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An integrated QFD framework with multiple formatted and incomplete preferences: A sustainable supply chain application

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ABSTRACT

Merging sustainable development with the business, and taking goals into account from its three dimensions (i.e., economic, environmental and social) which are derived from customer and stakeholder requirements have been a potential source of competitive differentiation for firms. Academic and corporate interest in sustainable supply chain (SSC) management has also risen considerably in recent years. This paper examines the components and elements of SSC management and how they serve as a foundation for an evaluation framework. By using quality function deployment (QFD) as a product/system planning and improvement tool, an effective SSC structure can be obtained. QFD uses a matrix called the "House of Quality" (HoQ), and constructing the HoQ is a critical step in the application of QFD as it translates customer requirements into engineering characteristics. However, participants of HoQ construction sessions tend to provide information about their individual judgments in multiple formats such as numerically or linguistically depending on their different knowledge, experience, culture and circumstance. Furthermore, they can generate incomplete preferences which are challenging to assess in a consistent way. Therefore, the objective of this study is to apply an extended QFD methodology in SSC by introducing a new group decision making (GDM) approach that takes multiple preference formats and incomplete information into account and fusions different formats of expressions into one uniform group decision by means of the fuzzy set theory. To assess the validity of the proposed approach, a case study conducted at HAVI Logistics-Turkey is also presented in the paper.

1. Introduction

Quality function deployment (QFD) is a technique to translate customer needs into practical measures. This approach enables the firms to become proactive to quality problems rather than taking a reactive position by acting on customer complaints. QFD is comprised of 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's (DM) limitations of experiences, preferences or biases about the issues involved. Multiple DMs, thus GDM, are often preferred rather than a single DM to avoid bias and minimize the partiality in the decision process [7,10,22].

However, it is more difficult to assess the performance of this process with accurate quantitative evaluation due to its uncertain nature. In a GDM process, DMs generally give their own judgments in many different ways, numerically or linguistically, depending on their background. Several authors proposed GDM in QFD, which takes multi-format preferences into account [7,8,75]. Yet, there can be situations of a DM not having perfect and complete knowledge about the problem to be solved, or a DM not being able to efficiently express any kind of preference degree between two or more of the available options. Moreover, due to constraints as time pressure, lack of motivation, etc., DMs may develop preferences in which some of the elements cannot be provided. By involving the use of incomplete preference relations in GDM, such constraints for evaluations can be handled effectively and the evaluation would be stronger and healthier. Eventually, the GDM process in QFD needs to derive a single group preference from a number of incomplete or specific individual preference styles. Although QFD studies which address multiple formatted preferences exist, none of those handles incomplete information besides.

As QFD is a customer-driven tool, it is important to consider that in the current business environment, customer demands are diversified and supply chain management (SCM) now coming under increased scrutiny from customers and governments regarding their compliance with environmental and social responsibility [55]. To obtain more sustainable solutions, organization properties must meet both customer and sustainable SC requirements. Thus, this paper also proposes a sustainable QFD structure to clearly

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understand the CRs and determine characteristics to meet these expectations for a sustainable SCM.

Under such circumstances, an analytical tool is offered for perceiving and prioritizing the quantitative and qualitative, sometimes vague and imprecise or even incomplete preference of the customer in QFD. The objective of this study is to apply an extended QFD methodology to sustainable SC by introducing a GDM approach that takes multiple preference formats [7,8,22,68,75] and incomplete information [3,24,25,67,69,70] into account, and fuses different expressions into one uniform group decision by means of fuzzy set theory [62]. In addition, to assess the validity of the proposed approach and QFD structure, an application at a supply chain company, HAVI Logistics-Turkey, is presented in the paper. As the study of multiple and incomplete preferences is not widespread in the literature, there exists no references that combines both of these topics with QFD or any other methods, nor any other that applies those in sustainable SCM field.

The paper is organized as follows. Section 2 firstly provides brief information and presents the essence of the integrated approach, then explains the computational procedure step by step. Then Section 3 gives a literature survey about application area (sustainable SCM) and proposed QFD model. Application in HAVI Logistics Turkey is then given in Section 4. Section 5 concludes the study and gives future directions.

2. Integrated GDM approach for QFD

2.1. Multiple preference formats and incomplete preferences in GDM

Much has been published about QFD since the concept was initiated in the mid-1960s [4,5,20,33,40]. It is mainly a tool to help organizations seek out both spoken and unspoken needs, translate these into actions and designs, and focus various business functions toward achieving this common goal, empowering organizations to exceed normal expectations and provide a level of unanticipated excitement that generates value. One of the products and also heart of QFD is a "House of Quality" (HOQ) matrix, which enables a quick visual comparison of "what customers want" versus "how suppliers can give it to them". The basic format of the HOQ consists of six different major parts which are explained in Fig. 1. Detailed description of the HOQ steps applied in this study is given in Section 2.2.

As a typical HOQ process, DMs always give preference information on decision matrices to construct the HOQ. However, the DMs' judgments vary in form and depth. Since the DMs may have diverse cultural and educational background and value systems, their preference would be expressed in many different ways. Determining consensus group decisions is not an easy task under such complex circumstances. Thus, previous papers proposed studies in which the DMs are asked to express their preferences on a variety of criteria using different preference formats [71,75]. Multiple preference formats are also used in QFD applications [7,8,14,17,76]. Büyüközkan and Feyzioglu [7] extended the QFD methodology by introducing a GDM approach that takes into account multiple preference formats and fusing different expressions such as preference orderings, utility analysis, optimal subset method, linguistic preference relations and fuzzy pairwise comparisons. Zhang and Chu [76] proposed a study in which the DMs can give their judgments according to two formats: fuzzy pairwise comparisons and linguistic preference relations.

In these processes of decision making, complete linguistic preference relations are required from DMs for the evaluation of criteria and alternatives. Sometimes, however, it is difficult to obtain such a preference relation. Since each expert may have his/her own experience, there can be situations of an expert not having a perfect and complete knowledge about the problem to be solved. There may be cases in which an expert would not be able to efficiently express any kind of preference degree between two or more of the available options. This may be due to an expert not having a precise or sufficient level of knowledge of part of the problem or because the expert is unable to determine the degree to which some options are better than others [24]. Since the QFD approach involves multiple DMs and a group decision process, these kinds of problems can occur in the evaluation process of CRs. Thereby beside complete judgments, incomplete judgments are also introduced for linguistic preference relations. With the use of incomplete preference relations, such constraints for evaluations could be handled effectively and the evaluation would be stronger and healthier. It is inherent that every DM in the evaluation group may not have complete information; thus, it is necessary to involve

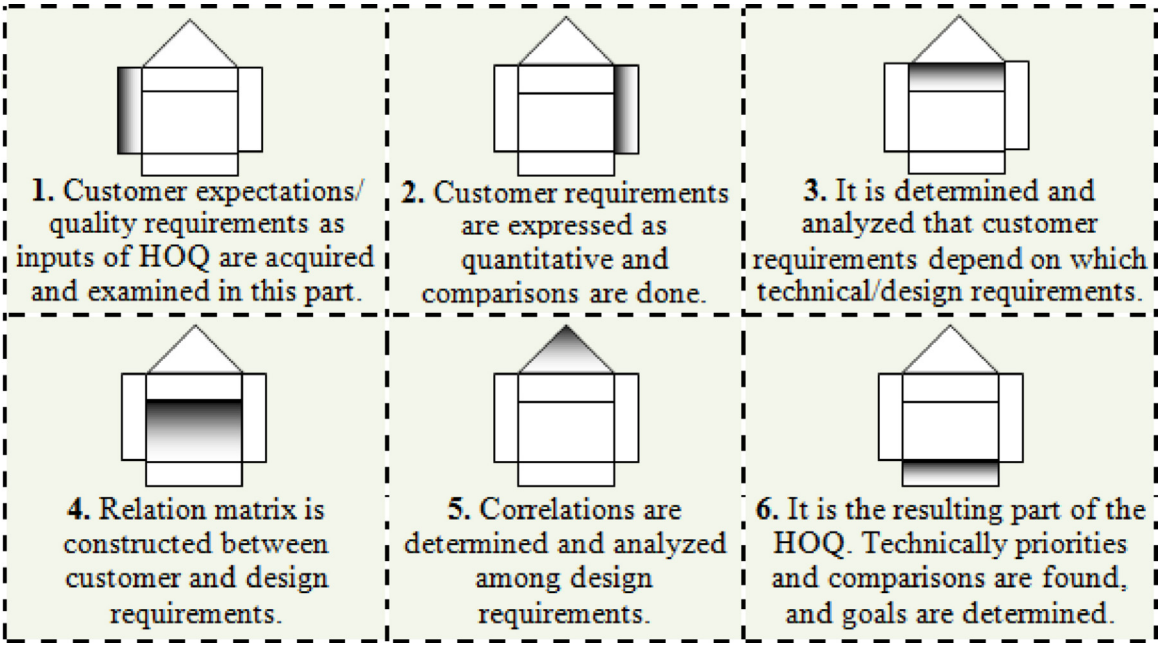

Fig. 1. Common parts of HOQ.

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