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On integrating multiple type preferences into competitive analyses of customer requirements in product planning

Yan-Lai Li [a,b,*], Jia-Fu Tang [b], Kwai-Sang Chin [c], Xing-Gang Luo [b], Yun Pu [a], Yu-Shi Jiang [d]

[a] School of Traffic, Transportation, and Logistics, Southwest Jiaotong University, Chengdu, Sichuan 610031, People's Republic of China
[b] Natural Key Lab of Integrated Automation of Process Industry in Northeastern University, School of Information Science and Engineering, Northeastern University, PO 135, Shenyang, Liaoning 110004, People's Republic of China
[c] Department of System Engineering and Engineering Management, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon Tong, Hong Kong, People's Republic of China
[d] School of Economics and Management, Southwest Jiaotong University, Chengdu, Sichuan 610031, People's Republic of China

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ABSTRACT

As a customer-driven product development methodology, quality function deployment (QFD) is a widely used methodology to translate customer requirements (CRs) into engineering characteristics (ECs) to achieve higher product performance and customer satisfaction. Product planning house of quality is of fundamental and strategic importance in the QFD system. Each customer has different preferences for the products of the corporation and its competitors. Furthermore, the customers tend to give their personal preferences in multiple expression formats, i.e., multiplicative judgment comparison matrix, utility value vector, and complementary judgment comparison matrix, relying on their cultural and educational background and value systems. In this paper, we propose an extension on incorporating the multi-format preference information into the relative satisfaction elevations of CRs, and present an integrated approach of the group decision-making, multi-format preference analyses, and three types of least square models for acquiring the sale points of CRs in order to tackle the relative satisfaction elevations and multi-format preference information in a combined way. Finally, a case study is provided to illustrate the effectiveness of the proposed approach.

1. Introduction

Manufacturing corporations are facing more and more intense competition in the global markets. They have realized that the efficient design and manufacture of products preferred by customers at more competitive costs and shorter lead time over those offered by their competitors are crucial to their survival and development. In this regard, quality function deployment (QFD), as a useful tool for customer-oriented product development, is an extensive methodology to translate customer requirements (CRs) into engineering characteristics (ECs) to meet customer expectations by bridging the communication gap between customers and design team (Akao and Mazur, 2003). The adoptions of quality function deployment are extensive product development practices in manufacturing corporations to cope with competitive global competition. These practices have proven that QFD is able to improve product development processes and deliver high-quality products that are highly focused on and responsive to CRs. When corporations direct their efforts towards meeting their CRs by using QFD, higher product quality, better customer satisfaction, and larger revenues are obtained owing to the minimization of internal conflicts, shorter development cycle times, and increased market penetration (Carnevalli and Miguel, 2008; Chen and Ko, 2011; Cristiano et al., 2000; Li et al., 2009, 2010b; Mirzapour Al-e-hashem et al., 2011; Min and Kim, 2008; Iranmanesh and Thomson, 2008; Kim et al., 2000; Kwong et al., 2008; Raharjo et al., 2008; Reich, 2000; Reich and Levy, 2004; Shen et al., 2001; Shin et al., 1997; Sireli et al., 2007; Wang and Chin, 2011; Yazdifar and Askarany, 2012; Zandi and Tavana, 2011; Zhai et al., 2010).

Product planning house of quality (PPHOQ) is of fundamental and strategic importance of QFD, since CRs are identified, incorporated the corporation's competitive priorities, and converted into ECs, and then the target levels for ECs are determined in PPHOQ (Cristiano et al., 2001a; Ganga and Carpinetti, 2011; Govers, 1996; Iranmanesh and Salimi, 2003; Karsak, 2004; Kim et al., 2007; Lai et al., 2008; Li et al., 2010a, 2011b; Raharjo et al., 2006; Tan and Raghavan, 2004; Tan and Shen, 2000). Since the aggregated importance ratings (IRs) of CRs are translated into the priority ratings of ECs which will largely affect the target value of ECs for product improvement, determining the aggregated IRs of CRs is a crucial step in the complex decision-making process of constructing PPHOQ, and considerable effort must be committed to properly acquire the aggregated IRs of CRs in order to keep the corporation to be successful (Carnevalli et al., 2010;

* Corresponding author. Tel./fax: +86 28 87600165.
E-mail address: lyl_2001@163.com (Y.-L. Li).

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Li et al., 2011a, 2012; Park and Kim, 1998; Reich and Paz, 2008; Xie et al., 2003).

Determining the aggregated IRs of CRs generally consists of four steps, which are essentially the input of CRs in constructing PPHOQ (Chan and Wu, 2002a, 2002b; Chan and Wu, 2005). These proposed hierarchical steps are described as follows:

Step 1. Identify customer requirements.
Step 2. Determine the fundamental IRs of CRs.
Step 3. Conduct competitive analyses of CRs and set the proper improvement targets of CRs.
Step 4. Determine the aggregated IRs of CRs.

Since CRs are the driving force in the PPHOQ, considerable efforts must be committed to properly capture those requirements in order to make a corporation successful. There are many methods available to collect CR candidates, including focus groups, individual interviews, listening and watching, complaints, natural field contact, warranty data, feedback, affinity diagram, and cluster analysis. In particular, grouping related CR candidates into a category is helpful in analyzing these candidates. Affinity diagram or cluster analysis can be used to organize CR candidates into the tree-like structure CRs for PPHOQ (Griffin and Hauser, 1993; Hauser and Clausing, 1988; Kwong et al., 2008). Determining the fundamental IRs of CRs has been extensively researched, and quite a number of approaches have been suggested in the QFD literature. For example, the simplest method for determining the fundamental IRs is based on a point scoring scale (Hauser and Clausing, 1988). Conjoint analysis method was attempted to determine the fundamental IRs (Griffin and Hauser, 1993). Some researchers described the use of analytic hierarchy process (AHP) for determining the fundamental IRs of CRs (Armacost et al., 1994; Chan et al., 1999; Lu et al., 1994; Wasserman, 1993; Xie et al., 1998). Recently, Ho proposed that the combination of AHP and QFD is one of the most commonly used techniques (Ho, 2008). As AHP's variants, fuzzy AHP (Kwong and Bai, 2003; Wang, 1999), analytic network process (ANP) (Ertay et al., 2005; Karsak et al., 2002; Partovi, 2006, 2007; Partovi and Corredoira, 2002; Raharjo et al., 2008), and fuzzy ANP (Kahraman et al., 2006; TBÃÃyÃÃkÃÃzkan et al., 2004) have increasingly been used recently. Fuzzy weighted average (Khoo and Ho, 1996; Chen et al., 2006) and gray model (Wu, 2006) have also been suggested for prioritizing CRs. To deal with incomplete, imprecise, and missing information in CRs, the evidential reasoning based approach (Chin et al., 2009), the rough set based approach (Zhai et al., 2007; Zhai et al., 2009; Li et al., 2009), and the rough set enhanced fuzzy approach (Zhai et al., 2008) were separately proposed to acquire the fundamental IRs of CRs. The group decision-making technique was also put forward to determine the fundamental IRs of CRs (Ho et al., 1999; Liu and Wu, 2007). Many papers have proposed many mature methods on the topics of the first two steps. This paper will focus on the third and fourth steps to acquire the aggregated IRs of CRs.

Knowing the corporation's strengths and weaknesses in key aspects of a product relative to its main competitors is essential for achieving competitive advantages. This can be conducted by asking the selected customers to provide their personal relative satisfaction estimations (RSEs) on each CR with respect to the corporation's product and its competitors' products of a similar kind using specific a scale. The sales points (SPs) of CRs can be obtained by analyzing the personal RSEs by scale approach (Chan and Wu, 2002b). To analyze the RSEs more objectively and convincingly, Chan and Wu (2005) proposed the use of the entropy approach, which measures the expected information content of a certain message and has become an important approach in the natural and social sciences, to acquire the SPs of CRs. In some cases, each one of the selected customers has different preferences for the products of the corporation and its competitors, which favor their opinions. Furthermore, the customers tend to give their personal preferences in multiple expression types, i.e., multiplicative judgment comparison matrix, utility value, and complementary judgment comparison matrix, relying on their cultural and educational background and value systems. However, the entropy approach cannot integrate the personal multi-type preference information into the corresponding RSEs of CRs. The fact that the preferences of the customers usually vary form and depth shows us that PPHOQ needs to be extended by integrating the preference information with multiple expression types to the RSEs of CRs in order to perform the competitive analyses of CRs in a conjunct, comprehensive, and accurate way. In this paper, an integrated approach of the group decision-making, multi-type preference analyses, and three types of least square models is presented for acquiring the SPs of CRs in order to tackle the RSEs of CRs and multi-format preferences, corresponding to each one of the selected customers, in a combined way. An approximate function for determining the aggregated IR of a CR is proposed based on the integration of the fundamental IR, the SP, and the improvement ratio of average satisfaction evaluation of this CR. The proposed approach can be capable of exploiting the RSEs and multi-type preference information in a conjunct, systematic, and accurate way.

The rest of the paper is organized as follows. In Section 2, we summarize the processes of determining the fundamental IRs of CRs. Section 3 develops the integrated approach of the group decision-making, multi-type preference analyses, and three types of least square models for acquiring the SPs of CRs. Section 4 specifies the process of determining the final IRs of CRs based on the integration of the fundamental IR, the SP, and improvement ratio of average satisfaction evaluation of each CR. Section 5 illustrates a case study to empirically verify the feasibility and effectiveness of the proposed approach. The characteristics and limitations of the proposed approach are discussed in Section 6.

2. Determining the fundamental IRs of CRs

The motivation of PPHOQ is to design a product that embeds the initial and potential abstract CRs as effectively as possible (Chan and Wu, 2002b, 2005). Since CRs are the driving force in PPHOQ, a QFD team must commit considerable effort to properly capture these requirements (Cristiano et al., 2001a). CR candidates are collected by focus group, individual interviews, listening and watching, and the use of existing information. Once CR candidates are collected, they then have to be organized into several categories (Xie et al., 1998). Affinity diagram or cluster analysis can be used successfully to organize these candidates. Suppose that through appropriate ways, L customers, denoted as $\text{Cust}_h(h=1,2,\ldots,L(L=L_1+L_2+L_3))$, have been selected, and M CRs have been identified based on the opinions of these L customers and the QFD team. These M CRs are denoted as CR_1, CR_2, …, CR_j, …, CR_M, respectively. A well-defined CR structure using a tree diagram looks as shown in Fig. 1.

CRs are usually of different importance degrees from customers' perspectives. The appropriate ways of obtaining customers' perceptions are by individual interviews and mail surveys (Govers, 2001; Kim and Kim, 2009; Kwong et al., 2008). Suppose that Cust_h supplies a relative IR of CR_j, denoted as rir_{hj}, according to some a scale. Then, based on the relative IRs of CR_j corresponding to each one of the L selected customers, the fundamental IR of CR_j is computed by using AHP, denoted as ir_j^{fun}. For convenience, the fundamental IRs of the M CRs can be described as $\boldsymbol{IR}^{\text{fun}} = (\ ir_1^{\text{fun}},\ \ ir_2^{\text{fun}},\ \ \ldots,\ \ ir_j^{\text{fun}},\ \ \ldots,\ \ ir_M^{\text{fun}}\ )^{\text{T}}$.