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Determining the final priority ratings of customer requirements in product planning by MDBM and BSC

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ABSTRACT

Quality function deployment (QFD) has been widely used to translate customer requirements (CRs) into engineering characteristics (ECs) in product planning and improvement. Product planning house of quality (PPHOQ) is of fundamental and strategic importance in the QFD system. Correctly determining the final priority ratings of CRs is essential in the process of constructing PPHOQ, because it will largely affect the target value of ECs for product improvement. This paper present a systematic and operational method based on the integration of a minimal deviation based method (MDBM), balanced scorecard (BSC), analytic hierarchy process (AHP) and scale method to determine the final priority ratings of CRs. To exploit the competition and preference information of product improvement, the MDBM is developed to determine the CPRs of CRs. A concept of the total output of achieving the ITPE of a CR is introduced and analyzed by using the integration of BSC, AHP and scale method in a qualitative and quantitative way, and then the priority rating of achieving the ITPE of this CR is determined. Finally, a case study is provided to illustrate the effectiveness of the proposed method.

1. Introduction

Manufacturing corporations are facing more and more intense competition in the global markets. They have realized that efficient design and manufacture of products preferred by customers at more competitive cost and shorter lead time over those offered by their competitors is crucial to their survival and development. The adoption of quality function deployment (QFD) is an extensive practice in manufacturing corporations to cope with competitive global competition. QFD is a planning and problem-solving methodology that translates customer requirements (CRs) into engineering characteristics (ECs) of a product (Akao & Mazur, 2003). When corporations direct their efforts towards meeting their CRs, internal conflicts are minimized, development cycle times are shortened, and market penetration is increased, owing to improve product quality, gain better customer satisfaction, and obtain larger revenues (Carnevalli & Miguel, 2008; Fung, Tang, Tu, & Wang, 2002; Iranmanesh & Thomson, 2008; Kim, Moskowitz, Dhingra, & Evans, 2000; Kwong, Chen, Chan, & Wong, 2008; Li, Tang, Luo, Yao, & Xu, 2010; Shen, Xie, & Tan, 2001; Shin, Kim, & Chandra, 1997; Soota, Singh, & Mishra, 2008).

Generally, QFD utilizes four sets of matrices called house of quality (HOQ) to translate CRs into ECs, subsequently, into parts characteristics, process plans, and production requirements (Chan & Wu, 2002a; Chen, 2009; Karsak, 2004; Kannan, 2008; Kim, Kim, & Min, 2007; Kumar, Barua, & Gaindhar, 2000; Kuo, Wu, & Shieh, 2008; Li, Tang, Luo, & Xu, 2009; Min & Kim, 2008; Raharjo, Xie, & Brombacher, 2006; Reich & Paz, 2008; Tang, Fung, Xu, & Wang, 2002; Xie, Tan, & Goh, 2003). The first set of matrices is called product planning house of quality (PPHOQ), is of fundamental and strategic importance in the QFD system, since the customer requirements for the product are identified, and incorporating the producing corporation's competitive priorities, converted into ECs, and then determine the target levels for ECs of improved products. In the complex decision process, determining the final priority rating (PRs) of CRs in PPHOQ is a crucial step. Since the final PRs of CRs are finally translated into the initial importance ratings of ECs which will largely affect the target value of ECs for product improvement, considerable efforts must be committed to properly acquire the final PRs of CRs in order to keep the corporation successful.

Determining the final PRs of CRs generally consists of five steps, which are essentially the input of CRs in the construction of PPHOQ (Chan & Wu, 2002b, 2005). These proposed hierarchical steps are described as follows.

Step 1. Identify customers and acquire their requirements.
Step 2. Determine the fundamental PRs of CRs.

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Step 3. Conduct competitive analysis of CRs.
Step 4. Set the proper improvement targets of CRs.
Step 5. Determine the final PRs of CRs.

Since CRs are the driving force in the PPHOQ, considerable efforts must be committed to properly capture those requirements to keep a corporation successful. There are many methods available to collect CR candidates, including focus group, individual interviews, listening and watching, complaints, natural field contact, warranty data, feedback, affinity diagram, and cluster analysis. Grouping related CR candidates into a category is helpful to analyzing these candidates. Affinity Diagram or cluster analysis can be used to organize CR candidates as a tree-like structure CRs for PPHOQ (Griffin & Hauser, 1993; Hauser & Clausing, 1988; Kwong, Chen, Chan, & Luo, 2008). As one of the key issues of PPHOQ construction, determining the fundamental PRs of CRs have been extensively researched and quite a number of approaches have been suggested in the QFD literatures. For example, the simplest method for determining the fundamental PRs is based on point scoring scale (Hauser & Clausing, 1988). Conjoint analysis method was attempted to determine the fundamental PRs (Griffin & Hauser, 1993). Some researchers described the use of analytic hierarchy process (AHP) for determining the fundamental PRs of CRs (Armacost, Componation, Mullens, & Swart, 1994; Chan, Kao, Ng, & Wu, 1999; Lu, Madu, Kuei, & Winokur, 1994; Wasserman, 1993; Xie, Goh, & Wang, 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 & Bai, 2003; Wang, 1999), analytic network process (ANP) (Ertay, Kahraman, & Ruand, 2005; Karsak, Sozer, & Alptekin, 2002; Partovi, 2006; Partovi, 2007; Partovi & Corredoira, 2002; Raharjo, Brombacher, & Xie, 2008) and fuzzy ANP (Büyüközkan, Ertay, Kahraman, & Ruan, 2004; Kahraman, Ertay, & Büyüközkan, 2006) have increasingly been used recently. Fuzzy weighted average (Chen, Fung, & Tang, 2006; Khoo & Ho, 1996) and grey model (Wu, 2006) have also been suggested for prioritizing CRs. To deal with incomplete, imprecise and ignorance information in CRs, the evidential reasoning based approach (Chin, Wang, Yang, & Poon, 2008), the rough set based approach (Zhai, Khoo, & Zhong, 2007, 2009) and the rough set enhanced fuzzy approach (Zhai, Khoo, & Zhong, 2008) were separately proposed to acquire the fundamental PRs of CRs. Group decision-making technique was proposed to determine the fundamental PRs of CRs (Ho, Lai, & Chang, 1999; Liu & Wu, 2007, 2008). Many papers have proposed many mature methods on the topics of the first two steps. This paper will focus on the third step and the fourth one to acquire the final PRs of CRs.

The competitive priority ratings of CRs can generally be obtained by analyzing relative performance estimations of a corporation and its competitors from selected customers' perceptions, usually using the sales point concept. To analysis the corporations' competitive performance estimations more objectively and convincingly, the traditional sales point concept was modified or other methods were applied. As a concept in information theory, entropy method measures the expected information content of a certain message and becomes an important concept in natural and social science. The use of entropy method to obtain the competitive priority ratings (CPRs) of CRs was proposed by Chan and Wu (2005). It assumes that when the corporations perform the same, it means there is a good opportunity to be excellent. In fact, each of selected customers has different preference for the products of the corporation and its competitors. The judgments of competitive performance estimations and preferences of these customers depend on their psychological aspects, such as experience, learning, states of mind, and so forth. Therefore, the consistencies between these preferences and competitive performance estimations are rarely satisfied. Therefore, this paper will propose a minimal deviation based method (MDBM) to determine the CPRs of CRs, based on the idea of minimal deviations to express these inconsistencies.

The improvement ratio of performance estimation (IRPE) of a CR was integrated into customer competitive analyses (Chan & Wu, 2002b, 2005; Lai, Xie, Tan, & Yang, 2008; Tan & Shen, 2000; Tan, Xie, & Shen, 1999). Nevertheless, the IRPE is one of the customer outputs of achieving the improvement target of performance estimation (ITPE) of a CR. The total output of achieving the ITPE of a CR must be estimated from the short- and long-term objectives which balanced scorecard (BSC) can be provided. Because achieving the ITPEs of CRs as a project is suitable for the use of BSC, the total output of achieving the ITPE of a CR will be determined from the five perspectives – the four original perspectives of BSC (financial, customer, internal-business processes, learning and growth) and a feasibility perspective in a qualitative and quantitative way, and then the priority rating of achieving the ITPE of this CR will be estimated.

The above literature review clearly shows that quite a lot of efforts have been made to determine the final PRs of CRs. Nevertheless, these researches could not exploit competition and preference information, and estimate the short- and long-term outputs of achieving the ITPEs of CRs in a comprehensive and accurate way. The purpose of this paper is to develop a comprehensive and systematic method to determine the final priority rating of CRs, on the basis of the proposed MDBM for dealing with the competition and preference information of CRs, and the integration of BSC, AHP and scale method for estimating the priority ratings of achieving the ITPEs of CRs. It can be used to help the QFD team to rate the final PRs of CRs by the integration of the fundamental PR, the CPR, and the PR of achieving the ITPE of each CR. It is capable of exploiting the competition and preference information of product improvement, estimating the short- and long-term outputs of achieving the ITPEs of CRs, and using the proposed unified hierarchical steps in a reliable, systematic, comprehensive, and accurate way.

The rest of the paper is organized as follows: in section 2, we summarize the processes of determining the fundamental PRs of CRs. Section 3 develops the MDBM for acquiring the CPRs of CRs. Section 4 analyzes the priority ratings of achieving the ITPEs of CRs by the integration of BSC, AHP and scale method. Section 5 specifies the method for determining the final PRs of CRs based on the integration of the fundamental PR, the CPR, and the priority rating of achieving the ITPE of each CR. Section 6 illustrates a case study of digital video to empirically verify the feasibility and effectiveness of the proposed method. The characteristics and limitations of the proposed method are discussed in Section 7.

2. Determining the fundamental PRs of CRs

The motivation of PPHOQ is designing a product that embedded the initial and potential abstract CRs as well as possible (Chan & Wu, 2002b, 2005). Since CRs are the driving force in PPHOQ, QFD team must commit considerable effort to properly capture these requirements (Xie et al., 1998). CR candidates are collected by focus group, individual interviews, listening and watching, and using existing information. Once CR candidates are collected, then they have to be organized to several categories. Affinity diagram or cluster analysis can successfully be used to organize these candidates. Suppose that, through appropriate ways, K customers, denoted as Cust_k ($k = 1, 2, \ldots, K$), have been selected and M CRs have been identified based on the opinions of these K customers and the QFD team. These M CRs are denoted as $\mathrm{CR}_1, \mathrm{CR}_2, \ldots, \mathrm{CR}_j, \ldots, \mathrm{CR}_M$, respectively. A well-defined CR structure using tree diagram looks as shown in Fig. 1.

CRs usually are of different priority degree from customers' perspective. The appropriate ways of obtain customers' perceptions