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A systematic methodology to deal with the dynamics of customer needs in Quality Function Deployment

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ABSTRACT

In the context of a customer-driven product or service design process, a timely update of customer needs information may not only serve as a useful indicator to observe how things change over time, but it also provides the company a better ground to formulate strategies to meet the future needs of its customer. This paper proposes a systematic methodology to deal with customer needs' dynamics, in terms of their relative weights, in the QFD. Compared to previous research, its contribution is three-fold. First, it proposes the use of a forecasting technique which is effective to model the dynamics of Analytic Hierarchy Process (AHP) based importance rating. This is owing to the fact that the AHP has been applied very extensively in the QFD and there is, unfortunately, almost no tool to model the dynamics. Second, it describes more comprehensively on how future uncertainty in the weights of customer needs may be estimated and transmitted to the design attributes. Third, it proposes the use a quantitative approach that takes into account the decision maker's attitude towards risk to optimize the QFD decision making analysis. Finally, an example based on a real-world application of QFD is provided to show the practical applicability of the proposed methodology.

1. Introduction

Quality Function Deployment (QFD) has been widely known to be one of the most useful tools in customer-driven products or services development (Bergman & Klefsjö, 2003; Chan & Wu, 2002; Raharjo, Brombacher, & Xie, 2008; Xie, Tan, & Goh, 2003). It has been applied successfully in various fields. Some recent examples of its applications are in ERP system selection (Karsak & Özogul, 2009), shipping investment decision making (Celik, Cebi, Kahraman, & Er, 2009), semiconductor system-on-a-chip product design planning (Hung, Kao, & Juang, 2008), and processes selection (Chakraborty & Dey, 2007; Nagahanumaiah, Subburaj, & Ravi, 2008).

The most prominent strength of QFD is the focus on customer needs and the coherent translation of those needs into each phase of product development process. Since it is used primarily in early stage of product or service development process, it therefore involves quite a lot of subjectivity and uncertainty (Raharjo et al., 2008). With respect to the uncertainty involved, Kim, Kim, and Min (2007) suggested a very useful classification. They divided the source of the uncertainty into four types, namely, fuzziness, incompleteness heterogeneity, and fluctuation. Some most recent examples of research of each type are as follows, 'fuzziness' (Liu, 2009; Wang, 2009; Zhang & Chu, 2009), 'incompleteness' (Chin, Wang, Yang, & Poon, 2009; Han, Kim, & Choi, 2004), 'heterogeneity' (Kim & Kim, 2009; Kim et al., 2007), and 'fluctuation' (Min & Kim, 2008; Raharjo, Xie, & Brombacher, 2006; Wu, Liao, & Wang, 2005; Wu & Shieh, 2006).

This paper will focus on dealing with the last type of uncertainty, that is, 'fluctuation' in the customer needs over time. Almost all previous research which deal with such uncertainty have not adequately addressed the issue of how to estimate and manage future uncertainty of customer needs in QFD decision making analysis. Raharjo et al. (2006) briefly mentioned the use of interval estimate, as opposed to a point estimate, as a better measure for future customer needs in QFD. In line with their work, this paper will elaborate more extensively on how one may, in a more systematic fashion, estimate the future uncertainty and eventually use an optimization technique with respect to it.

The aim of the paper, in general, is to propose a novel systematic methodology to deal with the customer needs' dynamics in QFD. The term 'dynamics' here is interpreted as the change of customer needs' *relative* weights over time. Specifically, it will extend the existing research in three directions. First, it proposes the use of a newly developed short-term forecasting technique (Raharjo, Xie, & Brombacher, 2009) which is effective to model the dynamics of Analytic Hierarchy Process (AHP) based importance rating. This

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is owing to the fact that the AHP has been applied very extensively in the QFD (Ho, 2008), and there is almost no tool to model the dynamics. Second, it describes more comprehensively on how future uncertainty in the weights of customer needs may be estimated and transmitted to the design attributes. Third, it proposes the use a quantitative approach that takes into account the decision maker's attitude towards risk to optimize the QFD decision making analysis.

The paper is organized as follows. In the next section (Section 2), the notion of dynamic QFD (DQFD) will be described in terms of its significance, model, and tools used. Section 3 will elaborate the proposed systematic methodology to deal with the customer needs' dynamics along with their future uncertainty. An example based on a real-world application of QFD (Raharjo, Xie, Goh, & Brombacher, 2007) will be provided to illustrate how the proposed methodology works in practice (Section 4). Section 5 will discuss the issue of forecasting technique's selection and a possible implication of the methodology to development of innovative products. Finally, a summary of the main contribution and possible future works are provided in Section 6.

List of acronyms

QFD	Quality Function Deployment
VOC	Voice of Customer
FVOC	Future Voice of Customer
HoQ	House of Quality
DQ	Demanded Quality
QC	Quality Characteristic
IR	importance rating
SD	stochastic dominance

2. The dynamic QFD

This section describes the notion of dynamic QFD (DQFD) that can be considered as an extension of the standard QFD (Cohen, 1995) since it takes into account the change over time. In this paper, the emphasis is placed on the need to deal with the dynamics in the relative weights of customer needs. Those weights are commonly referred to as 'importance rating' in the House of Quality (HoQ). The following subsections will first explain why it is important to consider such change. Afterwards, how to quantitatively incorporate it in the HoQ along with its future uncertainty will be elaborated. Throughout this paper, the term Demanded Quality (DQ) and Quality Characteristics (*QC*) will be used to refer to customer attributes or requirements (*Whats*) and the design parameters or the technical attributes (*Hows*), respectively.

2.1. Why is it important to incorporate customer needs' dynamics?

QFD starts and ends with the customer. It is known that it always takes some time from the time when the customer voice is collected until the time when the product is ready to be launched (see Fig. 1). The time-lag duration may certainly vary from one product to another. For example, if it takes one year time, then the question is whether the product which is about to be launched may still meet the customer needs since it is created based on the customer voice which was collected one year ago. The answer to this question is very likely to be a 'no' in the context of today's rapidly changing market.

The accuracy of information in the customer needs, which is also referred to as the Voice of Customer (VOC) in the HoQ, is very critical to the success of a QFD application (Cristiano, Liker, & White, 2001). In other words, for a QFD application to be successful, the dynamics of customer needs or VOC *during* product creation process should be taken into account. One way to tackle the change over time problem is to base the QFD analysis on the forecasted VOC, rather than the past VOC.

In the existing QFD literature, a number of forecasting techniques have been developed for forecasting future VOC (FVOC), in terms of importance rating, in the HoQ, for example, using double exponential smoothing (Xie et al., 2003), fuzzy trend analysis (Shen, Xie, & Tan, 2001), grey theory (Wu et al., 2005), and Markov chain analysis (Wu & Shieh, 2006). In the same line, as to incorporate time dimension in QFD analysis, Min and Kim (2008) studied the cumulative effect of DQs over time on one target customer value (CV) at a final point of time. Nevertheless, all of the above mentioned studies rely only on a point estimate of the forecast. As suggested briefly in Raharjo et al. (2006), it might be better to also use an interval estimate, that is, the future uncertainty of the forecasted point, in addition to the point estimate.

In the next subsection, how the forecasting results of the VOC, both in terms of point estimate and interval estimate, are incorporated in the HoQ will be described. For ease of reference, the enhanced QFD will be referred to as dynamic QFD (DQFD).

2.2. The DQFD model

The dynamic QFD (DQFD) model extends the input data of the traditional QFD model (Cohen, 1995) by employing a set of VOC data, in terms of importance rating values, which are obtained in a certain period of time. Thus, it may serve as a more generalized model of the traditional QFD. The basic dynamic QFD model for m DQs and n QCs is shown in Fig. 2.

It is quite common to first normalize the relationship matrix (R_{ij}), while considering the correlation among the QCs, using the method proposed by Wasserman (1993) as follows:

$$R_{ij}^{norm} = \frac{\sum_{k=1}^{n} R_{ik}\cdot\gamma_{kj}}{\sum_{j=1}^{n}\sum_{k=1}^{n} R_{ij}\cdot\gamma_{jk}}, \quad i = 1,2,\ldots,m;\ j = 1,2,\ldots,n, \tag{1}$$

where R_{ij}^{norm} is the normalized relationship values between the ith DQ and the jth QC, and γ_{jk} is the value to denote the degree of correlation between the jth QC and the kth QC and vice versa (symmetrical). The value of the R_{ij}^{norm} can be interpreted as the incremental change in the level of fulfillment of the ith DQ when the jth QC is fulfilled to a certain level (see Wasserman, 1993; Xie et al., 2003).

When the correlation between the QCs (γ_{jk}) is assumed to be non-existent, then the above formula can be reduced to a simple row normalization procedure as follows:

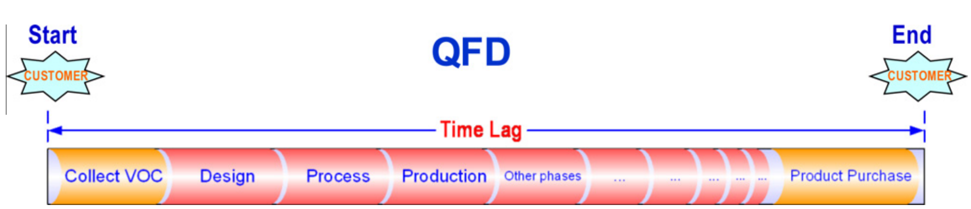

Fig. 1. Time-lag problem when using QFD.