# OPTIMIZING SUPPLIER SELECTION USING ARTIFICIAL INTELLIGENCE TECHNIQUE IN A MANUFACTURING FIRM

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**Abstract: Selection of good supplier has always been a challenge for any manufacturing company. Supplier selection is a multi-criteria decision making problem. In this competitive world, there is a need to deal with complexity and uncertainty of the problems. Artificial intelligence techniques can better deal with such situations ex. Fuzzy logic. Fuzzy logic approach can consider linguistic terms of decision makers using Fuzzy inference system (FIS). This paper concludes the effectiveness of using FIS over conventional technique and the result have been shown using a case study for a manufacturing firm.**

**Keywords: Fuzzy inference system, fuzzy logic, supplier selection**

## 1 Introduction:

In any manufacturing industry such as Machinery and plant construction, Electronics, Pharmaceuticals, Automotive, Textiles etc., out of large number of parts and components, some components are made in-house and others are procured from suppliers. In this context, supplier selection has been an important part of supply chain. Supplier selection strategy is a need for any manufacturing company. Selection of suppliers is a multi-criteria decision making. These criteria can be quantitative as well as qualitative. Dickson, 1966 [1] gave 23 criteria for supplier selection out of which 3 important factors which have been considered by many researchers for selecting a supplier are Quality, price and delivery.

Decision maker's opinion for weightage of criteria and sub-criteria during supplier selection process is considered in linguistic terms instead of numerical values [2]. Linguistic term is simple to express perceptions [2]. A Linguistic variable is a variable whose values are expressed in terms of words or sentences instead of numbers [3].

In many situations, decision problems are too complex or too ill-defined and linguistic variable is useful for such conditions. Conventional methods for supplier selection are inadequate to express linguistic terms which are imprecise or vague in nature [3]. So use of fuzzy logic, an artificial intelligence technique has increased to overcome this issue. The uncertainty in supplier selection case may arise due to vagueness, imprecision or uncertainty and fuzzy set theory is adequate to deal with them. In such cases the variable is probably fuzzy and can be represented by a membership function. Membership function defines the fuzziness in a fuzzy set irrespective of the elements in the set, which are discrete or continuous. Fuzzy set theory performs numerical computation by using linguistic labels stipulated by membership functions [3].

Since, real world problems have complexity and vagueness and AI techniques can deal such problems effectively. AI techniques are generally used for complex and uncertain problems [4, 5]. AI techniques include Genetic Algorithm, Neural network, fuzzy logic, Particle swarm optimization etc. [4]. Due to many complex and uncertain situations, researchers are integrating various techniques or using fuzzy

logic along with conventional supplier selection methods. In this paper, fuzzy logic approach using MATLAB has been used for a supplier selection case. Fuzzy logic deals with uncertainty and vagueness of the expert's opinion effectively. .

## 2 Literature review:

M. Kumar et. al., 2004 [6] used fuzzy mixed integer goal programming, J.L. Yang et. al., 2008 [7] used fuzzy AHP, D.M. Manuel et. al., 2010 [8] used fuzzy MOP and S.I. Omurca, 2013 [5] used fuzzy TOPSIS to deal with supplier selection problem. Many researchers used hybrid optimization models. M.C. Yu et. al., 2012 [9] applied fuzzy multi-objective mixed-integer programming model and fuzzy AHP, K.K. Arpan et. al., 2014 [10] used fuzzy AHP and fuzzy goal programming. Application of fuzzy logic with some techniques helps to cope with uncertainty and complexity of the situation. N. Garcia, 2013 [11] used Fuzzy Decision support system (FDSS) because of the following reasons:

1 FDSS are more intuitive and easier to implement in purchasing departments.

2 FDSS offers a robust enough behavior by allowing to mitigate certain inconveniences detected in too simple evaluation methods as those of weighing factors.

3 FDSS make it more intuitive to include knowledge in the decision process and improve its interpretation.

4 FDSS allow the uncertainty associated with certain variables to be incorporated.

Proposed approach of L. Osiro, 2014 [12] is based on fuzzy inference. Fuzzy inference system (FIS) has been implemented in MATLAB. In this paper, usefulness of FIS has been shown by comparing with conventional technique.

## 3 Case study and Results:

A fuzzy logic application have been shown for a multi-criteria supplier selection problem which considered 5 factors namely variety, quality, distance, delivery and price for a firm manufacturing agricultural and construction equipment as shown in table 1[13]. They [13] proposed weighted linear model for the case. This paper shows the effectiveness of using fuzzy logic in MATLAB to solve the supplier selection process of such case. FIS has been used in which 243 rules were provided as shown in figure 1. Triangular membership function was used for input and trapezoidal membership function for output (selection rating) as viewed in figure 2 and 3. Fuzzy logic approach is very effective using MATLAB. FIS makes the approach very effective. Once rule has been set, it is easy to use the approach by putting the inputs and getting crisp output value of different suppliers. It can be observed in figure 4 in which output value is calculated by FIS when input as crisp value is given. Supplier with highest crisp output value will be considered the best supplier. Top 5 suppliers are supplier 8, followed by 16, 10, 11 and 12 using FIS. Supplier 10 and 11 were in top 5 suppliers list using weighted linear model by [13]. Supplier 8, 16 and 12 are excellent in quality. This difference is due to different relative importance of weights using different optimization tools. But FIS is easy to use and it's a very fast process. Once rule base have been set in MALTAB, supplier selection case can be done multiple times for this particular case

| Supplier number | Supply variety (Unit) | Quality (%) | Distance (Mile) | Delivery (%) | Price index (%) |
|---|---|---|---|---|---|
| 1 | 2 | 100 | 249 | 90 | 100 |
| 2 | 13 | 99.79 | 643 | 80 | 100 |
| 3 | 3 | 100 | 714 | 90 | 100 |
| 4 | 3 | 100 | 1809 | 90 | 100 |
| 5 | 24 | 99.83 | 238 | 90 | 100 |
| 6 | 28 | 96.59 | 241 | 90 | 100 |
| 7 | 1 | 100 | 1404 | 85 | 100 |
| 8 | 24 | 100 | 984 | 97 | 100 |
| 9 | 11 | 99.91 | 641 | 90 | 100 |
| 10 | 53 | 97.54 | 588 | 100 | 100 |
| 11 | 10 | 99.95 | 241 | 95 | 100 |
| 12 | 7 | 99.85 | 567 | 98 | 100 |
| 13 | 19 | 99.97 | 567 | 90 | 100 |
| 14 | 12 | 91.89 | 967 | 90 | 100 |
| 15 | 33 | 99.99 | 635 | 95 | 80 |
| 16 | 2 | 100 | 795 | 95 | 100 |
| 17 | 34 | 99.99 | 689 | 95 | 80 |
| 18 | 9 | 99.36 | 913 | 85 | 100 |

Table 1: Measures of suppliers under criteria

Following are the advantage of using FIS over conventional approach by W.L. Ng, 2008 [13]:
1) Need not to normalize the values of criteria
2) No rank reversal occurs
3) No need to manually solve the values of criteria for getting the selection order
4) FIS helps to handle ambiguity
5) It easily consider linguistic terms of decision makers



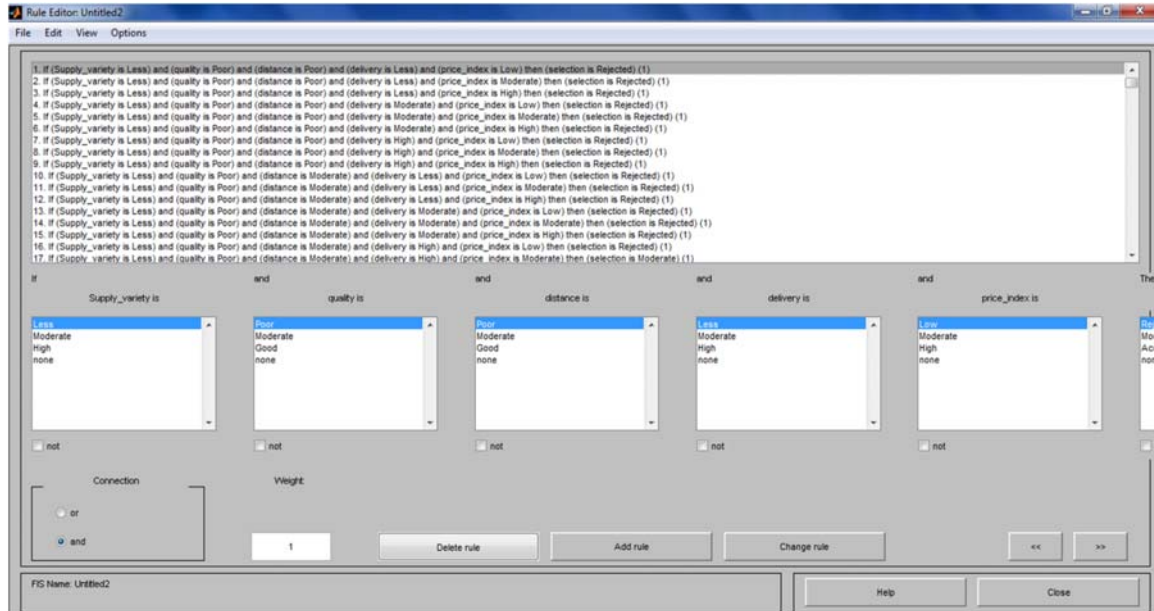Fig 1 : Rules for FIS
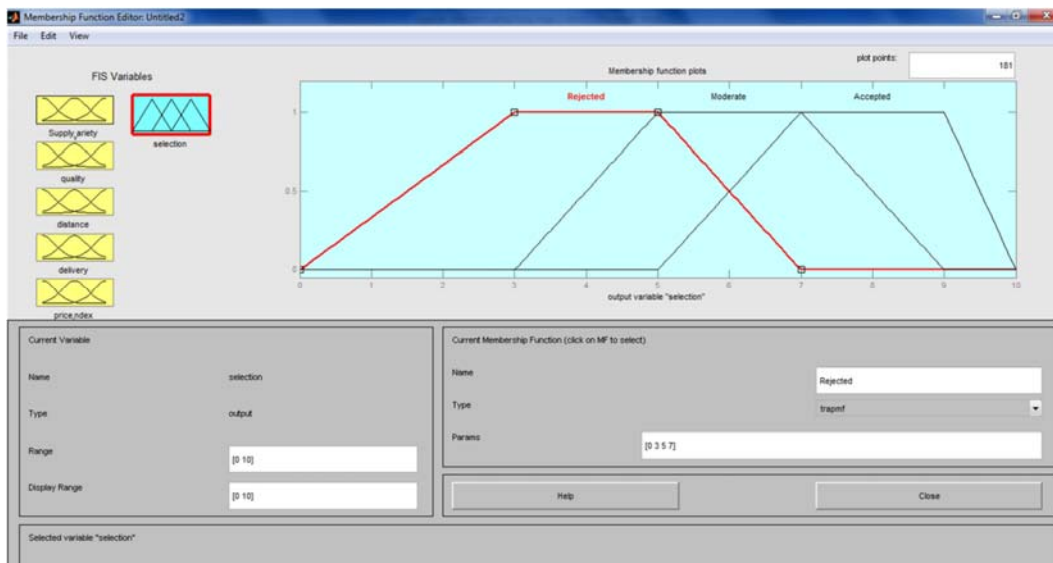


Fig 2 : Membership function for supply variety in FIS

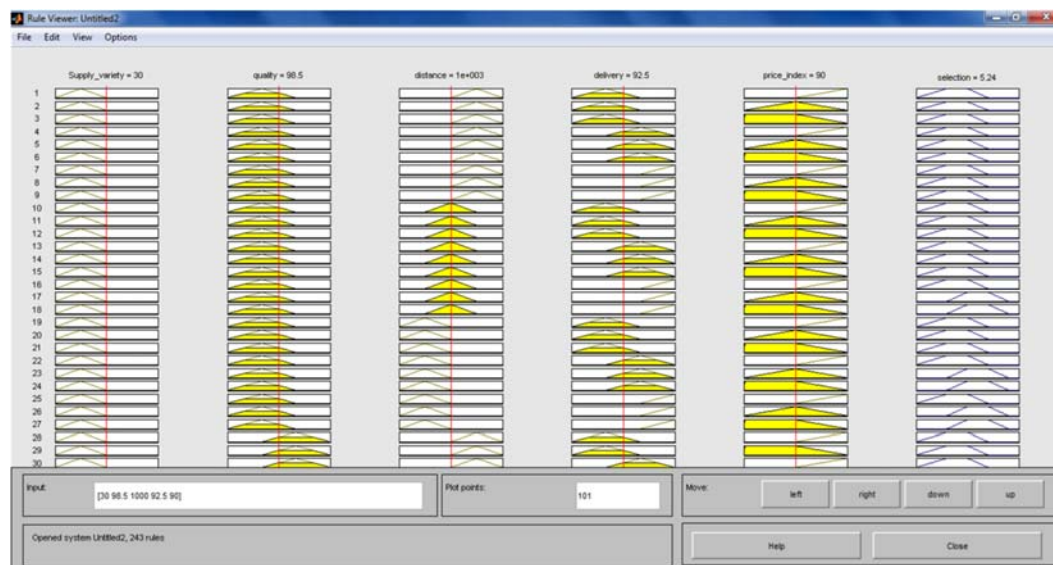Figure 3: Membership function for output in FIS



Figure 4 : Rule viewer for getting crisp output value in FIS

**4  Conclusion and scope for future research:**
Use of fuzzy logic is a need in real-world situation.  Researchers are focussing on using fuzzy logic or hybridization of fuzzy set with conventional methods.  Fuzzy logic helps to overcome the difficulty of dealing with problems having uncertainty and ambiguity.  In this paper, purpose of using of fuzzy logic in MATLAB is presented using FIS.   FIS takes the linguistic terms and finally a crisp output is obtained. Surface viewer in MATLAB shows the relation of any 2 inputs with output as shown in figure 5.

So effect of inputs on variable can be easily understood with the help of surface viewer of FIS.  Use of other intelligence techniques for supplier selection case by integrating fuzzy logic can be future research area.  In this paper, 243 rules were made for 5 inputs in FIS.  But as the number of criteria increases, many rules need to be formed which makes use of FIS very complex. So, there is a need for techniques which can consider multiple criteria for supplier selection for future research.
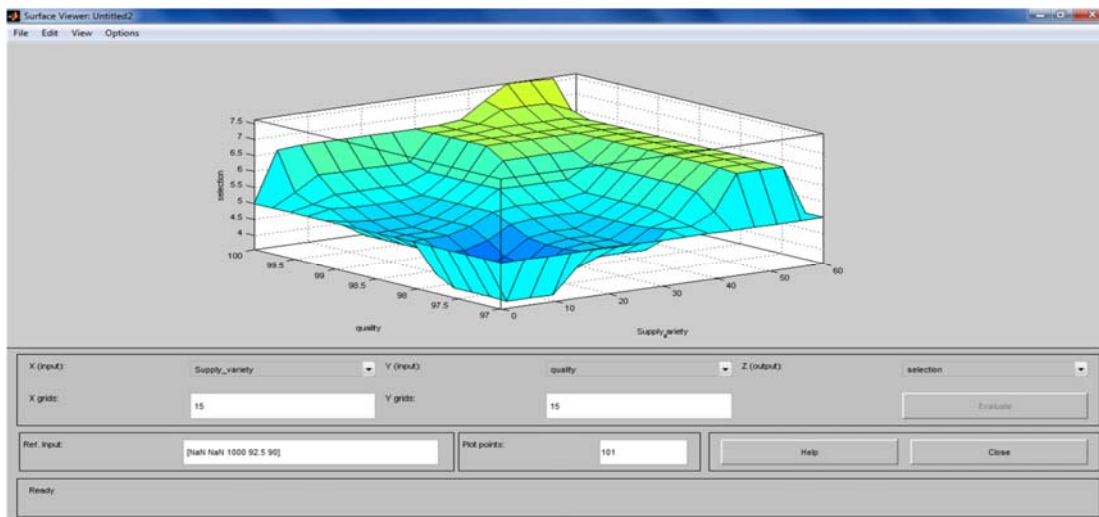
Fig 5: Surface viewer of FIS for supply variety and quality as input

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