TITLE -SUPPLIER SELECTION: FUZZY-AHP APPROACH

Affiliation : Institute of Technology, Banaras Hindu University, Varanasi

1) *RAJESH SINGH (Corresponding author)

Research Scholar,
Department of Mechanical Engineering,
IT-BHU, Varanasi (U.P.) INDIA-221005
Contact No. 9415203502
rajeshsingh_sms@rediffmail.com

2) S.K.SHARMA

Professor ,
Department of Mechanical Engineering,
IT-BHU, Varanasi, (U.P.) INDIA-221005
Contact No. 9335416507
sksharma.mec@itbhu.ac.in

Abstract

The primary objective of the paper is to identify the performance measurement indicator for best supplier and secondly to develop an appropriate Fuzzy-AHP model for evaluating the suppliers. Fuzzy-AHP is an efficient tool to handle the fuzziness of the data involved in deciding the preferences of different decision variables. The linguistic level of comparisons produced by the customers and experts for each comparison are tapped in the form triangular fuzzy numbers to construct fuzzy pair-wise comparison matrices. An elaborate computer program is also included for quick response of the respondents.

1. Introduction

Supplier selection considers numerous factors, such as quality, responsiveness, discipline, delivery, financial status, technical capability, and facility; these are the performance measures of supplier selection. A firm may have some competence in all areas and exceptional competence in only a few. This leads to confusion in selection of supplier. In this paper supplier evaluation is done using a Fuzzy-Analytical Hierarchy Process. The paper takes into consideration the uncertainty and vagueness normally found in executives while evaluating suppliers. In a typical supply chain, coordination between manufacturer and suppliers is the important link in the distribution channel. The competitive environment drives organizations highly dependent on the success of supplier selection process. Any deficiency in coordination of the process will lead to excessive delays and poor customer service. In fact, suppliers are manufacturer's external organizations or business partners, and indeed their performance will decide the future performance of the whole supply chain.

The analytic hierarchy process (AHP) is usually used for multi-attribute decision-making problems like supplier selection. The drawback with this approach is its inability to adequately handle the inherent uncertainty and imprecision associated with the mapping of the decision-makers perception to exact numbers. However, in many practical cases the human preference model is uncertain and decision makers might be reluctant or unable to assign an exact number. Since some of the evaluation criteria are subjective and qualitative in nature, it is very difficult for the decision maker to express the preferences using exact numerical values and to provide exact pair wise comparison judgments. To improve this and to facilitate supplier selection process, the paper discusses a fuzzy - AHP approach using triangular fuzzy numbers to represent decision makers' comparison judgments and fuzzy synthetic extent analysis method to decide the final priority of different decision criteria.

Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth - truth values between "completely true" and "completely false". It is used where uncertainty is present.

2. Literature survey

In the past, several methodologies have been proposed for the supplier selection problem but most of them have limited their studies to domestic sourcing only. As a result, many important criteria which are critical in deciding the global supplier have not been discussed properly. Some of the well-known examples of systematic analysis for domestic supplier selection include a categorical method, weighted point method, matrix approach, and vendor performance matrix

Approach, vendor profile analysis (VPA), analytic hierarchy process (AHP), and multiple objective programming (MOP). Although both AHP and MOP have some advantages over other existing approaches, they are still suffering from some criticisms. AHP cannot effectively take into account risk and uncertainty in assessing the supplier's performance because it presumes that the relative importance of attributes affecting the supplier's performance is known with certainty. The drawback of MOP is that it requires arbitrary aspiration levels and cannot accommodate subjective criteria. Apart from the above-mentioned techniques, Choy and Lee[3] used the case-based reasoning approach for intelligent supplier selection to enhance the performance of the selection as compared to traditional approaches. Verma and Pullman [4] studied the perceived importance of supplier selection criteria and identify the relative weights of the attributes in actual selection of suppliers. Liu et al. [5] used data envelopment analysis (DEA) to compare the performance evaluation of different supplier for best selection. O'Brien and Ghodsypour[6] proposed integration of an AHP and linear programming to consider both tangible and intangible factors in choosing the best suppliers and placing optimum order quantities among them. Wang et al. [7] used the advantages of AHP and preemptive goal programming to incorporate both quantitative and qualitative factor in supplier selection problem. The mathematical programming model applied to supplier selection has problems in including qualitative criteria that are very important in the decision making, especially for supplier partnership policies models.

3. FUZZY –AHP MODEL-

The conventional AHP method is incapable of handling the uncertainty and vagueness involved in the mapping of one's preference to an exact number or ratio The major difficulty with classical AHP is its inability in mapping human judgments .In recent years it has been observed the due to confusion in decision makers mind probable deviations should be integrated to the decision making process in Fuzzy-AHP, pair wise comparisons are done using fuzzy linguistic preference scale. For simplicity the reciprocal fuzzy numbers are replaced by individual Triangular Fuzzy Numbers in the pair wise comparison matrix.

3.1 ***Fuzzy set and triangular fuzzy numbers-***

The major contribution of fuzzy set theory is its capability of representing vague data .A fuzzy set is a class of objects with a membership function ranging between zero and one. It was specifically designed to mathematically represent uncertainty and vagueness. Fuzzy set theory implements groupings of data with boundaries that are not sharply defined (i.e fuzzy).any methodology or theory implementing groupings of data with boundaries that are not sharply defined(i.e fuzzy).any methodology or theory implements " crisp " definitions such as classical set theory, arithmetic, programming ,may be "fuzzified" by generating the concept of crisp set to a fuzzy set with blurred boundaries .the benefit of extending crisp theory and analysis methods to fuzzy techniques is the strength in solving real-world problems, which inevitably entail some degree of imprecision in the variables and parameters measured and processed for application.

A triangular fuzzy (TFN) is the special class of fuzzy number whose membership is defined by three real number ,expressed as (l,m,u).the triangular membership function is represented as follows-

Structure of the triangular function

Membership function-

$$\mu A = \begin{cases} (x-l)/(m-l), & l<=x<=m \\ (u-x)/(u-m), & m<=x<=u \\ 0, & \text{otherwise} \end{cases}$$

The operational laws between two triangular fuzzy numbers M1& M2 are as follows-

M1+M2 = (l1+l2, m1+m2, u1+u2)

M1*M2=(l1l2, m1m2, u1u2)

3.2 ***Conceptual Hierarchy of Fuzzy-AHP model-***

Analytical problem starts by laying out the overall hierarchy of decision making problem. The hierarchy is structured from the top (the overall goal of the problem) through the intermediate levels (criteria sub-criteria on which subsequent levels depend) to the bottom level (the list of alternatives).Each criteria in the lower level of hierarchy is compared with respect to the criteria in the upper level of hierarchy The criteria in the same level are compared using pair-wise comparison.

3.3Selection criteria for suppliers

Owing to the large number of factors affecting the supplier selection decision, an orderly sequence of steps should be required to tackle it. The problem taken here has four level of hierarchy, and the different decision criteria, sub criteria and the decision alternatives, will be further discussed. The main objective here is the selection of best global supplier for a manufacturing firm. Application of common criteria to all suppliers makes objective comparisons possible. The criteria which are considered here in selection of the global supplier are:

- Cost
- Quality
- Service
- Supplier's profile
- Risk factor

These criteria can be decomposed into various other attributes as follows-

- Cost (C1*)*

This criterion is one of the important criteria in assessing the global supplier because it can dictate the international procurement cost. Profit maximization cannot be achieved without the cost minimization. The factors (attributes) affecting this criterion can be stated as follows:

- *Price of product (SC*1*)*

The firm always requires the minimum price of the product to increase the profitability. The firm therefore must find a low-cost supply base where it can minimize manufacturing cost related to the production of the product

- *Distribution cost (SC*2*)*:

This contains the lengthy distribution channel cost, transport expenses, inventory cost, handling and packaging cost, damages during transportation and insurance costs.

- . Quality (C2)

The most important factor leading to international sourcing is the high quality of the products, which makes a good impression to the customer

- *Rejection rate (SC*3*)*

The rejection rate of the product is defined in the terms of the number of parts rejected by the customers in fixed time period because of some quality problems. It also includes the defective parts detected in the incoming quality control and the production line

- *Assessment quality (SC*4*)*

This encounters the issues like whether or not the frequent quality assessment of the parts has been done by the supplier

- *Service (C*3*)*

The performance of the supplier in providing service to the manufacturer is the prime criteria to decide its suitability for a particular product. The good service given by the supplier may help in increase the customer base and therefore, this criterion is important in global supplier selection. It is analyzed based on the following attributes:

- *Delivery (SC*5*)*

The ability of the supplier to follow the predefined delivery schedule is always the prime criteria for selection in this fast moving world.

- *Technological utilized (SC*6*)*

Technology is advancing at a very fast pace in this competitive world to satisfy the customer first and get its appreciation. Furthermore, suppliers are more likely to assume greater responsibility for outsourced design, engineering service, prototype development and research to increase the performance of the products. The

suppliers' ability to provide advanced technological and R&D support to produce a good product is of prime concern in global supplier selection

- *Lead time (SC7)-*

Time between order and placement of material.

- *Ease of communication (SC*8*)*

The ease of communication and negotiability with the suppliers decide the long-term relation between the supplier and manufacturer. Since languages, business customs, ethics and communication devices vary from country to country.

- *Supplier's profile (C*4*)*

The performance and past history of the suppliers help in taking decisions for its selection. The value-of partnership should be analyzed based on its track record
to decide the superiority of it over other alternative suppliers. Some of the important characteristics of suppliers are summarized below:

- *Financial status (SC*9*)*

The financial status of the supplier can be analyzed by getting the information about the annual turnover of the supplier and their financial structure based on the past history.

- *Response of customers (SC*10*)*

The response of the customers towards the supplier is one of the important factors to decide the performance of the supplier. Suppliers with good customer base should be preferred than the others.

- *Performance history (SC11)*

The performance history of the supplier should be analyzed carefully keeping
in mind the competitive nature of the supplier, its past production schedule, response to market, and its ability to make commercial relations and business references.

- *Production facility and capacity (SC*12*)*

The production facilities and ability of the supplier to increase its capacity should also be taken into account to judge the best one. The potential production capability of each supplier should be analyzed to meet a specified production plan and also to develop a new product according to the market demand.

- . *Risk factor (C*5*)*

Owing to a number of exogenous factors influencing international sourcing, global supplier selection is much riskier than its domestic counterpart. Consequently,
the global supplier selection decision is most strongly affected by perceived risks. They can be stated as below:

- *Geographical location (SC*13*)*

The location of the supplier and its physical and social status should be analyzed properly before selection of global partner. The mother country of the supplier, the location of plant, the nature of natural calamities, and other factors should be checked before the selection because for long-term relation it may create problems in the supply of the goods.

- *Political stability (SC*14*)*

The political status of the supplier's country and its nature towards the business policies may affect the long-term relationship between the supplier and the manufacturer. The more stable government should be preferred. Because, during the change of political leadership, different foreign country's policies will be changed accordingly and this may create big problems in further maintaining the relationship with suppliers. In this connection, this must be analyzed in great precision with the help of the relevant experts.

- *Economy (SC*15*)*

The economic status of the supplier's country may affect the currency exchange rate, local price control and so forth. This can result in higher hidden costs for international sourcing and into during the supplier selection

3.3 FUZZY PAIR WISE COMPARISON*:-* Once the hierarchy is established, the pair wise comparison evaluation takes place. All the criteria on the same level of the hierarchy are compared to each of the criteria of the preceding (upper) level .A pair wise comparison is performed by using fuzzy linguistic terms in the scale of 0-10 described by triangular fuzzy numbers in the table.

FUZZY SCALE OF PREFERENCE

LINGUISTIC VARIABLE	*CRISP AHP SCALE*	*TFN*	*RECIPROCAL TFN*
EXTREMELY PREFFERED	*9*	(8, 9, 9)	(1/9, 1/9, 1/8)
VERY STRONGLY TO EXTREMELY PREFFERED	*8*	(7, 8, 9)	(1/9, 1/8, 1/7)
VERY STRONGLY PREFFERED	*7*	(6, 7, 8)	(1/8, 1/7, 1/6)
STRONGLY TO VERY STRONGLY PREFFERED	*6*	(5, 6, 7)	(1/7, 1/6, 1/5)
STRONGLY PREFFERED	*5*	(4, 5, 6)	(1/6, 1/5, 1/4)
MODERATELY TO STRONGLY PREFFERED	*4*	(3, 4, 5)	(1/5, 1/4, 1/3)
MODERATELY PREFFERED	*3*	(2, 3, 4)	(1/4, 1/3, 1/2)
EQUALLY TO MODERATELY PREFFERED	*2*	(1, 2, 3)	(1/3, 1/2, 1)
EQUALLY PREFFERED	*1*	(1, 1, 1)	(1, 1, 1)

To reflect pessimism, most likely and optimistic decision making environment, triangular fuzzy numbers with minimum value, most plausible value & maximum value are considered.
Here the fuzzy comparison matrix is defined as

$$A = \begin{matrix} 1 & a12 & \ldots\ldots & a1n \\ a2 & 1 & \ldots & a2n \\ a31 & a32 & 1\ \ldots & a3n \\ \ldots & \ldots & an\ n\text{-}1 & 1 \end{matrix}$$

Where $a_{ij} = \{a_{ij}(l), a_{ij}(m), a_{ij}(u)\}$ is the relative importance of each criteria in pair-wise comparison and are the minimum value, most plausible value & maximum value of the triangular fuzzy numbers.

Generation of criteria and sub –criteria weight-

The normalization of the geometric mean (NGM) method is applied to compute weight form the fuzzy pair-wise comparison matrices which is given by

$$W_i = (a_i) / \sum_{i=1}^{i=n} a_i \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\text{Where} \quad a_i = \left(\prod_{j=1}^{j=n} a_{ij} \right)^{1/n}$$

In the above equation a_i is the geometric mean of criteria, a_{ij} is the comparison value of criteria i to criteria j and W_i is the i^{th} criteria weight where $W_i > 0$ and

$\sum W_i = 1$

For group evaluation, it is required to aggregate evaluator's opinions into one. Considering the evaluation given by expert

$E_i = (a_l^{(i)}, a_m^{(i)}, a_u^{(i)})$

The aggregated of all experts judgments can be calculated using average means

$$A = \left(1/n \sum_{i=1}^{i=n} a_l^{(i)},\ 1/n \sum_{i=1}^{i=n} a_m^{(i)},\ 1/n \sum_{i=1}^{i=n} a_u^{(i)} \right) \ldots\ldots\ldots\ldots..(2)$$

The final weight vector is generated by defuzzifying the average given by

$$w_{(i)} = \left(\left(1/n \sum_{i=1}^{i=n} a_l^{(i)} + 2 \ \ 1/n \sum_{i=1}^{i=n} a_m^{(i)} + \ \ 1/n \sum_{i=1}^{i=n} a_u^{(i)} \right) /4 \right) \ldots\ldots.(3)$$

the weight of i^{th} sub criteria under k^{th} main criteria is obtained by

$(w_k * s_k)$…….(4)

***3.4Calculation of overall score for alternatives*-**Once the weight of criteria are evaluated and are multiplied to obtain global weight of sub criteria, it is required to calculated the overall score of alternatives for their evaluation. The overall score of alternatives is obtained by

$$A_z = \sum_{i=1}^{i=n} s_i * a_{zi} \qquad \text{……..(5)}$$

Where s_i is the weight of i^{th} sub criteria and a_{zi} is the weight of z^{th} alternative with respect to i^{th} sub criteria.

4.0 Conclusion

In this paper a fuzzy extended AHP approach has been presented to select the best global supplier for a manufacturing firm to supply one of its most critical parts used in assembling process. The main criteria and sub criteria have been decided which are based on the current business scenario and experience of the experts in the respective fields. The large number of criteria and sub criteria demonstrated the complexities being involved in the selection of global supplier. Each factor affecting the supply of the product have been analyzed and discussed. . The model discussed in this paper is proved to be simple, less time taking and having less computational expense as compared to other existing decision making systems. The use of model does not involve cumbersome mathematical operation and so making it of general use for solving practical multi attribute decision making problems. The Fuzzy-AHP has the ability to capture the vagueness of human thinking style and effectively solve multi-attribute decision making problems.

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