Information Sciences 181 (2011) 5523–5533

Contents lists available at SciVerse ScienceDirect

Information Sciences

journal homepage: www.elsevier.com/locate/ins

A linear goal programming approach to determining the relative importance weights of customer requirements in quality function deployment ☆

Ying-Ming Wang [a,*], Kwai-Sang Chin [b]

[a] Institute of Decision Sciences, Fuzhou University, Fuzhou 350108, PR China
[b] Department of System Engineering and Engineering Management, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon Tong, Hong Kong

ARTICLE INFO

Article history:
Received 12 May 2010
Received in revised form 6 June 2011
Accepted 13 August 2011
Available online 23 August 2011

Keywords:
Quality function deployment
Customer requirement
Customer preference
Preference format
Goal programming
Group decision making

ABSTRACT

Quality function deployment (QFD) is a planning tool used in new product development and quality management. It aims at achieving maximum customer satisfaction by listening to the voice of customers. To implement QFD, customer requirements (CRs) should be identified and assessed first. The current paper proposes a linear goal programming (LGP) approach to assess the relative importance weights of CRs. The LGP approach enables customers to express their preferences on the relative importance weights of CRs in their preferred or familiar formats, which may differ from one customer to another but have no need to be transformed into the same format, thus avoiding information loss or distortion. A numerical example is tested with the LGP approach to demonstrate its validity, effectiveness and potential applications in QFD practice.

1. Introduction

Quality function deployment (QFD) is a total quality management (TQM) tool that translates the voice of the customer into the voice of the engineer. It has been successfully applied in various industries. To implement QFD, customer requirements (CRs) have to be identified and assessed. In particular, determining a set of correct importance weights for CRs is important because the importance weights have significant effects on the target values of engineering characteristics. Various methods have been suggested in QFD literature to determine the relative importance weights of CRs. The simplest method to prioritize CRs is the use of the *L*-point Likert scale, e.g., 1–5, however, this method is considered unable to capture effectively human perception [13]. Akao [1], who is widely regarded as the father of QFD, suggested an approach involving the use of the analytic hierarchy process (AHP) [21]. Armacost et al. [2] illustrated the applications of the AHP in prioritizing the CRs in an industrialized housing. Considering the vagueness and uncertainty in subjective judgments, Kwong and Bai [13,14] suggested the use of fuzzy AHP to determine the relative importance weights of CRs. Karsak et al. [12] used the analytic network process (ANP) to prioritize CRs and hence consider the interdependence among CRs. Büyüközkan et al. [5], Ertay et al. [9], and Kahraman et al. [11] all applied fuzzy ANP to prioritize CRs. More applications of

☆ The work described in this paper is supported by the National Natural Science Foundation of China (NSFC) under the Grant No. 70925004 and also substantially supported by a grant from City University of Hong Kong (Project No. 7002571).
* Corresponding author. Tel.: +86 591 22866681; fax: +86 591 22866677.
E-mail addresses: msymwang@hotmail.com, ymwang@fzu.edu.cn (Y.-M. Wang).

0020-0255/$ - see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.ins.2011.08.016

the AHP and its variants, such as fuzzy AHP, ANP, and fuzzy ANP in assessing the relative importance weights of CRs can be found in Refs. [3,8,15,18,19].

Chan et al. [6], Chan and Wu [7] and Hsu and Lin [10] used fuzzy and entropy methods to assess the relative importance weights of CRs. They utilized the fuzzy method to convert customers' importance assessments of CRs into fuzzy numbers. The relative importance ratings of CRs were obtained using fuzzy arithmetic. The entropy method in the information theory was applied to analyze customers' assessments of the performance of competitive products and to obtain the competitive priority ratings of CRs. The two sets of ratings were then combined to produce the final importance ratings of CRs. Mehdizadeh [17] presented a fuzzy centroid-based method for ranking CRs with competition consideration. Prasad et al. [20] suggested using conjoint analysis for the prioritization of CRs in the house of quality (HOQ).

CRs are considered dynamic and could vary from time to time. The analysis of future CRs is critical to the long-term competitiveness of organizations, and the early prediction of future CRs can help organizations provide better products. Based on these points of view, Shen et al. [22] utilized fuzzy trend analysis to listen to the future voice of customers. Wu et al. [27] applied gray theory to analyze dynamic and future CRs. Wu and Shieh [28] employed a Markov chain model to analyze CRs in the future and track the importance trends of CRs from the viewpoint of probability.

The assessment of the relative importance weights of CRs is a group decision-making behavior. According to the literature, the existing approaches for weight assessment all require customer preferences to be provided in the same format such as the *L*-point Likert scale, pairwise, or fuzzy pairwise comparison matrices. No customers can be allowed to provide a different preference format to express their preferences better. Such requirement is argued to be too demanding and may not be realistic in QFD practice. Not all customers can provide judgments in the same format because of the differences in backgrounds, education, domain knowledge, judgment capabilities, and so on. Some of them may prefer to provide their preferences in their preferred formats or those with which they are familiar. Thus, people contributing to QFD can naturally present their preferences in the formats that they prefer or are familiar with. Although the free expressions of preferences make QFD complicated, they undoubtedly make it more realistic, more flexible and more practical than before. Thus, scientific and advanced methodologies capable of handling different preference formats need to be developed to help implement QFD realistically and successfully.

Our literature survey reveals that among few researchers, only Büyüközkan and Feyzioğlu [4] and Büyüközkan et al. [5] looked into multiple preference formats in QFD. Büyüközkan and Feyzioğlu [4] put forward a group decision-making approach based on multiple preference formats in QFD in the hope of better capturing and analyzing the CRs in software development. In their approach, customers are categorized into several focus groups, each with a different importance weight. Members within the same focus group are treated equally. Different preference formats within each focus group are first transformed into the relative importance relation matrices of the same format using different transformation functions. These relative importance relation matrices of the same format are then aggregated into a collective relative importance relation matrix using the ordered weighted geometric (OWG) operator with the fuzzy linguistic quantifier *at least half*. The collective relative importance relation matrix is further exploited to calculate the quantifier guided importance degrees of the CRs in a fuzzy majority sense using the OWG operator again. The quantifier-guided importance degrees of the CRs are then normalized as the relative importance weights of the CRs for the focus group. The relative importance weights of the CRs for the different focus groups are finally weighted and averaged as the final relative importance of the CRs.

Büyüközkan et al. [5] modeled multiple preference formats in a different way and presented a different fuzzy group decision-making approach to respond better to CRs in product development with QFD. In this approach, numerical expressions are first transformed into preference relation matrices using the given transformation functions. These preference relation matrices are then converted into linguistic fuzzy preference relation matrices using a numerical-linguistic transformation function. Each linguistic fuzzy preference relation matrix is aggregated using the linguistic ordered weighted averaging (LOWA) operator with the fuzzy linguistic quantifier *at least half* to obtain a linguistic priority vector. The individual linguistic priority vectors are again aggregated using the LOWA operator with the fuzzy linguistic quantifier *most* to produce a collective linguistic priority vector for the focus group. All the collective linguistic priority vectors for the different focus groups are finally combined with the given group importance vector to produce a final linguistic priority vector, which serves as the relative importance weight vector of the CRs.

Although multiple preference formats in QFD practice have been studied, the types of preference formats investigated by Büyüközkan and Feyzioğlu [4] and Büyüközkan et al. [5] are very few and insufficient. Moreover, their approaches require multiple preference formats to be transformed into the same format using pre-specified transformation functions. As the transformed information is very difficult to be precisely equalized to the original one, preference transformation may thus result in information loss or information distortion. A more natural way than information transformation is to model different preference formats without any transformation. Based on this point of view, we propose a linear goal programming (LGP) approach to assess the relative importance weights of CRs. The LGP approach does not require any information transformation and can therefore avoid information loss or information distortion.

The rest of the paper is organized as follows: In Section 2, some possible preference formats that customers may use to express their preferences are introduced, and the LGP approach to modeling them together is proposed. In Section 3, a numerical example using the proposed LGP approach is examined to verify its validity, effectiveness, and potential applications in assessing the relative importance weights of CRs. Section 4 concludes the paper.