An integrated FIS-QFD model for evaluation of internet service provider

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ABSTRACT

The supplier selection is a multi criteria decision making which consist both qualities and quantities metrics. A lot of investigations have been published in the supplier selection area and, most of the proposed models focused on manufacturing environments and a few papers have been allocated for service industries. proposed system utilizes new method that transfer the house of quality (HOQ) approach typically of quality function deployment (QFD) problems to the supplier selection process also this model can rate both qualitative and quantitative criteria's and select suitable suppliers effectively. Symmetrical fuzzy triangular numbers (STFNs) are used to capture the vagueness in people's linguistics assessments and also in this model the weights of decision makers are different and this parameter is calculated by fuzzy inference system.

Keyword

Internet service provider , Quality function development , Fuzzy inference system

1. INTRODUCTION

Due to worldwide competition in today global economies firms must focus on Quickly And precisely responding to customer demand and must be connected with the customer satisfaction . These pressure prompt business enterprises actively invest in supply chain management and also more manufacturing organizations are adopting total quality management (TQM) and just in time (JIT) concepts. The role of the supplier and supply chain management become increasingly important [1]. supply chain management (SCM) attempts to reduce supply chain (SC) risk and uncertainty thus improving customer service and optimizing inventory levels , business processors , cycle times and resulting in created competitive , customer satisfaction and portability [2]. Suppliers play an important role in achieving the objective of supply management they enhance customer satisfaction in a value chain. The object of supplier selection is to identify supplier with the highest potential for meeting and firm's need constantly at an acceptable cost [3]. Supplier selection in industry is a cross functional, group decision - making problem and frequently solved by non- programmed decision-making process and involving long term commitment for a company [4].

The outsourcing firm selects the most appropriate suppliers by considering service price, waiting time or service capacity, and builds long term and profitable relationships with them [5]. We aim to develop an integrated model for supplier management and fill the gap in the literature. Besides, the new model combines both qualitative and quantitative criteria simultaneously. Moreover, unlike the case of parts purchasing, there is only a limited number of studies that model the service supplier selection problem [6], [7], [8]. In this article, we propose a novel model for Internet service provider (ISP) selection and evaluation which can be applied for most of the service sectors. In addition, most published models in this area focus only on the customer perspective or supplier's performance perspective, or competition situation, and hence these models pay no attention to all of these factors simultaneously. In order to solve the above shortages we propose a novel method that considers competition position, current performance and customers' viewpoint concurrently.

This paper proposes a decision model that consists of two phases. In the first phase, FIS model will determine the weight of each decision makers and in second phase QFD model will be integrated with a quantitative model to select the best ISPs.

2. LITERATURE REVIEW

The earliest review in supplier selection is by Moore and Fearon (1973) [9] where they focused on industry applications of computer-assisted supplier selection models. Kingsman (1986)[10] highlighted the inadequacy of classical inventory management models for tracking purchasing decisions and described some of the major models that applied in contractor evaluation and selection. Holt (1998) [11] reviewed and compared several decisional methods were used for the different purchasing decision-making stages In particular. De Boer et al (2001)[7] positioned the contributions in a framework that takes into account the diversity of procurement situations in terms of complexity and importance and covers all phases in the supplier selection process from initial problem definition, the formulation of criteria, the qualification of potential suppliers, to the final choice among the qualified suppliers.

De Boer et al (2001)[7] did not restrict the review to the final choice models. They recognized the prior steps to the ultimate stage and presented the main published works that deal with all the supplier selection process. These stages are problem formulation, formulation of criteria, qualification and final selection. Recently, Amid et al (2011) [12] have presented a literature review that covers the entire purchasing process. They proposed different classifications of the published models based on single and multiple periods and items.

3. CRITERIA SELECTION

Determining the criteria is the first step in supplier selection process. Dickson (1966)[13] identified 23 different criteria based on a questionnaire sent to 273 purchasing agent and managers from United States and Canada. The most prominent ones were quality, delivery, performance history, warrant and claim policy, production facilities and capacity, net price, and technical capabilities. Ellram (1990)[14] applied hierarchy framework including financial, performance, technology, organizational culture and strategy, and other factors. Weber, Current, and Benton (1991) [15] selected price, delivery, quality, facilities and capacity, geographic location, and technology capability as the most important factors in supplier selection. Mandal and Deshmukh (1994)[16] proposed interpretive structural modeling (ISM) as a technique based on group judgment to identify and summarize relationships between supplier choice criteria through a graphical model. They suggested it aids the purchaser by separating dependent criteria from independent criteria. Vokurka, Choobineh, and Vadi (1996)[17] developed an expert system that covers multiple phases in the supplier selection process among which the formulation of supplier selection criteria. Other (non-experts) users may consult the system to obtain suggestions as to which criteria to use in a particular situation. Ghodsypour and O'Brien (1998)[18] stated that cost, quality, and service have considerable effects on supplier selection parameters. Kahraman et al (2003)[19] mentioned that selection criteria typically fall into one of four categories: supplier criteria, product performance criteria, service performance criteria, and cost criteria. Humphreysa, Wong and Chan (2003)[20] integrated environmental criteria into the supplier selection process. Bottani and Rizzi (2006)[21] presented a multi attribute approach for selection and ranking of the most suitable 3PL service provider. They applied service criteria such as breath of service, business experience, characterization of service, compatibility, financial stability, flexibility of service, performance, price, physical equipment and information, quality, strategic attitude, trust and fairness. Recently, Huang and Keskar (2007)[22] presented basic structure with seven categories for selecting the criteria based on the firms' strategy. In addition, they organized these categories into three tracks such as product related, supplier related, and society related. Furthermore, they determined sub criteria for each one. Demirtas and Ustun (2008)[23] defined 14 different criteria under Benefits, Opportunities, Costs, and Risks (BOCR) merits. Lin (2009)[24] proposed a method to select suppliers by considering the effects of interdependence among these selection criteria price, quality, delivery and technique Zouggari and Benyoucef (2012)[8] classified criteria's in four group : quality , innovation , risk , performance strategy

4. TECHNIQUE SELECTION

Models for evaluating suppliers can be divided into two groups on the basis of the structure they adopt: flat models and hierarchical models. In the first group, there are models and methods that consider all factors relevant to the evaluation at the same level. The second group contains all the models that require a structuring of criteria into a hierarchical framework, the best known of which is the analytic hierarchic process (AHP) proposed by many authors [25]. Supplier selection is a typical multi-attribute problem that involves both qualitative and quantitative factors. To deal with this problem, some authors have adopted other techniques, e.g. whole number multiple-objective linear programming [26]. total cost of ownership and statistical methods [27]. Other authors have tried to integrate qualitative and quantitative aspects in the problem of supplier selection. Since not every supplier selection criterion is quantitative, usually only a few quantitative criteria are included in the optimization formulation This problem is recognized by Ghodsypour and O'Brien (2000)[28], who proposed an integrated method that uses AHP and linear programming to deal with both qualitative and quantitative criteria. Following this philosophy, Sarkis and Talluri (2000)[29] proposed the analytical network process (ANP) technique and Wang et al (2004) [30] proposed an integrated analytic hierarchy process (AHP) and preemptive goal program (GP) based on multi-criteria decision-making methodology.Innovative approaches based on artificial intelligence techniques such as Fuzzy Logic [31]. And neural nets Albino etc al (1998)[32] match very well with decision-making situations where supplier evaluation is also perceptive and decision makers express heterogeneous judgments.

Application of quality function deployment (QFD) as a tool for supplier selection has been limited. To date there have been few works that have applied this tool for supplier evaluation purposes. Ansari and Modarress (1994) [33] discussed the roles of suppliers in the various phases of QFD. Holmen and Kristensen (1998)[34] illustrated how the house of quality (HOQ) can be used in the pre-interactive stage of a single product development project, and how the identified correlations and non-correlations between the characteristics of the planned product can be used by a customer as a practical approach for discrimination between the three types of suppliers. Temponi, Yen, and Tiao (1999)[35] developed a fuzzy logic-based extension to HOQ for capturing imprecise requirements to both facilitate communication of team members and have a formal representation of requirements. Bevilacquaetc al (2006)[36] suggested a new method that transfers the house of quality approach typical of QFD problems to the supplier selection process by using triangular fuzzy numbers.

Recently Feng etc al (2011)[37] propose a A decision method QFD model for supplier selection in multi-service outsourcing . Na (2012)[38] suggested a An integrated model for supplier selection under a fuzzy situation by using a Fuzzy preference programming and QFD . chen and chao (2012)[39] developed a model for supplier selection by using consistent fuzzy preference relations The proposed procedure utilizes the structure of criteria in quality function development model and employs consistent fuzzy preference relations (CFPR) to construct the decision matrices. Wang etc al (2012)[40] proposed a new Fuzzy-QFD approach based decision support model for licensor selection the proposed hybrid fuzzy-QFD approach can successfully deal with complex licensing selection criteria to find an optimal solution and has the potential for handling multiple criteria decision-making problems in the patent marketplace.

5. QUALITY FUNCTION DEVELOPMENT

Quality function deployment is a planning tool used to fulfill customer expectations. It is disciplined approach to product design, engineering, and production and provides in-depth evaluation of a product. An organization that correctly implements QFD can improve engineering, productivity, and quality and reduce costs, product development time, and engineering changes.

QFD focuses on customer expectations or requirements, often referred to as the voice of customer. It is employed to translate customer expectations, in terms of specific requirements, into directions and actions, in terms of engineering or technical characteristics, that can be deployed through: product planning, part development, process planning, production planning, service industries [41]. Further details on the benefits of using QFD can be found in [42]. The primary planning tool used in QFD is the House of Quality. The HOQ translates the voice of customer into design requirements that meet specific target values and matches those against how an organization will meet those requirements. The structure of HOQ can be thought of as a framework of a house, as shown in Fig. 1[41].Sener and Karsak (2011) [43] determined QFD aims to maximize customer satisfaction, requirements related to enterprise satisfaction such as cost budget, extendibility, and technical difficulty also need to be considered . Lin (2012)[44] developed Fuzzy measurable house of quality and quality function deployment for fuzzy regression estimation problem as the proposed model Quality function deployment (QFD) is combined with a mapping pattern of ''function--principle--structure'' to extract product characteristics from customer demands . wang etc al (2012) [40] proposed Decision Making Model Based on QFD Method for Power Utility Service Improvement Adila Hashim and Dawal (2012)[45] , used Kano Model and QFD integration approach for Ergonomic Design Improvement .

6. FUZZY SET THEORY

In dealing with a decision process the decision makers is often face with doubts , problems and uncertainties . to cope with and handle such uncertainties and inaccuracies he generally relies on tools provide by probability ever its nature the principal that an accuracy what ever its nature , is governed by random law . To deal with this kind of uncertainty correctly we can resort to fuzzy logic . fuzzy sets are sets whose elements have degrees of membership . fuzzy set have been introduced by Zadeh (1965)[46] as an extension of the classical notion of set . FST permits the gradual assessments of the membership of elements in a set : it is described with the aid of a membership function μ(x) valued in a real unit interval [0,1] There are various types of fuzzy numbers , each of them may be more suitable than others for analyzing a given ambiguous structure : the present analysis use triangular fuzzy numbers [36]. because they are intuitive as (a,b,c) and the membership function μ(x) is defined as following . In this study, fuzzy opinions are represented as triangular fuzzy numbers (TFNs) because they are intuitive and easy to use. A TFN can be defined as (a,b, c) which is shown in Fig. 2.

$$\mu_A(x) = \begin{cases} \frac{x-a}{b-a} & a \leq x \leq b \\ \frac{c-x}{c-b} & b \leq x \leq c \\ 0 & \text{otherwise} \end{cases}$$

7. FUZZY INFERENCE SYSTEM

Zadeh (1965) [46] introduced the theory of fuzzy sets. This theory proposes making the membership function operations over the range of real numbers [0, 1]. New operations for the calculation of logic membership functions were proposed and showed to be a reasonable tool to generalize classic logic. The use of linguistic variables and mathematical relationships in this technique, gives the decision making process more adequacy. Fuzzy logic systems are particularly suited to model the relationship between variables in environments that are either ill-defined or very complex. Fuzzy systems provide the means of representing the expert knowledge of humans about the process in terms of fuzzy (IF–THEN) rules. A fuzzy rule is the basic unit for capturing knowledge in fuzzy systems. A fuzzy rule, like a conventional rule in artificial intelligence, has two components: an 'if' part and a 'then' part which are also referred to as antecedent and consequent, respectively. The Sugeno and Mamdani types of fuzzy inference systems can be implemented in the fuzzy logic toolbox of MATLAB [47]. When the output membership functions are fuzzy sets, the MFIS is the most commonly used fuzzy methodology [48]. The main idea of the Mamdani method is to describe the process states by linguistic variables and to use these variables as inputs to control rules [49] . In MFIS which is a particular type of fuzzy inference system, in addition to knowledge base and a fuzzy inference engine, there is a fuzzifier that represents inputs numerical as fuzzy set, and a defuzzifier that transforms the output set to crisp (Fig. 3).

8. CASE REVIEW

INDAMIN SAIPA is the first and greatest shock absorber manufacture in IRAN that has been founded in 1974 and 441 personnel work in INDAMIN . The company purchases its Internet services from a famous ISP. An Interne service provider (ISP) is a business or organization that provides consumers or business access to the Internet and related services [50]. In the past, the most ISPs were run by the phone companies. Now, ISPs can be started by just about any individual or group with sufficient money and expertise. As a result, ISP selection is an important issue. Dial up technology and asymmetric dig ital subscriber line (ADSL) are two important types of Internet services in Iran. If you want to connect to your office network, download and exchange music and video files, you'll want a speed broadband connection, such as ADSL [51]. Recently, new problems in connections have revealed. According to the importance of Internet quality on the customer satisfaction especially in hotels, the manager of company has decided to select multiple ISPs, and design a performance assessment process. The project is conducted by systems manager (DM1) in central office. Furthermore, purchasing manager (DM2) and marketing manager (DM3) contribute in decision-making process.

In this case The members of committee organize meeting to determine the required criteria. They organize criteria in two groups: service related and supplier related. Besides, supplier related group is categorized to qualitative and quantitative ones which have been shown in Fig. 4.

8.1 determine the weight of decision makers

The experience, authority of DMs are not equal in practice [52]. Therefore, it is necessary to determine the weights of DMs. Suppose the weight of DM_n is r_n. This parameter can be calculated by linguistic variables. In this case study, experience and authority index have been considered, and it is supposed that a DM with more experience and authority is more reliable than others.

In this model fuzzy inference system is used to determined the weights of decision makers therefore For all decision makers membership function of the authority and experience index parameter were recorded in four quality features " low , medium , medium high , high" (fig 5 and 6) . figure 7 shows the outputs of fuzzy system in seven quality features "very low , low , medium low , medium , medium high , high, very high ,"

Many researchers have investigated techniques for determining rules, and expert knowledge is the one most commonly used [53]. In this study the set of rules based on expert knowledge to construct the fuzzy model are given in Table 1. The MFIS used here has 4*4 = 16 rules based on the membership functions considered for inputs.. The fuzzy system is implemented using some fuzzy inference system properties in Table 2. Determination of membership functions in terms of shape, boundaries and overlapping has a significant effect on the MFIS output. This greatly depends on the expert knowledge. Finding the accurate shape and the boundaries for the membership functions increases the accuracy of the results. In this research some properties of applied system, such as membership functions' shape, , which is to determine the overlapping amount and condition among the membership functions, input and output levels, and rules, were tested to find the optimum results. Results showed with applying triangular and trapezoidal membership functions for input and output improved the accuracy. This results show fuzzy logic has been able to model human expertise successfully The level of agreement between the MFIS and human expert is not usually 100% because fuzzy logic gives 'class' membership degrees [53].

The rule viewer allows interpreting the entire fuzzy inference process at once [54]. It also shows how the shape of certain membership functions influences the overall result [48]. Fig. 8 illustrates the rule viewer given inputs: experience =5 and authority = 12.5 then the corresponding output is the decision makers rate equal to 6 The result for 3 decision makers are shown in Table 3.

8.2 QFD model

8.2.1 Qualitative model

In this section, the QFD model is applied to consider qualitative criteria in supplier selection process. The QFD enables us to take into account the customers' judgments.

Step 1: Let U = {VL,L,ML,M,MH,H,VH} be the linguistic set used to express opinions on the group of criteria. The linguistic variables of U can be quantified using triangular fuzzy numbers (Fig7). Each of the three decision-makers establishes the level of importance or weight of each of WHATs (service related criteria) by means of a linguistic variable. The results are shown in Table 4.

Step 2: The weights assigned by decision-makers for customer requirement should be aggregated.

Suppose that , through appropriate ways, K decision makers have been selected and M customer's needs have been identified based the opinions of these K decision makers , the M customer's needs are denoted as $W_1, W_2, ..., W_m$

Suppose that for customer's need W_m decision maker K supplies a relative importance rating r_k then the resulting aggregated relative importance rating for W_m is computed by following equation :

the aggregated weights are calculated inTable5.

$$w_m = (r_1 * w_{m1} + r_2 * w_{m2} + \dots + r_k * w_{mk}) = \sum_{k=1}^{k} r_k * w_{mk}$$

(1)

step7: determination of HOW_s :

Technical requirement (TR) are specified as the HOW_s of the HOQ and also called measurable requirement TR are identified by multidisciplinary team .

suppose N technical measures have been developed , denoted as $H_1, H_2, \dots, H_N$

step8: determine the relationship between HOW_s and $WHAT_s$ the decision makers judges which HOW_s impact which $WHAT_s$ and up to what degree . in this situation team consensus is beneficial . all these relationship from a matrix with the $WHAT_s$ are row and the HOW_s as columns table 6 . let the relationship value between technical measure H_n and customer's need W_m be determined as b_{mn} then we can form the following relationship matrix between the HOW_s and

WHAT$_s$ tab :

$b_{11} = (r_1 * b_{111} + r_2 * b_{112} + \ldots + r_k * b_{11k}) = \sum_{k=1}^{k} r_k * b_{11k}$ (2)

$b_{mn} = (r_1 * b_{mn1} + r_2 * b_{mn2} + \ldots + r_k * b_{mnk})$ (3)

r_k = importance weight of decision maker k

b_{mnk} = relation value between technical measure H_n and customer's need W_m by decision maker k

step9: determine initial technical rating of HOW$_s$:

initial technical rating of HOW$_s$ are decided by two factors final importance rating of WHAT$_s$ and the relationship between HOW$_s$ and WHAT$_s$ these rating indicate basic importance of HOW$_s$:

$t_n = \frac{1}{m} (w_1 * b_{1n} + w_2 * b_{1n} + \ldots + w_m * b_{mn})$

(4)

the results calculated in Table7

step10: determine technical rating of each suppliers:

let the technical parameter of performance score of supplier S_L's product on technical measure H_n be determined as y_{nl} then we can form the technical comparison matrix of the supplier's products on the HOW$_s$

it is necessary to assess each supplier based on the criterion in question and combined said assessment with the weight of each criterion in order to establish a final ranking then S_n are aggregated based on the following equation.

$S_{ln} = (r_1 * S_{Ln1} + r_2 * S_{Ln2} + \ldots + r_k * S_{Lnk})$ (5)

where n = 1,2 ,… ,N

step11: determine the rank of each supplier :

for final ranking of each supplier the FR index express each supplier satisfies a given requirement the FR index is a triangular fuzzy number that's from previously calculated scores by equation below

$FR = \frac{1}{m} (S_{L1} * t_1 + S_{L2} * t_2 + \ldots + S_{Ln} * t_n)$ (6)

The simple method for ranking fuzzy numbers is centroid method that is adopted to defuzzify FR index in this paper Chou and chang (2008) [52] a defuzzified triangular fuzzy number A = (a,b,c) is calculated by equation below and in addition the scores are normalized in 0-1 scale by using (8) and finally scores can be ranked table 9 .

$DF = \frac{1}{3} (a+b+c)$ (7)

$$FS = \frac{DFL - \min l = 1,2,\ldots,L\{DFL\}}{\max l = 1,2,\ldots,,L\{DFL\} - \min l = 1,2,..,L\{DFL\}} \quad (8)$$

8.2.2 Quantitative model

It is undeniable that quantitative metrics such as price have tremendous effects on decisions. Ng (2008)[54] proposed a weighted linear program for the multi-criteria supplier selection problem that can be easily implemented with a spreadsheet package. Besides, the model can be applied to practical situation and does not require the user with any optimization background. However, this model only considers quantitative criteria. In this section, we use this model for quantitative metrics. Then, the QFD model and this model will be composed to take into account both of qualitative and quantitative criteria in supplier selection process. The model consists of the following steps.

Step1: List all measures in the same sequence as importance of criteria. Table 10 shows the results.

Step 2: Transform measures so that all measures are positively related to scores and normalized in a 0–1 scale: we consider a situation in which a set of H ISPs are available and we want to select them according to K quantitative criteria. The measure of ISP$_h$ under criterion k is denoted as x_{hk} (h = 1,2, . . .,H, k = 1,2, . . .,K). We normalize all measures x_{hk} into a 0–1 scale by Eq. (9) and denote them as y_{hk}. For negative criteria, first you must take reciprocal conversions. Table 11 lists the results

$$Y_{hk} = \frac{XtL - \min L = 1,2,\ldots,L\{XtL\}}{\max L = 1,2,\ldots,,L\{XtL\} - \min L = 1,2,..,L\{XtL\}} \quad (9)$$

Step 3: Calculate all partial averages by Eq. (10).

$1/k(\sum_{y=1}^{h} Y_{hg})$ (10)

k = 1; 2; . . . ; K

Step 4: Compare and locate the maximum among these partial averages. The corresponding value is the score of each ISP.

Step 5: Rank the scores and identify important ISPs. Table 12 shows the scores.

8.2.3 Combined model

In two previous section the score and rank of each suppliers based on qualitative and Quantitative measures are calculated in this section combination of model and final score and final rank are calculated suppose FS_1 is the final score of qualitative model and FS_2 is the final score of quantitative model .furthermore α and β are the weights of the QFD model respectively which α + β = 1 . this parameters are determined by DM$_s$ and the final score of suppliers are calculated by (11) Table 13 shows the results.

$\alpha * FS_1 + \beta * FS_2 = s_L$ (11)

9. CONCLUSION

In this paper we have proposed a new model for ISP selection and evaluation problem. We utilized a combination of fuzzy QFD model and a quantitative model for ISP selection and the fuzzy inference system is used to determined the weights of decision makers .The principal advantages of our model are in fivefold: First, we focused on supplier selection and evaluation in service industries specially Internet Service Provider selection and evaluation problem. second , the proposed model can rate both qualitative and quantitative criteria and select suitable suppliers effectively. Third the model considers customer, competition, and performance simultaneously. Forth , the proposed approach can adequately deal with the inherent uncertainty and imprecision of human decision-making. Finally, this research investigated the differences among decision makers by devoting unequal weights by application of fuzzy inference system.

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