the needs that affect their purchase decisions conjointly, rather than evaluate each customer needs individually.

(2) Choosing the method of data collection: For the purpose of this paper, a full-profile approach is selected for more than six and less than ten factors [63]. This approach is able to reduce the number of comparisons through the use of fractional factorial designers. It also presents a more realistic description achieved by defining levels of each customer need and a more explicit portrayal of the trade-offs among all customer needs [58].
(3) Creating the profiles: According to a relatively large number of factors and levels, this paper employs a fractional factorial design to select only a subset of profiles.
(4) Calculating part–worth utility for each level of customer need.
(5) Calculating the relative important of each customer need.
(6) Evaluating and interpreting the results.

The following paragraphs represent the equations for calculating the part–worth utility for each level and relative important of each customer need. These equations were taken under a procedure introduced by Hair et al. [58], and modified to appropriate mathematical formulation for the purpose of this paper. In order to obtain equations, the following notations are defined in Table 1:

$i=1,\ldots,I$ — ith customer need
$l=1,\ldots,Li$ — lth level of ith customer need
$k=1,\ldots,K$ — kth segment
$m=1,\ldots,Mk$ — mth customer in kth segment
$n=1,\ldots,N$ — nth profile
$T=\sum_{i=1}^{I} Li$ — total number of levels

The part–worth utility for each level (PW_{ikl}) can be obtained by Eq. (1):

$$PW_{ikl} = \pm\sqrt{\frac{X_{ikl^2}\times T}{\sum_{i=1}^{I}\sum_{l=1}^{L_i} X_{ikl}^2}} \tag{1}$$

$$i = 1,\ldots,I,\ k = 1,\ldots,K\ ,\ l = 1,\ldots,Li$$

where PW_{ikl} is when X_{ikl} is negative and is — when X_{ikl} is positive, and

$$X_{ikl} = Y_{ikl} - \left(\frac{\sum_{i=1}^{I}\sum_{l=1}^{L_i} Y_{ikl}}{T}\right) \tag{2}$$

$$i = 1,\ldots,I,\ k = 1,\ldots,K,\ l = 1,\ldots,Li$$

where

$$Y_{ikl} = \frac{\sum_{m=1}^{M_k}\sum_{n=1}^{N} U_{kmn}\times Z_{\ln}}{\sum_{n=1}^{N} Z_{\ln}\times M_k} \tag{3}$$

$$i = 1,\ldots,I,\ k = 1,\ldots,K,\ l = 1,\ldots,L$$

where $Z_{\ln}=1$ if nth profile includes lth level, otherwise 0. U_{kmn}, which is calculated on a questionnaire concerning customers' benefits, denotes the utility of nth profile for mth customer in kth segment.

Table 1 Representation of notations

Segments $k=1,\ldots,K$	Customers $m=1,\ldots,Mk$	Profiles (variables) $n=1,\ldots,N$			Needs $i=1,\ldots,I$	Levels $l=1,\ldots,Li$	Segments $k=1,\ldots,K$		
		...	n	...			...	k	...
...	...	...	...	...	...	...	...	...	...
	k	...	...	...		i	...	...	...
	m	...	U_{kmn}	...		l	...	PW_{ikl}	...
	...	...	...	...		...	...	...	...
...	...	...	...	...	...	...	...	...	...

The relative importance of ith customer need in kth segment (λ_{ik}) can be obtained using the following equation:

$$\lambda_{ik} = \frac{\max PW_{ikl} - \min PW_{ikl}}{\sum_{i=1}^{I} (\max PW_{ikl} - \min PW_{ikl})} \times 100 \quad (4)$$
$$i = 1, \ldots, I, \; k = 1, \ldots, K, \; l = 1, \ldots, Li$$

In order to calculate PW_{ikl} and λ_{ik} according to all customers, index k should be omitted from the equations.

4.2 Benefit segmentation

The marketing research literature describes numerous segmentation approaches such as geographic, demographic, life style and product benefits, used to divide a heterogeneous market into homogenous subsets of segments [64]. Among these approaches, benefit segmentation, which was developed by Haley [65], as an approach to understanding and developing segment structures is demonstrably superior to other approaches [66]. While other segmentation approaches are descriptive, benefit segmentation is casual [65]. Benefit segmentation is also useful in suggesting physical change in a product and is often able to identify new product development opportunities [67]. More recently, Haley [68] suggested that the new era of mass customization has increased the necessity and usefulness of the benefit segmentation approach to meet the increasingly diversified customer needs. Moreover, a huge number of studies have convincingly demonstrated the usefulness of benefit segmentation for different application areas. Some of the most important studies in this regard were conducted by Lee et al. [66], Botschen et al. [69] and Lee et al. [70].

4.3 Two-stage clustering method

In this study, an integration of Ward's minimum variance method and K-means method, namely, two-stage clustering method, is used to cluster customers based on the their main benefits into meaningful homogeneous sub-groups which may exist within the market. In the first stage, Ward's method is used to determine the initial number of clusters which the K-means method requires. There are some reasons to apply ward's method for benefit segmentation as follows: Firstly, Ward's method has worked well in earlier studies with similar data [58, 64]. Secondly, it can perform well by considering ordinal data [71]. Thirdly, based on the findings of 12 empirical studies which compared the performance of various clustering methods, Ward's method outperforms other hierarchical clustering methods except in the presence of outliers [72, 73]. Fourthly, the method tends to unify segments such that the variation within these segments does not increase too drastically [74]. However, it is a desired result from this research to see remarkably homogeneous segments, and to develop a customized product that is able to meet most the needs of each segment.

The assignment role in Ward's method rests on the minimum increase in loss information with each grouping. At each step in the analysis, union of every possible pair of clusters is considered, and the two clusters in the minimum increase in loss information are combined [71]. Information loss is defined by Ward's method in terms of an error sum of squares ($E.E.S$). The $E.E.S$ is computed as [75]:

$$E.E.S = \sum_{k=1}^{K} \left(\sum_{m=1}^{M_k} X_{km}^2 - \frac{1}{M_k} \left(\sum_{m=1}^{M_K} X_{km} \right)^2 \right) \quad (5)$$

where X_{km} denotes the trait value for the mth customer in the kth segment, k is the total number of segments at each stage, and M_k is the number of customers in the kth segment.

Although Ward's method has performed successfully in some of the earlier marketing studies, it is sensitive to the presence of outliers. Therefore, it is desirable to combine this method with a non-hierarchical method, which is resistant to outliers. Punj and Steward [72] suggested that integration of Ward's method and K-means method can provide better solution for clustering. The main reason for such integration is that Ward's method can provide the optimal number of clusters and starting point of each cluster which the K-means method requires to determine the final solution due to its efficiency. K-means with a derived point generally performs better than other methods across all conditions and provides the best recovery of cluster structure [72].

4.4 Three comparative indices

In the final step, three indices are used to make a basis for comparison between the development of a generic product for all customers and a customized product for each segment. These indices, which are simple and could be perceived as ad hoc, are briefly described as follows:

4.4.1 The commonality percentage index (CPI)

A product family comprises a set of technical requirements that remains common from product to product, and others that vary from product to product [76]. Hence, the *CPI* is a measure of how well the product family design utilizes common technical requirements. It is computed as the following equation:

$$CPI = \frac{\sum_{j=1}^{J} \sum_{k=1}^{K} E_{jk}}{J \times K} \times 100 \qquad E_{jk} \in \{0, 1\} \quad (6)$$
$$j = 1, 2, \ldots, J, \; k = 1, 2, \ldots, K$$

where J and K denote the total number of technical requirements and segments, respectively. E_{jk} is equal to 1 when jth technical requirement in kth segment is common to jth technical requirement in other segments and 0 when it is uncommon. The *CPI* has scores ranging between 0 to 100 percent, where a value of zero percent represents no commonality and a value of 100% represents the highest possible commonality. However, a higher *CPI* is better, since it indicates that the different products within the product family are being achieved with fewer unique technical requirements.

4.4.2 The cost reduction index (CRI)

It is essential that company is able to operate with the lowest possible production cost. In this paper, the *CPIk* is savings in production cost when the company decides in favour of meeting customized technical requirements for customers in kth segment rather than generic technical requirements. The index can be obtained as the following equation:

$$CRI_k = \sum_{j=1}^{J} \left(C_j - C_{jk}\right) \quad k = 1,\ 2, \ldots, K \tag{7}$$

where C_{jk} and C_j are the cost of production to meet jth technical requirement of a customized product in kth segment and a generic product, respectively, and C_j - C_{jk} is a measure of cost reduction for customers in kth segment while using a customized technical requirement rather than a generic technical requirement.

4.4.3 The satisfaction percentage index (SPI)

Although higher cost reduction motivates the company to adopt more commonality among products in a family, it may negatively affect customers satisfaction if a product does not appeal to the customers for whom it is designed. While a product family targets a certain market segment, each customized product is designed to address a specific set of customer needs within the market segments. Hence, SPI_k is defined as a measure of customer satisfaction, and can be declined when the customers in kth segment have to buy a generic product rather than a customized product. It is calculated as the following equation:

$$SPI_k = \left(1 - \sum_{j=1}^{J} D_{jk} \times W_{jk}\right) \times 100 \; D_{jk} \in \{0, 1\} \tag{8}$$

$$k = 1,\ 2, \ldots, K$$

where

$$W_{jk} = \frac{\sum_{i=1}^{I} \lambda_{ik} \times r_{ij}}{\sum_{j=1}^{J} \sum_{i=1}^{I} \lambda_{ik} \times r_{ij}} \; j = 1,\ 2, \ldots, J, \tag{9}$$

$$k = 1,\ 2, \ldots, K$$

where W_{jk} is the normalized weight of jth technical requirement for kth segment, λ_{ik} is the relative importance of ith customer need for kth segment, and r_{ij} is the quantified relationship between ith customer need and jth technical requirement. D_{jk} has a value of 0 and 1, where a value of 0 indicates that jth technical requirement for all customers and the customers in kth segment are common, and a value of 1 indicates that it is uncommon.

5 Illustrative example

A real case of design for office chair was used to illustrate the performance of the proposed methodology. The study was conducted by a company identified as a well-known brand in chair manufacturing industry. The company usually offers several models of office chair that are designed on the basis of customer needs and ergonomic standards. Figure 5 shows four popular models of office chair. In recent years, there has been a steady growth in demand for popular models of office chairs. Therefore, it was a matter of company's policy to undertake a marketing research in order to improve its design process based on the main customer's benefit.

Consequently, a QFD project in combination with marketing research techniques was set up to follow the company's policy. In regard to the proposed methodology, the QFD team launched project as follows:

Fig. 5 Four office chair models in company

Table 2 Factors and levels for office chair

	Factors (customer needs)	Levels (Number of level in 27 profiles)
CN1	To rest my arm	L11: Unimportant to me (9/27)
		L12: Important to me (in a fixed position) (9/27)
		L13: Very important to me (can be rotate side ways) (9/27)
CN2	Ability to move around	L21: I need a fixed chair that couldn't be moved in any way (18/27)
		L22: I need a chair that could be moved to carpets or hard surfaces (9/27)
CN3	Smooth, easy, one-touch seating position adjustment	L31: Yes (18/27)
		L32: No (9/27)
CN4	To adjust the movement of back and seat	L41: Could be moved simultaneously (Synchro) (18/27)
		L42: Could be moved independently (9/27)
CN5	Suitability for height	L51: A short range travel (18/27)
		L52: A long range travel (for taller users) (9/27)
CN6	To give my back the comfort and support its needs	L61: To sit with more open hip angle then other (9/27)
		L62: To match the natural contour of your spine (9/27)
		L63: To sit with more open hip angle and To match the natural contour of your spine (9/27)
CN7	Durability and life expectancy	L71: A great deal to me (intense use) (18/27)
		L72: Not a great deal to me (9/27)
CN8	Pleasing appearance	L81: Very attractive to me (18/27)
		L82: Not very attractive to me (9/27)

5.1 Conjoint analysis for all the customers

The QFD team immediately initiated the project with a thorough search for the basic needs of the customers. It was too difficult and time-consuming for the team to make a comprehensive list comprising the basic needs. To deal with this problem, company started to collect a profile of possible customer needs based on the historical data about customer complaints, interviews, direct observations, and then organized them in a customer data dictionary. After a group decision making, eight basic needs or factors and 18 related levels were identified to conduct a conjoint analysis. Table 2 presents the factors and levels identified as important by the QFD team.

In the following step, the QFD team adopted a full-profile method to conduct a conjoint study. This method requires that respondents rank or rate a huge number of profiles or stimulus. Despite a careful selection of factors and levels, there were still too many possible profiles $(3*2*2*2*2*3*2*2=576)$ for the respondents to choose from. To reduce the number of profiles to manageable size, while at the same time maintaining randomness, a fractional factorial design, using SPSS conjoint, was used. The SPSS generated a parsimonious orthogonal array of 27 profiles. Given the large number of profiles generated, it was useful to have a rating system from 1 to 10 in increments of one (1 = least likely and 10 = most likely) for 27 profiles. Tables 3 and 4 show a few number of profiles and an example of a profile card, respectively.

The QFD team followed the study through face-to-face interviews with 80 prospective customers who wanted to make a purchase for office chair. The demographic information from the potential customers consisted of gender (male = 60%, female = 40%), age (less than 40 years = 42.5%, middle-aged = 40%, more than 60 years = 17.5%), salary (low = 15%, reasonable = 50%, high = 35%), height (short = 25%, average = 62.5%, tall = 12.5%),

Table 3 Design of profiles

Profiles	CN1			CN2		CN3		CN4		CN5		CN6			CN7		CN8	
	L11	L12	L13	L21	L22	L31	L32	L41	L42	L51	L52	L61	L62	L63	L71	L72	L81	L82
1	√			√			√		√	√		√				√		√
...																		
10			√		√	√		√			√		√		√		√	
...																		
20		√			√		√	√		√				√	√			√
....																		
27		√		√			√	√		√			√		√		√	

Table 4 Example of a profile card

Profile number: 10									
I need an office chair that could									
rest my arm in a rotating position						travel in a long range			
move it to carpets or hard surfaces						match the natural contour of my spine			
adjust its seating position easily						remain in good condition for a long time			
adjust its movement of back and seat simultaneously						concern me with its appearance			
How likely are you to buy office chair that meet these needs									
	Least likely	....						Most likely	
1	2	3	4	5	6	7	8	9	10

amount of working time per day (short = 30%, long = 70%) and education level (high school = 15%, bachelor = 60%, master or doctorate = 25%). The prospective customers were asked to rate the 27 profiles. After gathering the necessary data, a conjoint analysis was conducted using the conjoint analysis option in the categories procedure of SPSS. Table 6 shows the part–worth utility for each level and the relative importance of each factor. The Pearson's R and Kendall's tau statistics (0.96) gave a good fit to the data derived from the study.

5.2 Market segmentation by customers' benefits

- Two-stage clustering

After gathering the data of customer's benefits for 27 profiles using conjoint study, a two-stage clustering method consisting of Ward's method and *K*-means method was employed to segment 80 prospective customers based on similarities in the main benefits. In the first stage, Ward's method was used to determine the optimal number of clusters. Based on the benefits derived from 27 profiles, 80 prospective customers were completely assigned to three segments using Ward's method in the SPSS software. Segments 1, 2 and 3 included 10 (12.5%), 32 (40%) and 38 (47.5%), customers, respectively. Schwarz's Bayesian criterion (BIC) gave the best fit for three clusters.

The second stage used *K*-means method to fine-tune the results from Ward's method. In performing the *K*-means method, the initial seed points were taken from the cluster centers on 27 profiles. Using the mean values on 27 profiles as seed points, *K*-means method refined three clusters. After the refinement, just two customers from segment 2 became a member of segment 1. As a result, the three clusters had 10 (12.5%), 30 (37.5%), and 40 (50%) of the prospective customers.

- Interpretation of the clusters

Figure 6 was used to provide a basis for comparison between the segments on the profile of interest. This figure gives a simple graphical aid for examining the segments in terms of either profile used to form the segments. Here the profiles and mean values on a particular profile are identified along the X-axis and Y-axis, respectively. According to the cluster mean values for the profiles and demographic information, three segments can be interpreted as follows. More detailed demographic information concerning each segment is also contained in Table 5.

Segment 1 This segment has the highest mean value on profile 11 and relatively high values on profiles 4 and 26. As shown in Fig. 6 this segment significantly differs from segments 1 and 2 in the considerable number of profiles. It has less emphasis on profiles 10, 15, 16, 17, 18 and 22, which are often attractive to the customers in segments 1 and 2. Customers in segment 3 tend to be older and less educated, and have lower salaries. They usually spend a short period of time working on computer at home.

Segment 2 This segment displays the highest mean values on profiles 18 and 23 and relatively high values on profiles 2, 10, 12, 14, 15, 16, and 22. It also displays low values on

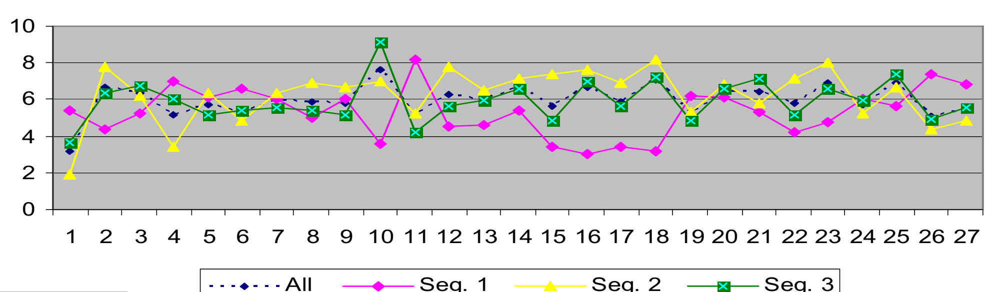


Fig. 6 Representation of mean values on profiles for all the customers and each segment

Table 5 Detailed demographic information about each segment

Segment 1 (n=10, 12.5%)	Segment 2 (n=30, 37.5%)	Segment 3 (n=40, 50%)
All the customers are males	The ratio of females is the highest (n=25)	The ratio of males is the highest (n=33)
Most of them are less-educated (bachelor = 2, high school = 8)	Most of them are well-educated (doctorate and master = 2, bachelor = 24, high school = 4)	Are well-educated (doctorate or master = 18, bachelor = 22)
Most of them have short height (average = 165 cm)	Most of them have average height (average = 171 cm)	Most of them have tall height (average = 178 cm)
Have lower salaries (average = US $480 per month)	Have reasonable salaries (average = US $845 per month)	Have high salaries (average = US $1370 per month)
Somewhat likely to be older (average = 62 years)	Somewhat likely to be younger (average = 29 years)	Somewhat likely to be middle-aged (average = 46 years)
Tend to spend a short period of time working on computer per day (average = 2.5 hours)	Often tend to spend a long period of time working on computer per day (average = 7 hours)	Tend to spend a quite long period of time working on computer per day (average = 5.5 hours)

profiles 1, 4 and 26. Customers in segment 2 tend to be well-educated and middle-aged, and have reasonable salaries. Most of customers in this segment are females and under the age of 35.

Segment 3 This segment has the highest mean value on profile 10 and relatively high values on profiles 25, 18 and 21. It also has low values on profiles 1 and 11. Segment 1 often consists of middle-aged customers who are well-educated and have higher salaries. Most of customers in this segment are males and tend to spend a long period of time working on computer per day. The customers of tall height are often included in segment 1.

- Validity of the clusters

An analysis of variance (ANOVA) as additional analysis was employed to determine the most significant differences across three clusters in terms of 27 profiles. According to Malhotra [64] the variables that significantly differentiate between segments can be identified via one-way ANOVA. In this paper, one-way ANOVA was used to examine which of the profiles differed among the three segments. The univariate F test for each clustering profile showed that only two profiles did not significantly differ at the $p<0.05$ significant level among the three segments, i.e., profile 20 ($F=0.58$, p-value = 0.561) and profile 24 ($F=1.35$, p-value = 0.266). At the $p<0.01$ significant level, profiles 7 ($F=4.38$, p-value = 0.039), 20 and 24 were not different among the three segments.

Table 6 The part–worth utility and relative importance for all the customers and each segment

	Levels	The part–worth utility				The relative importance			
		Overall	Seg. 1	Seg. 2	Seg. 3	Overall	Seg. 1	Seg. 2	Seg. 3
CN1	L11	+0.160	−0.485	+0.775	+0.125	0.262	0.35	0.306	0.176
	L12	−0.05	+0.251	−0.406	+0.01				
	L13	−0.11	+0.234	−0.369	−0.126				
CN2	L21	+0.052	−0.0085	+0.16	+0.05	0.151	0.006	0.124	0.105
	L22	−0.104	+0.0042	−0.32	−0.10				
CN3	L31	−0.0155	−0.0596	−0.065	−0.097	0.045	0.085	0.0504	0.204
	L32	+0.031	+0.119	+0.130	+0.194				
CN4	L41	−0.0130	−0.123	−0.022	−0.008	0.038	0.176	0.008	0.017
	L42	+0.0260	+0.246	+0.011	+0.016				
CN5	L51	+0.0162	−0.0425	−0.080	+0.095	0.047	0.061	0.062	0.20
	L52	−0.0324	+0.085	+0.160	−0.190				
CN6	L61	+0.024	−0.174	+0.161	+0.11	0.223	0.22	0.207	0.17
	L62	+0.103	−0.115	+0.32	−0.132				
	L63	−0.127	+0.289	−0.481	+0.022				
CN7	L71	−0.028	+0.0255	−0.130	−0.011	0.081	0.036	0.1009	0.023
	L72	+0.056	−0.051	+0.260	+0.022				
CN8	L81	−0.052	+0.0468	−0.181	−0.05	0.151	0.066	0.1405	0.105
	L82	+0.104	−0.0935	+0.362	+0.10				

Table 7 Technical requirements for office chair

TR1	Height and width adjustable arms
TR2	Degree of base movement
TR3	Pneumatic or manual height adjustment
TR4	Tilt mechanism
TR5	Range of seat pan height
TR6	Back height adjustment
TR7	Back angle adjustment
TR8	Types of high quality materials (fabrics & textiles) used
TR9	Number of colors used
TR10	Shape of components

5.3 Conjoint analysis for each segment

Apart from conjoint analysis for all the customers, a conjoint analysis was conducted on the data supplied by the customers comprising each segment. For each assigned segment, Table 6 also shows the part–worth utility for each level of customer need and the relative importance of each customer need. According to the table, there are the differences in what kinds of needs and levels the customers in each segment perceive. This preliminary result offered the company a valuable suggestion concerning the development a product family of office chairs in term of the customer needs in each segment.

5.4 The HOQ mechanism

The QFD team identified 10 technical requirements with the use of the current documents (Table 7). The QFD team also determined the relationship matrix after a brainstorming meeting. In order to rank technical requirements according to their impact on the customer needs using relationship matrix, a 1-3-9 scale was used to denote weak, medium, and strong relationships between customer needs and technical requirements.

Figure 7 shows the rank of technical requirements for all the customers and each segment. It is readily apparent that the relative importance and rank of technical requirements differs between three segments. For example, Range of seat pan height (TR1) has the highest rank for segment 3 while having lower ranks for segments 1 and 2.

5.5 The analysis of the results

In order to calculate three indices, the QFD team considered the levels of technical requirements that were relevant to all the customers and each segment. In this case, part–worth utilities with a negative value (see Table 6) and relationship matrix (see Fig. 7) were deemed to determine the relevant technical requirements. For example, "long range of seat pan height" was considered suitable for customers in

Levels			Customer needs	TR1	TR2	TR3	TR4	TR5	TR6	TR7	TR8	TR9	TR10	All	Seg.1	Seg.2	Seg.3
				Technical Requirements										The relative Importance			
L11	L12	L13	CN1	•									%À	**0.262**	**0.35**	**0.306**	**0.176**
L21	L22	-	CN2		•									**0.151**	**0.006**	**0.124**	**0.105**
L31	L32	-	CN3			•	◘	◘						**0.045**	**0.085**	**0.0504**	**0.204**
L41	L42	-	CN4				•		○	◘				**0.038**	**0.176**	**0.008**	**0.017**
L51	L52	-	CN5				◘	•						**0.047**	**0.061**	**0.062**	**0.20**
L61	L62	L63	CN6	◘			◘		•	•	○			**0.223**	**0.22**	**0.207**	**0.17**
L71	L72	-	CN7								•			**0.081**	**0.036**	**0.1009**	**0.023**
L81	L82	-	CN8	○							•	•	•	**0.151**	**0.066**	**0.1405**	**0.105**

		TR1	TR2	TR3	TR4	TR5	TR6	TR7	TR8	TR9	TR10
Customer Segments (Normalized)	1	0.25	0.004	0.049	0.173	0.052	0.139	0.162	0.073	0.038	0.061
	2	0.226	0.071	0.029	0.065	0.045	0.118	0.119	0.151	0.08	0.099
	3	0.139	0.06	0.116	0.119	0.153	0.098	0.10	0.084	0.06	0.071
Segment 1 ranks		1	10	8	2	7	4	3	5	9	6
Segment 2 ranks		1	7	10	8	9	4	3	2	6	5
Segment 3 ranks		2	9	4	3	1	6	5	7	9	8
All the customers (normalized)		0.193	0.084	0.025	0.079	0.034	0.126	0.131	0.143	0.084	0.10
All the customers		1	6	10	8	9	4	3	2	6	5

Strong	•	9
Medium	○	3
Weak	◘	1

Fig. 7 The ranking of technical requirements (overall and each segment)

Table 8 The relevant levels of technical requirements for all the customers and each segment

	% of all	TR1	TR2	TR3	TR4	TR5	TR6	TR7	TR8	TR9	TR10
Segment 1 (product 1)	12.5 %	Without	Fixed	Pneumatic	Synchro mechanism	Short range	Nok	Ok	Nok	Nok	Nok
Segment 2 (product 2)	37.5 %	Fixed	To be moved	Pneumatic	Synchro mechanism	Short range	Ok	Ok	Ok	Ok	Ok
Segment 3 (product 3)	50 %	Adjustable	To be moved	Pneumatic	Synchro mechanism	Long range	Ok	Nok	Ok	Ok	Ok
All (generic product)	100%	Adjustable	To be moved	Pneumatic	Synchro mechanism	Long range	Ok	Ok	Ok	Ok	Ok
		Unique to each segment	Common to 2 segments	Common	Common	Common to 2 segments	Common to 2 segments	Common to 2 segments	Common to 2 segments	Common to 2 segments	Common to 2 segments

Table 9 The replacement cost of technical requirements

The replacement of ... with...		The cost ($)
Short range of seat height	Long range of seat height	1.8
Fixed armrest	Adjustable armrest	5.3
Without armrest	Adjustable armrest	7.6
Fixed base	Moving base	2.5
Simple back	Back height adjustment	6.4
Simple back	Back angle adjustment	4.5
Not very high quality materials	Very high quality materials	18.8
One color	Range of colors	2.1
Usual shape	Upholstered and waterfall seat cushion	12.7

segment 3 according to relationship with "A long range travel (CN5/L52)" and its part–worth (−0.190). Table 8 shows the technical requirements that are suitable for all the customers and each segment. The three indices were calculated as follows:

- **The CPI**: In this paper, the total number of technical requirements and segments were equal to 10 and 3, respectively. Therefore, there was a reasonable possibility that QFD team could develop 30 unique levels of technical requirements. As depicted in Table 8, 20 levels of 30 possible levels became common to the three segments. A value of 66.6% to *CPI* indicated that three products from product family could be achieved fewer unique technical requirements.
- **The CRI**: In order to obtain CRI_k, the QFD team estimated the cost of production of a generic office chair at US $120. The team also estimated the current replacement cost of two possible levels of each technical requirement according to Table 9. For instance, company was unwilling to cost at US $7.10 (US $5.30US $1.80) associated with the replacement of Fixed armrest and Short range of seat height, which were of interest to segment 2, with Adjustable armrest and Long range of seat height. Thus, the development of a product family instead of a generic product allowed company the possibility of bringing out the cost of production at US $68.10, US $112.90 and US $115.50, which resulted in a savings of US $51.90, US $7.10 and US $4.50, for customers in segments 1, 2 and 3, respectively.
- **The SPI**: In order to calculate SPI_k, the QFD team drew attention to the relative importance of each set of technical requirements, according to Fig. 7. It was too easy to assume that company should satisfy all its customers' needs in each segment. However, the development of a generic product made it impossible to wholly satisfy the needs of each segment. A value of 38.4%, 72.9% and 90% to SPI_k led to a decrease of

61.6%, 27.1% and 10% on complete customer satisfaction in segments 1, 2 and 3, respectively.

As a result, it is a matter of company's policy to develop a product family rather than a generic product according to the results of this research. According to this policy, company would be able to increase the satisfaction percentage and cost reduction indices while keeping a relatively high value of commonality percentage index.

6 Conclusions and further research

A methodology composed of two techniques, conjoint analysis and two-stage clustering method, was proposed in this paper, highlighting the importance of marketing research in the early stage of the HOQ process. Conjoint analysis was used to fill the conceptual gap between customers and designers and to create a reasonable balance among the different levels of customer needs. A two-stage clustering method, using Ward's method and *K*-means method, was employed to cluster customers based on the similar benefits derived from the conjoint study. The paper also proposed three indices to analyze the results of developing a generic product compared with a customized product for each segment. In order to gain a practical understanding of the proposed methodology, a case study based on a family of office chairs was presented. This case study demonstrated the applicability and benefits of using the proposed methodology and signaled the opportunity for a company to improve its product designs.

Future research in this regard can be carried out by integrating a product family strategy to subsequent phases of QFD. Since it is too difficult for the QFD team to select the basic customer needs from a long list and to conduct a relevant conjoint analysis, it would be worthwhile to perform a factor analysis in the early stage of the HOQ process. In this case, a factor analysis makes it possible to identify the basic customer needs; to draw up a short list of factors and levels; to generate a small number of profiles that should be rated by prospective customers.

Acknowledgements We gratefully acknowledge the Nilper Company for their participation on this project, and also anonymous referees for their valuable comments and suggestions.

References

1. Akao Y (1990) Quality function deployment: integrating customer requirements into product design. Productivity Press, Cambridge
2. Cohen L (1995) Quality function deployment: how to make QFD work for you. Addison-Wesley, Reading
3. Prasad B (1998) Review of Q. F. D. and related deployment techniques. J Manuf Syst 17(3):221–234
4. Chan LK, Wu ML (2002) Quality function deployment: a literature review. Eur J Oper Res 143:463–497
5. Cristiano JJ, Liker JK, White CC III, (2000) Customer-driven product development through quality function deployment in the US and Japan. J Prod Innovat Manage 17(4):286–308
6. Huang GQ, Mak KL (1999) Web-based collaborative conceptual design. J Eng Des 10(2):183–194
7. Hsiao SW (2002) Concurrent design method for developing a new product. Int J Ind Erg 29:41–55
8. Chan LK, Wu ML (2005) A systematic approach to quality function deployment with a full illustrative example. Omega 33:119–139
9. Temponi C, Yen J, Tiao WA (1999) House of quality: a fuzzy logic-based requirements analysis. Eur J Oper Res 117:340–354
10. Büyüközkan G, Fiyzioglu O, Rual D (2007) Fuzzy group decision-making to multiple preference formats in quality function deployment. Comp Ind 58(5):392–402
11. Shen XX, Tan KC, Xie M (2000) An integrated approach to innovative product development using Kano's model and QFD. Eur J Innovat Manage 3(2):91–99
12. Tan KC, Shen XX (2000) Integrating Kano's model in the planning matrix of quality function deployment. Tot Qual Manage 11(8):1141–1151
13. Franceschini F, Rossetto S (1998) Quality function deployment: how to improve its use. Tot Qual Manage 9(6):491–500
14. Benner M, Linnemann AR, Jongen WMF, Folstar P (2003) Quality Function Deployment (QFD)—can it be used to develop food products? Food Qual Pref 14:327–339
15. Mill H (1994) Enhanced quality functional deployment. World Class Des Manuf 1(3):23–26
16. Tu YL, Fung RYK, Tang JF, Kam JJ (2003) Computer aided customer 21(10–11), 743–753
17. Balthazar PA, Gargeya VB (1995) Reinforcing QFD with group support systems: computer-supported collaboration for quality in design. Int J Qual Reli Manage 12(6):43–62
18. Büyüközkan G, Feyzioglu O (2005) Group decision making to better respond customer needs in software development. Comp Ind Eng 48:427–441
19. Ho ESSA, Lai YJ, Chang SI (1999) An integrated group decision-making approach to quality function deployment. IIE Trans 31 (6):553–567
20. Erol I, Ferrell WG Jr (2003) A methodology for selection problems with multiple, Conflicting objectives and both qualitative and quantitative criteria. Int J Prod Econ 86:187–199
21. Kahraman C, Ertay T, Büyüközkan G (2006) A fuzzy optimization model for QFD planning process using analytic network approach. Eur J Oper Res 171:390–411
22. Wasserman GS (1993) On how to prioritise design requirements during the QFD planning process. IEE Trans 25(3):59–65
23. Iranmanesh SE, Salimi MH (2003) An investigation of rank reversal when using fuzzy importance levels in QFD analysis. Int J Reli Qual Saf Eng 10(2):185–203
24. Xie M, Tan KC, Goh TN (2003) Advanced QFD application. ASQ Quality Press, Milwaulee
25. Wu HH, Liao AYH, Wang PC (2005) Using grey theory in quality function deployment to analyse dynamic customer requirements. Int J Adv Manuf Technol 25:1241–1247
26. Bae SM, Ha SH, Park SC (2005) A web-based system for analyzing the voices of call center customers in the service industry. Exp Sys Appli 28:29–41
27. Adiano C, Roth AV (1994) Beyond the house of quality: dynamic QFD. Bench Qual Manage Technol 1(1):25–37
28. Kim JK, Han CH, Choi SH, Kim SH (1998) A knowledge-based approach to the quality function deployment. Comp Ind Eng 35 (1–2):233–236
29. Hsiao SW, Liu E (2005) A structural component-based approach for designing product family. Comp Ind 56:13–28

30. Partovi FY, Corredoira RA (2002) Quality function deployment for the good of soccer. Eur J Oper Res 137:642–656
31. ReVelle JB, Moran JW, Cox CA (1998) The QFD handbook. Wiley, New York
32. Reich Y, Levy E (2004) Managing product design quality under resource constraints. Int J Prod Res 42(13):2555–2572
33. Fung RYK, Tang JF, Tu PY, Chen Y (2003) Modelling of quality function deployment planning with resource allocation. Res Eng Des 14(4):247–255
34. Lai X, Xie M, Tan KC (2005) Dynamic programming for QFD optimization. Qual Reli Eng Int 21(8):769–780
35. Bode J, Fung RYK (1998) Cost engineering with quality function deployment. Comp Ind Eng 35(3–4):587–590
36. Karsak EE (2004) Fuzzy multiple objective decision making approach to prioritize design requirements in quality function deployment. Int J Prod Res 42(18):3957–3974
37. Zhou M (1998) Fuzzy logic and optimization models for implementing QFD. Comp Ind Eng 35(1–2):237–240
38. Kwong CKK, Bai H (2002) A fuzzy AHP approach to the determination of importance weighted of customer requirement in quality function deployment. J Intell Manuf 13:367–377
39. Fung RYK, Chen YZ, Chen L, Tang JF (2005) A fuzzy expected value-based goal programming model for product planning using quality function deployment. Eng Optimiz 37(6):633–647
40. Kim KJ, Moskowitz H, Dhingra A, Evans G (2000) Fuzzy multicriteria models for quality function deployment. Eur J Oper Res 121(3):504–518
41. Chen Y, Chen L (2006) A non-linear possibilistic regression approach to model functional relationships in product planning. Int J Adv Manuf Technol 28:1175–1181
42. Karsak EE, Sozer S, Alpteki SE (2002) Product planning in quality function deployment using a combined analytic network process and goal programming approach. Comp Ind Eng 44:171–190
43. Hauser JR, Clausing D (1988) The house of quality. Harvard Bus Rev 66(3):63–73
44. Korti A (2006) Analyzing customer value using conjoint analysis: the example of a packaging company. University of Tartu, Tartu, Faculty of Economics and Business Administration
45. Chen CH, Khoo LP, Yan W (2005) PDCS—a product definition and customisation system for product concept development. Exp Syst Appli 28(3):591–602
46. Chen CH, Khoo LP, Yan W (2002) A strategy for acquiring customer requirement patterns using laddering technique and ART2 neural network. Adv Eng Infor 16(3):229–240
47. Yan W, Khoo LP, Chen CH (2005) A QFD-enabled product conceptualization approach via design knowledge hierarchy and RCE neural network. Know-Based Syst 18:279–293
48. Yan W, Khoo LP, Chen CH (2007) Identification of different demographical customer preferences for product conceptualization. J Eng Des 18(1):39–54
49. Sohn SY (1999) Quality function deployment applied to local traffic accident reduction. Acc Anal Prev 31(6):751–761
50. Kim JK, Han CH, Choi SH, Kim SH (1998) A knowledge-based approach to the quality function deployment. Comp Ind Eng 35 (1–2):233–236
51. Fung RYK, Chen Y, Tang J (2006) Estimating the functional relationships for quality function deployment under uncertainties. Fuz Sets Sys 157:98–120
52. Sohn SY, Choi IS (2001) Fuzzy QFD for supply chain management with reliability consideration. Reli Eng Syst Saf 72 (3):327–334
53. Ertay T, Büyüközkan G, Kahraman C, Ruand D (2005) Quality function deployment implementation based on analytic network process with linguistic data: an application in automotive industry. J Intell Fuzzy Syst 16:221–232
54. Chen Y, Tang J, Fung RYK, Ren Z (2004) Fuzzy regression-based mathematical programming model for quality function deployment. Int J Prod Res 42(5):1009–1027
55. Baier D, Brusch M (2005) Linking quality fuction deployment and conjoint analysis for new product design. In: Baier D, Decker R, Schmidt-Thieme L (eds) Data analysis and decision support. Springer, Berlin, pp 189–198
56. Pullman ME, Moore WL, Wardell DG (2002) A comparison of quality function deployment and conjoint analysis in new product design. J Prod Innovat Manage 19:354–364
57. Katz GM (2004) Practitioner note: a response to Pullman et al.'s (2002) Comparison of quality function deployment versus conjoint analysis. J Prod Innovat Manage 21:61
58. Hair JF Jr, Anderson RE, Tatham RL, Black WC (1995) Multivariate data analysis, 4th edn. Prentice Hall, Upper Saddle River
59. Akao Y, Mazur G (2003) The leading edge in QFD: past, present and future. Int J Qual Reli Manage 20(1):20–35
60. Gustafsson A, Ekdahl F, Bergman B (1999) Conjoint analysis: a useful tool in the design process. Tot Qual Manage 10(3):327–343
61. Kamakura WA (1988) A least squares procedure for benefit segmentation with conjoint experiments. J Mar Res 25(2):157–167
62. Van der Pol M, Ryan M (1996) Using conjoint analysis to establish consumer preferences for fruit and vegetables. Brit Food J 98(8):5–12
63. North E, De Vos R (2002) The use of conjoint analysis to determine consumer buying preferences: a literature review. J Fami Ecol Cons Sci 30:32–39
64. Malhotra NK (1993) Marketing research- an applied orientation. Prentice-Hall, Englewood Cliffs
65. Haley R (1968) Benefit segmentation: a decision-orientated research tool. J Mar 32:30–35 (July)
66. Lee G, Morrison AM, O'Leary JT (2006) The economic value portfolio matrix: A target market selection tool for destination marketing organizations. Tour Manage 27:576–588
67. Haley R (1995) Benefit segmentation: a decision-orientated research tool. Mar Manage 4(1):59–62
68. Haley R (1999) Benefit segmentation—thoughts on its past and its future. J Seg Mar 3(1):5–11
69. Botschen G, Thelen EM, Pieters R (1999) Using means-end structures for benefit segmentation: An application to services. Eur J Mar 33(1/2):38–58
70. Lee DH, Kim SH, Ahn BS (2000) A conjoint model for Internet shopping malls using customer's purchasing data. Exp Syst Appli 19:59–66
71. Everitt BS (1993) cluster analysis, 3rd edn. Edward Arnold, London
72. Punj G, Stewart DW (1983) Cluster analysis in marketing research: review and suggestions for application. J Mar Res 20:134–148
73. Sharma S (1996) Applied multivariate techniques. Wiley, New York
74. Hardle W, Simar L (2003) Applied multivariate statistical analysis. Springer Verlag, Berlin-Heidelberg-New York
75. Dillon WR, Goldstein M (1984) Multivariate analysis methods and applications. Wiley, New York, p 173
76. Timothy WS, Jonathan RAM, Farrokh M (2001) Product platform design: method and application. Res Eng Des 13:2–22