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A Case Study of Appropriate Supplier Selection of RFL industry by using Fuzzy Inference System (FIS)

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ABSTRACT

Best supplier selection has become the prerequisite of the business success of any organization. In this era of industrialization the supplier selection process is going in a traditional manner which is very impractical practice. All though there are some research works regarding this issue, but there are some limitations in decision making process. This paper is stood against these limitations and totally focused on appropriate supplier selection using Fuzzy Inference System (FIS). The successful conversion of the qualitative factors into quantitative value makes the system error free which is being performed by FIS, a calculative decision making tool. A successful algorithm is designed for calculating the acceptance probability of suppliers by which the decision making phase is become convenient. Using MATLAB a built in software and the necessary predetermined variables with relevant membership function, the entire process reflects the best system for supplier selection.

Keywords: Supplier selection, Fuzzy inference system (FIS), Rule viewer, Surface viewer.

1. Introduction

In today's extremely competitive environment, effective supply chain management (SCM) is a pivotal issue as all the companies are trying to attain the goals of low cost, high quality, flexibility and more customer satisfaction. The suppliers who offer products or services that match or exceed the need of business can be recognized as effective supplier. The supplier selection process deploys a tremendous amount of firm's financial resources. Optimization of the supplier selection process depends upon the effectiveness of following steps like identifying suppliers, soliciting information from suppliers, setting contract terms, negotiating with suppliers and evaluating suppliers. The supplier selection process has undergone significant changes like increased quality guidelines, improved computer communication and increased technical capabilities during the past twenty years. Recently a new dimension is being added in the supplier evaluation process which is providing product or service when it is required, by the concept of Just-In-Time (JIT) manufacturing strategies. The idea of forming an outsource system is meant to establish a dynamic organization through the synergetic combination of dissimilar companies with different core competencies to perform a given business project to achieve maximum degree of customer satisfaction.[2] The selection of suppliers includes both tangible and intangible factors and the decision becomes complicated by lots of criteria and sub-criteria. There are huge numbers of supplier evaluation attributes like price, quality, delivery time, service, performance history, reliability, capacity etc. and managers, however, often need to make tradeoffs on these attributes.[1] In today's global economy, enterprise are increasingly striving to develop long-term strategic partnership with a few competent and innovative suppliers and collaborates with them in non-core process outsourcing in order to improve organizational performance and generate long-term competitive advantage. Today the average U.S. manufacturer spends roughly half its revenue to purchase goods and service which makes a company's success dependent on their interactions with suppliers. [3] So supplier should be selected based on how their actions will impact all the performance and competitive elements of the supply chain. On the other hand, academics and practitioners alike have recently shown interest of working with the concept of the optimization of supplier selection and business evaluation process in doctoral research. [4]

Organizations are looking for those manufacturers who can produce the goods with good qualities, low price and can deliver the goods on shorter lead time. In most of the cases manufacturers are failed to deliver the goods on due time because of the unfaithful supplier. There are cases when suppliers are delivering raw materials on due time but their quality is questionable. So manufacturers should be very careful of selecting the suppliers. Tremendous numbers of research are going on regarding supplier selection. Previously developed supplier selection methods can be classified in four major types: rating/linear weighting, total cost approaches, mathematical programming and statistical approaches.[5] Linear weighting method is the most common method in practice, assigns different weights to a number of criteria and the supplier with the best weighted total score is selected.[6] Mathematical programming models can optimize the explicitly stated objective and proved more effective than the linear weighting method.[7] In recent research works, the combination of these two models is being used widely. There are some works where linear programming and analytical hierarchy process (AHP) are being integrated

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to choose best supplier and to assign the optimum order quantity among selected suppliers.[8] Later AHP and preemptive goal programming based multi-criteria-decision-making (MCDM) methodology are being integrated and which are being proved to be very effective to satisfy capacity constraint.[9] The most recently developed method is Fuzzy goal programming approach which considers multiple objectives and deals with some of the parameters that are fuzzy in nature.[7]

During recent years, how to determine suitable suppliers in the supply chain has become a key strategic consideration. However, the nature of these decisions usually is complex and unstructured. In general many quantitative and qualitative factors such as quality, price, flexibility and delivery performance must be considered to determine suitable suppliers. In this method linguistic values are used to assess the ratings and weights for these factors. These linguistic ratings can be expressed in fuzzy numbers or fuzzy logic. Since human judgments including preferences are often vague and cannot estimate his preference with an exact numerical value. Fuzzy logic is a form of many-valued logic or probabilistic logic which deals with this decision vagueness. In contrast with traditional logic theory, where binary sets have two valued logic; true or false, fuzzy logic variables may have a truth value that ranges in degree between 0 to 1.Fuzzy logic has been extended to handle the concept of partial truth, where the truth value may range between completely true and completely false. Fuzzy theory can be collaborated with linear programming problems with a fuzzy objective and fuzzy constraints.[10] There are different ways to express fuzzy logics like trapezoidal or triangular fuzzy members or Gaussian membership functions. But most newly developed one is fuzzy inference system (FIS) which is a calculative decision making tool where both qualitative and quantitative factors are calculated in a probabilistic manner. FIS based works are not randomly used but there are some research works are available. Where there is a probabilistic result FIS are for accurate result. It is not easy to select an effective supplier because all the suppliers must be judged against some predetermined criteria. In these types of situations fuzzy inference system (FIS) is very effective because it considers the relationship between the criteria themselves; criteria and alternatives. In traditional approach all the supplier have been ranked in a fixed scale for all criteria and the supplier who achieves the highest score will be selected. But it has a serious limitation of not considering the weight of the selected criteria. To overcome this limitation Fuzzy Logic Toolbox built on MATLAB is used which provides tools to create and edit fuzzy inference systems within the framework of MATLAB. FIS utilizes the concept of fuzzy logic to transfer the expert's evaluation of these supplier selection criteria into a value which represents the acceptance probability. This developed approach considers a number of different unique criteria and the relationship between these criteria that may have significant effect on selection process and for which the chances of diverting the decision into the wrong direction which is considered as the most serious problem in the traditional approach has been eliminated.

2. Methodology

Supplier selection is the process by which the buyer identifies, evaluates and contracts with suppliers. The appropriate supplier selection is indeed a very tough job. In this paper supplier selection procedure is accomplished by completing the following steps.

2.1 Data collection

Data collection is the process of gathering information about alternative suppliers. Here both primary and secondary data are being collected. By direct interviewing, questioning some predetermined questionnaire and observing all alternative suppliers are the way followed for gathering primary data. By going through the previous history and published or unpublished reports of the suppliers, secondary data are being collected.

2.2 DoE for finding out important criteria

Design of Experiment (DoE) is a structured, organized method that is used to determine the relationship between different criteria affecting a process and the output of the process. DoE involves designing a set of ten to twenty experiments, in which all the relevant criteria are being varied systematically. The numbers of supplier evaluation criteria are being reduced by DoE according to the severity of their effect on selection process which is being done to make the process less time consuming and effective.

2.3 Measuring the acceptance probability using FIS

Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping then provides a basis from which decisions can be made. The following usual steps are being needed to accomplish for supplier selection using FIS.

- Input fuzzification: This step is to take the inputs and determine the degree to which they belong to each of the appropriate fuzzy sets by Gaussian Membership function.
- Antecedent matching: Here necessary rules have been made for supplier evaluation. Once the input has been fuzzified, the degree to which each part of the antecedent has been satisfied for each rule will be known.
- Rule fulfillment: A consequent of a rule is a fuzzy set represented by a membership function. In this step, the consequent is reshaped using a function associated with the antecedent.
- Consequent aggregation: Here all the rules have been combined in some manner in order to make a decision. Aggregation is the process by which the fuzzy sets that represents the output of each rule are combined into a single fuzzy set.
- Output defuzzification: Taking fuzzy set as input, defuzzification outputs a crisp value, which is

suitable for analysis and control. Actually acceptance probability of alternative suppliers is being calculated here.

1.4 Experimental Tools and Data

In this paper Fuzzy Logic Toolbox built on MATLAB is used which provides tools to create and edit fuzzy inference systems within the framework of MATLAB. The toolbox also provides Graphical User Interface (GUI) tools for building, editing and observing FIS in the fuzzy logic toolbox. There are five primary GUI tools: FIS Editor for displaying general information about FIS, Membership Function Editor for defining the degree of an element's membership in a fuzzy set which is being done by selecting qualitative range (worst, bad, good and best) for each supplier evaluation criteria, Rule Editor for constructing necessary supplier evaluation rules, Rule viewer for observing the changes in the result which have been occurred due to the small change in the input data and Surface viewer for showing relationship among two distinct criteria and the result, which represents the weight of those criteria.

3. Computational Study

Initially 25 different criteria have are been selected but all those criteria do not have the same effect on supplier evaluation method. By applying Design of Experiment (DoE) total number of criteria is being reduced to nine and these selected nine criteria affects the process most. This study is carried out for the supplier selection of 'Brass Metal' of RFL Industry and from previous data it is been found that there are 9 potential candidates for supplying this metal. Table1shows all the 9 selected criteria and the relative score of each candidate against these criteria which have been collected from previous data. Here 'S1' represents 'Supplier 1' and so on.

Table 1: Checklists for suppliers

Criteria	S1	S2	S3	S4	S5	S6	S7	S8	S9
Wastage	8	5	5.6	9	7.5	9	10	4	8
Ductility	10	9.5	8	7	7	7.8	9	8	8
Fluidity	7	7	9	8	6	7	6.5	9	10
Hardness	8.6	9	8	9	6	8.3	4	8	7.4
Responsiveness	7	6	7	8	7	8	7.8	9	5
Supplier Location	8	8	8	5	7	9	6	9.5	6
Technical Capabilities	7	8	7	8	9	6	7.9	7	8
Cost Effectiveness	5	7	9	6	6	8	9.2	6	7
Reputation	6	7	4	9	8	6	10	7.6	9

By using MATLAB software at first the input variables are inserted and the input variables are divided in to four ranges: Worst, Bad, Good and Best by Gaussian membership function. The input variables are the relative scores of the alternative suppliers against those selected criteria collected from previous data. Again by using the Gaussian membership the output variables which represent the process capability are being divided into seven ranges: Not Preferable (NP), Less than Equally Preferable (LEP), Equally Preferable (EP), Mutually Preferable (MP), Strongly Preferable (SP) and Very Strongly Preferable (VSP).

For calculating the acceptance probability of the alternative suppliers 65 different rules have been created and these rules are being created by establishing relations among all the selected criteria for each individual alternative supplier. The samples of rule building logics are as following:

- If (Wastage is Best) and (Ductility is Best) and (Fluidity is Best) and (Hardness is Best) and (Responsiveness is Best) and (Supplier Location is Best) and (Technical-Capabilities is Best) and (Cost_ Effectiveness is Best) and (Reputation is Best) and Then (Result is VSP)
- If (Wastage is Worst) and (Ductility is Worst) and (Fluidity is Worst) and (Hardness is Worst) and (Responsiveness is Worst) and (Supplier location is Good) and (Technical-Capabilities is Good) and (Cost_ Effectiveness is Good) and (Reputation is Good) and Then (Result is SP)

For example the relation among the scores of supplier 1 for all selected criteria will support any of the built 65 rules and thus transforming the output of that selected rule for supplier 1 into numerical value, acceptance probability will be calculated by Rule Viewer.

4. Result & Discussion

In this study nine suppliers are primarily selected to evaluate in FIS base analysis. These suppliers are evaluated on the basis of nine criteria and all these criteria do not affect the result evenly. To understand this effects surface viewer is a must. The Surface View is a three dimensional view which represents the relationship among two inputs and the results. The relation of Cost Effectiveness and Fluidity of Material with the Result is shown in Fig.1:

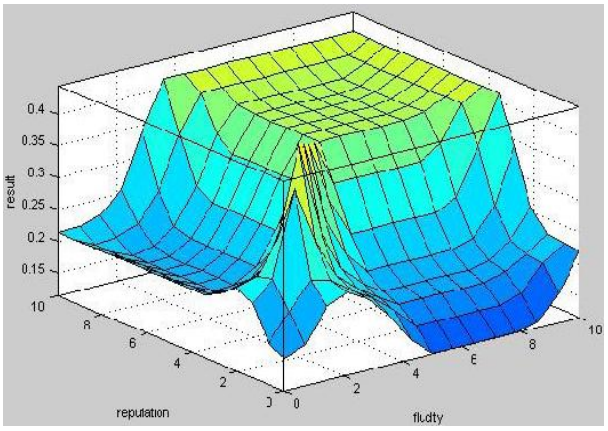

Fig.1: Surface Viewer (Cost Effectiveness and Fluidity with Result)

From the surface viewer it is seen that with the step wise increase of Cost effectiveness and Fluidity of Material, the result is also increased in ruled manner. It is also very helpful to understand the effect of a particular criteria on the result whether the effect is less or more than the other criteria.

In the Rule Viewer interface of MATLAB the score of each supplier against all the selected 9 criteria collected from previous data are put and thus the acceptance probability of all the alternative suppliers are calculated. For all the 9 suppliers the evaluation is performed by changing the value of input in the Rule Viewer interface to judge the efficiency of Rule viewer.Fig.2 is showing the Rule Viewer interface and acceptance probability which is 0.416 for supplier 1.

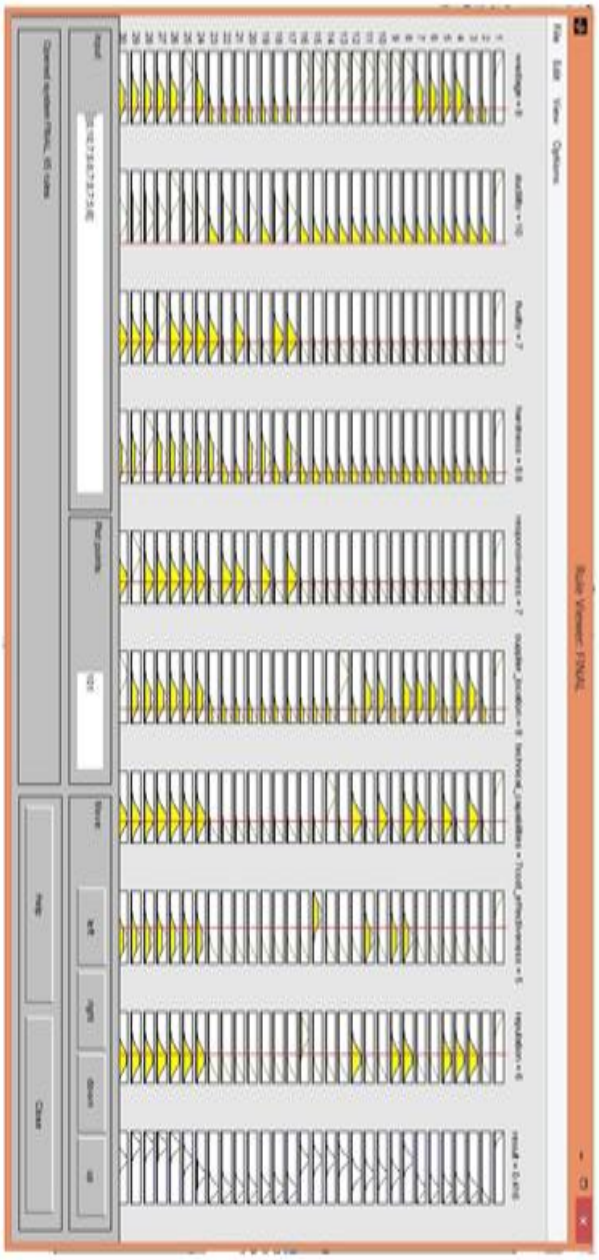

Fig.2: Rule Viewer for Supplier 1

In this study nine suppliers are selected to evaluate in FIS base analysis. Here suppliers are both judged with traditional approach and Fuzzy Inference System (FIS). The comparison between the results of these approaches is also shown. Table 2 shows the score calculated by traditional approach and acceptance probability calculated by FIS of each supplier.

Table 2: Score and Acceptance Probability of Suppliers

Supplier	Traditional Score	Acceptance Probability
S1	66.6	.416
S2	66.5	.419
S3	65.6	.430
S4	69	.492
S5	63.5	.438
S6	69.1	.488
S7	70.4	.438
S8	68.1	.487
S9	68.4	.438

In traditional system “Supplier 7” is selected for obtaining best score. In Fuzzy Inference System “Supplier 4” is selected for obtaining best acceptance probability which is .492 or 49.2%. From the research work it is become practical that there is a great variation between Traditional an FIS based work. Using FIS the calculative probability of acceptance is perfect on the basis of fuzzy logic, because these kind of qualitative factors are conveniently and correctly calculated only in Fuzzy Inference System. The rules are quite sensitive in the sense that a small amount of variance in the input will cause significantly different inference consequence, due to the crisp value. It indicates that FIS provides the facility of understanding the changes in the result by changing the value of all or some of the input variables. Traditional approach is quiet simple because here the final score of a particular supplier is the summation of the scores of that supplier against all the nine criteria. In this approach the weights of all the criteria are considered equal but it is not the true case. But FIS calculates and compares the weights of all the criteria and uses them in the calculation of acceptance probability. So the result becomes more accurate and more reliable.

5. Conclusion

Trough out this paper, an efficient approach for the evaluation technique of the best supplier selection based on readily available information and knowledge of experience is been accumulated. The developed approach considers a number of different unique factors that may have significant effect on selection process and utilizes the concept of fuzzy logic to transfer the experts’ evaluation of these factors into a value, representing the acceptance probability. The graphical

user interface (GUI) of MATLAB is used to determine the probability of acceptance for each supplier by using fuzzy logic. The works are been made more simple and attractive by the use of GUI tools. The FIS approach is been proved very efficient because it successfully considers the qualitative factors which is in linguistic form as well as quantitative factors.

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