Information Sciences 206 (2012) 30–41

Contents lists available at SciVerse ScienceDirect

Information Sciences

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

A new incomplete preference relations based approach to quality function deployment

Gülçin Büyüközkan *, Gizem Çifçi

Industrial Engineering Department, Faculty of Engineering and Technology, Galatasaray University, 34357 Ortaköy, İstanbul, Turkey

ARTICLE INFO

Article history:
Received 22 June 2010
Received in revised form 3 January 2012
Accepted 4 April 2012
Available online 12 April 2012

Keywords:
Incomplete preference relations
Quality function deployment
House of quality
Group decision making
Fuzzy sets
Collaborative software development

ABSTRACT

Quality function deployment (QFD) is a widely-used methodology for developing a design quality aimed at satisfying the customer and translating the customer's demand into design targets. As QFD methodology is based on the voices of customers, it requires a group of individuals, or decision makers (DMs), to express their preferences. However, there can be a bottleneck since DMs may not have a perfect knowledge of the problem to be solved. Thereby, the aim of this study is to improve the effectiveness of the evaluation process in QFD. The QFD methodology is extended by introducing a new group decision making (GDM) approach that takes into account incomplete information of DMs by means of the fuzzy set theory. The proposed approach is applied to a collaborative software development process to demonstrate its potential.

1. Introduction

Quality function deployment (QFD) is an effective tool that can aid in moving towards a more proactive product development. It is a customer-driven quality management system which incorporates the "voice of the customer" into appropriate company requirements at each stage of product development, from product planning and process design to manufacturing and delivery, to create higher customer satisfaction for the product [31,34,57]. As a proactive product development or planning methodology, successful applications of QFD have produced many benefits, including lower start-up costs, shorter design cycles, promotion of teamwork, and provision of documentation [7,13,21]. The QFD methodology can be used for both tangible products and non-tangible services, including manufactured goods, service industry, software products, IT projects, business process development, government, healthcare, environmental initiatives, and many other applications [10,20,22,53,72].

QFD is comprised of a major group decision making (GDM) processes. In practice, determining the weights of customer requirements (CRs) is a GDM process. This is mainly because of the risk of relying on a single decision maker (DM) with his/her limitations on experiences, preferences or biases about the issues involved, and the fact that individuals are often unable to clearly identify their own states. Multiple DMs, thus GDM, are often preferred to a single DM to avoid the bias and minimize the partiality in the decision process [15,25,40,75].

Generally, different and even subjective opinions are quite often in a GDM process due to the limitations of experience and imprecision. Obviously, the importance of each CR in QFD is determined, often with ambiguity, by a group of people. In addition, due to constraints as time pressure, lack of expertise in related issue, etc. DMs may develop incomplete preferences where some elements cannot be provided. Under such circumstances, fuzzy set theory [73] and incomplete preference relations [2,37,38,61,64–66] can be applied to deal with group decisions when the information is imprecise and missing. This

* Corresponding author. Tel.: +90 212 227 4480.
E-mail address: gulcin.buyukozkan@gmail.com (G. Büyüközkan).

0020-0255/$ - see front matter © 2012 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.ins.2012.04.010

paper develops a new fuzzy logic based GDM approach to QFD with incomplete preference relations. Moreover, a collaborative software development (CSD) example is provided to show that the proposed GDM approach can be effectively used in QFD. As the study of incomplete preferences in fuzzy environments is not widespread, there is no study in the literature that applies it in CSD field. In our knowledge, there is only one research realized by Han et al. [36] that combines fuzzy and incomplete preference relations to construct extended QFD model. While the mentioned paper also considers the incomplete information case for QFD, the way it treats the problem is very different from our approach. In their work, Han et al. [36] have assumed that there can be missing CRs weights and/or the quantified relationship between CRs and design requirements (DRs). They also postulated that any method relying on pairwise comparisons can be used only when there is complete information. In our study, we show that this later assumption can be relaxed, in other words, incomplete information in pairwise comparisons could be handled. Therefore, all CRs weights can be obtained rigorously. Another criticism with this mentioned work is that within a GDM setting, it is not possible in practice to arrive at a case where there is no information about the weight of a CR. Even when multiple customers could not evaluate the importance of a CR, there would be others who provide this information. This case is not considered in Han et al. [36]. In our approach however, every customer evaluation is investigated separately and a group consensus is reached by the method.

The paper is then organized as follows: In Section 2, the integrated concept of QFD is briefly presented. Section 3 details the computational procedure. A CSD example is then given in Section 4. Finally, Section 5 contains our concluding remarks.

2. A new integrated approach for QFD

QFD was originally developed by Yoji Akao in 1966 when the author combined his work in quality assurance and quality control points with function deployment used in Value Engineering. Mr. Akao described QFD as "method to transform user demands into design quality, to deploy the functions forming quality, and to deploy methods for achieving the design quality into subsystems and component parts, and ultimately to specific elements of the manufacturing process" [13].

Although there have been many QFD studies and applications in the literature over the past decades, different authors use different terms and methods and they also focus on different parts of the QFD system. There have been no consistent or unified accounts of the QFD concepts and procedures, which is uncommon for such a popular methodology and may be quite confusing for non-specialists [1].

The technique is characterized by a matrix called the House of Quality (HOQ) which is represented in Fig. 1 [35]. This matrix contains information about what to do (e.g., what customers want), how to do it (e.g., how technically customer requirements can be achieved), and the relationships between each of these aspects; prioritization of customer requirements (CRs) and technical/design requirements (DRs); and what are the company's target levels. Quality functions are deployed by carrying "how to do" into the successive HOQ as "what to do" [45]. The detailed steps of HOQ applied in this paper are discussed in Section 3.

2.1. GDM in QFD

The traditional QFD structure requires individuals to express their preferences [31], and it requires the involvement of several people. While analyzing priority of CRs, team members usually have difficulty in assigning measures of priority to a list of customer preferences. During the process, the members could have significantly different and subjective opinions based on their past experience. A fusion of GDM with a group-customer preference system is proposed in this research to resolve these issues. The purpose of this method is to enhance group consensus on the GDM outcome. Several authors [15,16,45,51] have previously studied the GDM methodology in QFD. Table 1 lists a sample of those studies which used GDM methods in QFD approach.

In the GDM process, to deal with the vagueness of customers' preferences in decision-making, fuzzy GDM approaches have been proposed. The fuzzy set theory has been applied to the field of management science, especially for treating vagueness and ambiguity in decision making problems. Lingual expressions, for example, satisfied, fair, dissatisfied, are regarded as the natural representation of the preference or judgment. Since the evaluation is resulted from the different evaluator's view of linguistic variables, its evaluation must therefore be conducted in an uncertain, fuzzy environment [11,14,49,59]. Therefore, this study includes fuzzy GDM to strengthen the comprehensiveness and reasonableness of the decision making process in QFD.

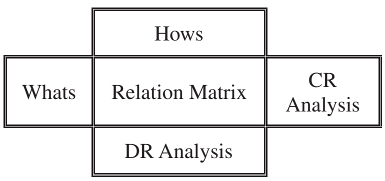

Fig. 1. HOQ for software development.