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Short Survey

Constructing the complete linguistic-based and gap-oriented quality function deployment

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ABSTRACT

This study attempts to construct a novel quality function deployment (QFD) model under a pure linguistic environment by assessing customer needs, evaluating the relationship between customer needs and solution schemes, and prioritizing the solution schemes. Customer needs that are difficult to quantify can be properly characterized using linguistic variables. The tolerance capacity of the results can also further enhance by the linguistic QFD, especially in the gap generated when converting customer needs to solution schemes. Hence, the essence for the proposed approach differs from the common numerical or approximate linguistic QFD model. Operation of the linguistic QFD is described in detail using an algorithm and simple example.

1. Introduction

Enterprises have to function compete internationally using global logistics to achieve high performance for an entire organization, especially in customer-oriented markets. Hence, an enterprise requires a powerful and efficient management technique, such as QFD, to improve performance and profit by identifying customer needs. Thus, the QFD model facilitates continued improvement based on customer needs and enhances customer satisfaction, thereby providing enterprises with the skills required for introspection and continued development.

However, according to the uncertainty in information, the QFD model is frequently unable to present information, such as the importance and satisfaction of customer needs, the relationship between customer needs and solution schemes, and the relevance among solution schemes, via accurate numerical data (Temponi, Yen, & Tiao, 1999). Therefore, displaying data in cardinal information will be unrealistic (Karsak, 2004). Moreover, to obtain cardinal information requires more time than that for ordinal information; consequently, enterprises lose market opportunities, and decision quality and efficiency is reduced. This study reconstructs the QFD model using linguistic ordinal information to provide appropriate information rapidly based on conformation of the original information (Wang, Chang, & Wang, 2007).

House of quality (HOQ) is the core of QFD and Fig. 1 presents the HOQ framework. Customer needs can be obtained subjectively from customers and then prioritized objectively from the marketplace. Solution schemes have to draft aimed at customer needs and the relationship matrix is formed by the relative evaluation between customer need and solution scheme. On the other hand, the correlative evaluation pair of solution schemes forms the correlation matrix. Finally, the prioritized customer needs, relationship matrix and correlation matrix are synthesized to prioritize the solution schemes. Thus, the QFD cycle has been completed using the top-down activities that represent customer needs effectively. Additionally, customer satisfaction will be increased significantly through QFD activities. As the purpose of this study is to construct a complete linguistic-based QFD model, the linguistic weighted aggregation (LWA) operator is employed to prioritize the solution schemes.

The next section discusses existing studies investigating fuzzy QFD models. The remainder of this paper is organized as follows. Construction of the complete linguistic-based QFD model is described in Section 3, and the algorithm for the proposed approach is presented via a flow chart in Section 4. A simplified example in Section 5 is employed to demonstrate how to activate the proposed technique. Finally, Section 6 presents discussions and conclusions obtained using this approach.

2. Developments and applications on fuzzy QFD

This section discusses existing literature that discusses applications of a fuzzy QFD model. Chen et al. (2006) adopted the linguistic form to evaluate the weights of customer needs and a relationship matrix. Defuzzification results, cost and difficulty of solution schemes were then introduced into multiple objective fuzzy linear programming to determine the execution level of solution schemes. Kahraman, Ertay, and Büyüközkan (2006) combined

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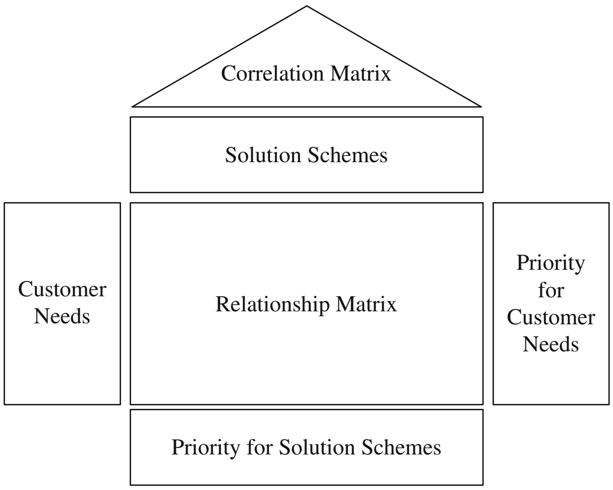

Fig. 1. House of quality.

defuzzification results obtained from a linguistic evaluation of customer needs using an analytical hierarchy process to weight customer needs, and then used fuzzy linear programming (FLP) to determine the implementation level of the solution schemes. Chan et al. (2005) presented the results of linguistic evaluations and HOQ operation on a crisp value and fuzzy number. Chen et al. (2003) performed the HOQ operation via α-cut defuzzification. Temponi et al. (1999) built a fuzzy logic-based linguistic evaluation matrix model. Kim, Moskowitz, Dhingra, and Evans (2000) developed a fuzzy multiple criteria model for HOQ operation and presented the results via fuzzy numbers that became the parameters of fuzzy regression in prioritizing solution schemes.

Yang, Wang, Dulaimi, and Low (2003) utilized linguistic variables defined in fuzzy numbers to weight customer needs and identify the relationship matrix in architectural design. Fuzzy number-based aggregation results were compared with the definition of linguistic variables to assess the eventual linguistic result. Karsak (2004) employed linguistic variables to weight customer needs and relationship matrix in a clothing design context. After obtaining the defuzzification results, cost and difficulty of solution schemes were incorporated into multi-objective FLP to resolve the fulfilled rate of solution schemes. Büyüközkan et al. (2005) developed the ordered weighted geometric operator to aggregate the information from the group-decision QFD model on the application of software design. Moreover, seven calculations for weighting are proposed to construct a complete numerical HOQ. Fuzzy linguistic quantifiers are then introduced to aggregate and prioritize solution schemes.

Although the previous studies have focused on the fuzzy QFD model, its operation still depends on defuzzification. Hence developing a direct linguistic QFD model is the primary purpose of this study.

3. Constructing the linguistic QFD

This section details how to construct the linguistic QFD using HOQ in sequence.

3.1. Obtaining and prioritizing the customer needs

Customer needs can be acquired using questionnaires, interviews, and through experience. Maintenance and complaint records can also be utilized. Determining the priorities of customer needs is the first task in this study that is concerned with evaluator linguistic cognition and judgment. Therefore, the difference between importance and satisfaction in customer needs is measured to prioritize customer needs. The prioritizing theorem is as follows: when the importance of customer need exceeds satisfaction; the customer need did not reached expectation. On the contrary, relatively less urgent is when satisfaction exceeds importance, meaning that the service surpassed expectation.

This study employed a linguistic scale defined by linguistic variables to evaluate the importance and satisfaction for each customer need. The linguistic variable is formed by several semantic elements (SEs) within a linguistic term set (LTS) (Herrera, Herrera-Viedma, & Martinez, 2000). The SE is defined in the unit interval [0,1] of the linear triangular membership function using the fuzzy set (x_L, x_m, x_R) (Fig. 2), where x_L and x_R are the left and right limits of the corresponding SE by the membership function, and x_m is the value at which the membership grade equals 1. Applications can also utilize a trapezoid membership function for defining SEs within an LTS.

The priorities of customer needs can be represented by a weight of magnitude; hence, how to determine the weight of each customer need is the focus of the following discussion. First, the difference between the importance and satisfaction of each customer need can be the basis for weighing need. The scale adjustment and normalization process can then acquire the weight of each customer need. Suppose that the importance and satisfaction of customer needs $(X_1, X_2, \ldots, X_m)$ are evaluated by linguistic variables $A = \{a_0, a_1, \ldots, a_p\}$ and $B = \{b_0, b_1, \ldots, b_q\}$, respectively. Both $a_i \in A$ and $b_j \in B$ indicate the importance and satisfaction of customer need X_n; D_n, E_n and W_n are the original difference, adjusted difference and normalized weight demonstrated in the following equations:

$$\text{original } D_n = i - j \quad n \in 1, 2, \ldots, m \tag{1}$$

$$\text{adjusted } E_n = D_n + q \quad n \in 1, 2, \ldots, m \tag{2}$$

$$\text{normalized } W_n = \frac{(D_n + q)}{(D_1 + q) + (D_2 + q) + \cdots + (D_m + q)} \quad n \in 1, 2, \ldots, m \tag{3}$$

Label	SE	(x_L, x_m, x_R)
s_0	None	(0,0,0.12)
s_1	Very Low	(0,0.12,0.25)
s_2	Low	(0.12,0.25,0.37)
s_3	Almost Low	(0.25,0.37,0.5)
s_4	Medium	(0.37,0.5,0.62)
s_5	Almost High	(0.5,0.62,0.75)
s_6	High	(0.62,0.75,0.87)
s_7	Very High	(0.75,0.87,1)
s_8	Perfect	(0.87,1,1)

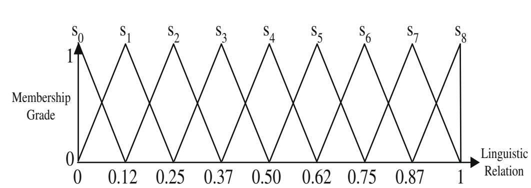

Fig. 2. Definition of linguistic variable with nine SEs.