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An extended QFD planning model for selecting design requirements with longitudinal effect consideration

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Abstract

An extended QFD planning model is presented for selecting design requirements (DRs) that consider longitudinal effect. In the proposed model, the longitudinal effect is incorporated by introducing a time dimension into the existing house of quality structure. As a consequence of explicitly considering the longitudinal effect, the proposed model yields not only an optimal set of DRs but also the timing of their selection. The proposed model is demonstrated through a case study for improving customer loyalty in the high-speed internet service.

Keywords: Quality function deployment; Longitudinal effect; QFD planning model; Project selection

1. Introduction

Quality function deployment (QFD) is a mechanism for translating the "voice of the customer" (called customer requirements; CRs) into the language of the engineers (called design requirements; DRs). DRs are subsequently translated into parts characteristics, process plans, and detailed production requirements. One of the acknowledged advantages of QFD is its ability to promote organizational consensus building and decision making (Cohen, 1995).

QFD has been widely used across various industries to improve customer value (CV) such as customer satisfaction or customer loyalty. Such an effort is called QFD planning. QFD planning is defined as a proactive "customer-driven planning" based on two major pieces of QFD information, namely, the DRs' impact on CRs and the CRs' effect on CV (Day, 1993). Through QFD planning, the decision-maker (DM) identifies the DRs that are essential to achieving the desired CV level.

The problems in QFD planning may be boiled down to two types: project selection type problems and resource allocation type problems. The project selection type problem is encountered in finding an optimal set of DRs to be undertaken among all DRs to improve the CV in the most efficient way (Ahn & Kim, 1999; Park & Kim, 1998). In this type, DRs can be regarded as projects for improving CRs, and thus are represented as 0–1 decision variables. The resource allocation type problem is encountered in determining the level of resources to be invested in DRs. As such, the DRs are represented as continuously controllable decision variables (Chen, Fung, & Tang, 2005; Fung, Tang, Tu, & Wang, 2002; Fung, Tang, Tu, & Chen, 2003; Tang, Fung, Xu, & Wang, 2002). Except for the different types of decision variables, both problems are fundamentally equivalent in the sense that they attempt to determine the optimal level of DRs to maximize the CV.

The existing QFD planning models have a common assumption – the CV at a certain time point is affected by the levels of CRs at the same time point only. In other words, the CRs' effect on CV is cross-sectional. However, this is not always the case in reality. The CV at a certain time point can be affected not only by the levels of CRs

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at the same time point but also by the levels of CRs at the previous time points collectively. This means that the CRs' effect on CV is longitudinal. For example, customer loyalty, one of the popular CVs, is known to be formed by longitudinal effect. Customer loyalty is defined as the customer's attitude to a product/service formed over a period of time (Ramaswamy, 1996; Stank, Goldsby, & Vickery, 1999). Namely, it is determined by a series of effects over a certain period of time (viz. longitudinal effect), rather than by the effect at a specific point of time.

The high-speed internet service is an internet-access service based on the ADSL (asymmetric digital subscriber lines) or VDSL (very high-speed digital subscriber lines) technology. The notion of customer loyalty in the high-speed internet service is very important because this market is highly competitive and nearly saturated. Kim et al. (2007) demonstrate that the customer loyalty in this service is, in fact, formed by the longitudinal effect. More specifically, the customer loyalty is shown to be affected by the levels of CRs for the recent two-month period.

This paper proposes an extended QFD planning model which takes the longitudinal effect into consideration. In the proposed model, a primary focus is placed on incorporating the longitudinal effect of CRs on CV. This is accomplished by introducing a time dimension into the CRs. As a consequence of explicitly considering the longitudinal effect, the proposed model yields not only an optimal set of DRs but also the timing of their selection.

A brief review of the house of quality chart and the previous developments in QFD planning is given in Section 2. An extended QFD planning model with longitudinal effect is proposed in Section 3. In Section 4, the proposed model is demonstrated through a case study in the high-speed internet service. Finally, conclusions are given in Section 5.

2. Background

2.1. House of quality chart

The "house of quality (HOQ)" chart is a principal tool for QFD (Akao, 1990; Hauser & Clausing, 1988). There is a set of standard components in an HOQ, including CRs and their relative weights; DRs and their computed absolute importance; relationship matrix between CRs and DRs; correlation matrix among DRs; and the CR and DR benchmarking data. A schematic of an HOQ chart is shown in Fig. 1a. The HOQ in Fig. 1a shows only the components that are of interest in this paper, and does not include the correlation matrix and the benchmarking data section.

In Fig. 1a, w_i denotes the relative weight of the ith CR (CR_i; $i = 1, \ldots, m$), AI_j is the absolute importance rating of the jth DR (DR_j; $j = 1, \ldots, n$), and R_{ij} is the relationship coefficient between CR_i and DR_j. The relative effect of CR_i on CV is quantified via w_i. AI_j is computed using w_i and R_{ij}:

$$AI_j = \sum_{i=1}^{m} w_i R_{ij}, \quad j = 1, \ldots, n. \tag{1}$$

2.2. Existing models in QFD planning

The aim of the QFD planning model is to select an optimal set of DRs or make resource allocation decisions on DRs for improving the CV under given conditions. Various forms of model formulation have been proposed in the QFD planning literature. They can be categorized into three types of models according to the objective function of the formulation – maximize the CV (Model 1); minimize the total cost (Model 2); or achieve a balance between the CV and the total cost (Model 3). The models presented in this section will be referred to as C-Model 1, C-Model 2, and C-Model 3. The prefix C indicates that they are the conventional QFD planning models (as opposed to the longitudinal QFD planning models which will be presented in Section 3.2). Each model is described below in more detail.

2.2.1. C-Model 1: maximize the CV

C-Model 1 attempts to maximize the CV under budget constraints. Park and Kim (1998) proposed a QFD planning model for an indoor air quality improvement problem. The model aims to maximize the customer satisfaction by determining an optimal set of DRs under organizational resource constraints. Ahn and Kim (1999) developed a model for determining an optimal set of DRs to maximize the incremental revenue of a commercial telecommunications service. Fung et al. (2002) developed a model to determine the level of DRs which considers the correlation among DRs and the fuzziness of the cost. Fung et al. (2003) proposed a model to allocate resources for improving DRs under the technical and financial constraints.

For the project selection type problem, the generic form of C-Model 1 can be stated as

$$\begin{aligned} &\text{Maximize} \quad CV = \sum_{j=1}^{n} AI_j x_j, \\ &\text{s.t.} \qquad\quad 0 < C = \sum_{j=1}^{n} c_j x_j \leqslant B, \\ &\qquad\qquad\quad x_j = 0 \text{ or } 1, \end{aligned} \tag{2}$$

where CV is the overall customer value, x_j is a 0–1 decision variable for DR_j (i.e., $x_j = 1$ if DR_j is selected, and $x_j = 0$ otherwise), C is the total cost, c_j is the cost required to undertake DR_j, and B is the given budget. AI_j is computed as in Eq. (1). The input parameters C, c_j, and B are usually given by the market or the DM. The model form in (2) can be restated for the resource allocation type problem with a minor modification.

2.2.2. C-Model 2: minimize the total cost

C-Model 2 aims to achieve the given target of CV (denoted as V) with the minimal total cost. Tang et al. (2002) and Chen et al. (2005) proposed models for this purpose under various conditions. The generic form of C-Model 2 is as follows: