# Prioritization of suppliers using a fuzzy TOPSIS in the context of E- Manufacturing

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**Abstract** - *E-Manufacturing is a transformation system that enables the manufacturing operations to achieve predictive near-zero-downtime performance as well as to synchronize with the business systems through the use of web-enabled and tether-free technologies. As E-manufacturing is different from traditional manufacturing by its characteristics; the supplier selection methods as well as criteria to be considered are to be reviewed. In today's competitive environment it is impossible to successfully produce low cost, high quality products with out satisfactory vendors. In supplier selection decisions two issues are of particular significance. One is what criteria should be used and other, what methods can be used to compare suppliers. There is a little consideration on Supply Chains (SC) in e-manufacturing and particularly suppliers are needed to be identified and networked. Hence the primary goal of the present research is to find the best supplier, to evaluate the suitable criteria to be considered and which method can be adopted for supplier evaluation in the context of e-manufacturing with respect to material classification. Thus at the beginning, all the needed materials and services used by the organization were identified and categorized with regard to their nature by ABC method. Afterwards, in order to reduce risk factors and maximize the organization's profit, purchase strategies are to be determined. Then, appropriate criteria are to be identified for primary evaluation of suppliers required to the organization* in *the context of E-manufacturing.*

***Key Words***: E-manufacturing, Supply Chain, ABC method, SSG (Statistical Source Group), Triangular fuzzy number.

## 1.INTRODUCTION

E-Manufacturing is a business strategy as well as a core competency for companies to compete in today's e-business environment. It is aimed to complete integration of all the elements of a business including suppliers, customer service network, manufacturing enterprise, and plant floor assets with connectivity and intelligence brought by the web-enabled and tether-free technologies and intelligent computing to meet the demands of e-business/e-commerce practices that gained great acceptance and momentum over the last decade. E-manufacturing integrates information and decision-making among data flow (of machine/process level), information flow (of factory and supply system level), and cash flow (of business system level).

### 1.1 Supplier selection-criteria

Traditionally organizations have been divided in operative functions such as production, planning, purchasing, marketing etc., in which supply chain is a strategy that integrates these functions, and also involved in manufacturing of a product from the procurement of raw materials to the distribution of final products to the clients. Hence in today's competitive environment it is impossible to successfully produce low cost, high quality product without satisfactory vendors, *Weber et al, (1991).*

In supplier selection decisions two issues are of particular significance. One is what criteria should be used and other, what methods can be used to compare suppliers. Weber (1991) pointed that supplier selection decisions were complicated by the fact that various criteria must be considered. Meanwhile, different approaches could be employed to make the selection. Weber et al. reviewed and classified 74 related articles which had appeared since 1966. Due to the economic globalization and with the development of global logistics, geographical location is no longer a major criterion in supplier selection, *Weber et al, (1991).*

### 1.2 Supplier selection under fuzzy environment

A key and perhaps the most important process of the purchasing function is the efficient selection of vendors, because it brings significant savings for the organization .While the traditional vendor evaluation methods primarily considered financial measures in the decision making process, more recent emphasis on manufacturing strategies such as just-in-time (JIT) has placed increasing importance on the incorporation of multiple vendor criteria into evaluation process. The decision makers (DMs) always express their preferences on the alternatives or on the attributes of suppliers, which can be used to help rank the suppliers or select the most desirable one in the context of E-manufacturing. Consequently, we consider supplier selection as a multiple-attribute decision-making (MADM) problem.

DM's judgments are often uncertain and cannot be estimated by an exact numerical value. Fuzzy Set Theory presents a framework for modeling the supplier selection problem in an uncertainty environment. In this theory, linguistic variables are used instead of crisp values. FST can be combined with other techniques to improve the quality of the final tools.

## 2. METHODOLOGY:

The methodology of the proposed algorithm is explained here with a hypothetical data.

Supplier is selected among five alternatives in the context of E-manufacturing by using fuzzy TOPSIS method for E-manufacturing unit of foundry type. In the beginning, an overall identification of purchasing process, its critical and reformable points were obtained by interviewing and studying all related documents. The point is that in all bids, the supplier which has offered lower price is accepted. New purchasing policies of organization are determined according to the selection of appropriate suppliers considering suitable criteria in the context of E-manufacturing. It makes the organization to decrease its tied-up capital and hence, they are interested in changing the purchasing process and use the proposed fuzzy TOPSIS method.

In methodology, the algorithm proposed in the context of E-manufacturing to select and evaluate the suppliers, is discussed. The materials classification by using the ABC analysis is discussed the detailed evaluation of fuzzy TOPSIS method is discussed here in order to compute the final score.

### 2.1 Classification of Materials

All the needed materials and services used by the organization are identified and categorized with regard to their nature into 4 main groups as below:

- Raw Materials
- Spare parts and equipments
- Consumer goods
- Services

Raw material group is chosen for examining the proposed framework. In order to make the verification practically, we have collected the data regarding the raw materials from the NELCAST company, which is the second largest foundry in India. At first we have explained the characteristics and concept of E-manufacturing to the SSG (Statistical Source Group) people of NELCAST company. SSG people provided hypothetical data regarding raw materials, annual value for purchasing materials are shown in Table-1. The annual value (in crores) for purchasing materials is $W(p)$ and the annual value portion for purchasing each material is $w(p)$.

All materials are ranked based on their annual value portions. The material with highest value portion is given rank 1 and the material with lowest value portion is given rank 9.

**Table -1:** Ranking of materials

| SL. NO. | MATERIAL GROUP | W(P) | w(p) | RANK |
|---|---|---|---|---|
| 1 | Scrap | 48.00 | 0.84302 | 1 |
| 2 | Carbon | 0.52 | 0.00927 | 5 |
| 3 | Ferro Silicon Mg | 5.94 | 0.10432 | 2 |
| 4 | Ferro Silicon | 1.26 | 0.02212 | 3 |
| 5 | Bentonite Powder | 0.72 | 0.01264 | 4 |
| 6 | Pitch Powder | 0.264 | 0.00463 | 6 |
| 7 | Calcium Carbide | 0.0096 | 0.00016 | 9 |
| 8 | Core Oils | 0.036 | 0.00063 | 8 |
| 9 | Sand | 0.18 | 0.00316 | 7 |

Based on the given data, these materials are classified into A, B and C by cumulated value portions, the result of this classification is shown in Table -2

**Table -2:** Classification of material

| MATERIAL GROUP | RANK | w^ | CLASS |
|---|---|---|---|
| Scrap | 1 | 0.84302 | A |
| Ferro Silica Mg | 2 | 0.94734 | |
| Ferro Silica | 3 | 0.96946 | B |
| Bentonite | 4 | 0.98210 | |
| Carbon | 5 | 0.99137 | C |
| Pitch Powder | 6 | 0.99600 | |
| Sand | 7 | 0.99916 | |
| Core Oils | 8 | 0.99979 | |
| Calcium Carbide | 9 | 0.99996 | |

## 2.2 Identification of Purchasing Strategy

Class A consists of Scrap, ferrosilica Mg. It indicates that 22.22% of all materials consist approximately 94.73% of total annual value that organization spends for buying them. These items are so valuable and require special care and strict control. Items in class B include 22.22% of all items and around 3.47% of total annual value, and at last items in class C, 55.55% of items and less than 2% of total annual value. For B items, moderate control should be used but C items are least important ones because of low price or low demand.

As it said, class A has too much importance and, thus, suitable strategies must be designed for managing them in the best way. Since C items have low usage value, it's more economic to make their supplier selection as simple as possible, hence the money and time spent minimum. Therefore, it's preferred to use local suppliers and short term contracts

## 2.3 Weighting the Criteria

Linguistic variables for fuzzy weighting criteria are shown in Table -3

**Table -3:** The linguistic variables for the ratings

| Linguistic Variables | Fuzzy Numbers |
|---|---|
| Very Low(VL) | (0,0,0.2) |
| Low(L) | (0.1,0.2,0.3) |
| Medium Low(ML) | (0.2,0.3,0.4) |
| Medium (M) | (0.35,0.5,0.65) |
| Medium High(MH) | (0.6,0.7,0.8) |
| High(H) | (0.7,0.8,0.9) |
| Very High(VH) | (0.8,1,1) |

The hierarchical fuzzy TOPSIS presented here has two levels. The first level consists of 5 main criteria and the second level has 10 sub-criteria. The importance weight of criteria and sub-criteria are represented in Table-4 and Table- 5 respectively.

**Table -4:** The importance weight of each criterion

| CRITERIA | WEIGHT |
|---|---|
| Quality | (0.8,1,1) |
| Delivery | (0.35,0.5,0.65) |
| Geographical Location | (0.6,0.7,0.8) |
| Communication Systems | (0.7,0.8,0.9) |
| Price | (0.35,0.5,0.65) |

As we use a triangular fuzzy number in this paper,the fuzzy number in this paper,the fuzzy weights are calculated with the respective equations.

**Table -5:** The final importance weight of each criteria

| SUB-CRITERIA | WEIGHT |
|---|---|
| Quality system certificate of supplier (QSCS) | (0.48,0.7,0.8) |
| Inspection methods & plans | (0.56,0.8,0.9) |
| Appropriateness of delivery dates | (0.21,0.35,0.52) |
| JIT Capability | (0.21,0.35,0.52) |
| Service capabilities | (0.36,0.49,0.64) |
| Ware house location | (0.21,0.35,0.52) |
| Communication capability | (0.42,0.56,0.72) |
| Advanced information &communication technologies | (0.49,0.64,0.81) |
| Approximation of market and material price | (0.12,0.25,0.42) |
| Price Deviation | (0.07,0.15,0.26) |

### 2.4. Computation of final score

There are 5 scrap potential suppliers $A_i$ (i=1,2,...,5) compared against 10 factors (defined in previous step) based on linguistic variables presented in Table-3

**Table-6:** Comparison of 5 scraps potential suppliers against 10 factors based on ratings

| C \ A | C6 | C7 | C8 | C9 | C10 |
|---|---|---|---|---|---|
| A1 | MG | VG | VG | MG | G |
| A2 | MG | VG | MG | G | F |
| A3 | G | F | MG | VG | MG |
| A4 | G | G | VG | MG | VG |
| A5 | VG | F | MG | VG | G |

| C \ A | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|
| A1 | F | MP | G | VG | F |
| A2 | G | MP | VG | F | MG |
| A3 | VG | G | F | F | VG |
| A4 | VG | G | MP | MP | G |
| A5 | F | VG | MP | VG | F |

Note: *C-CRITERION *A ALTERNATIVES

Construct fuzzy decision matrix and fuzzy weights, In order to make an easy procedure similar to *Saghafian and Hejazi*, all fuzzy numbers in our example are defined in close interval [0,1] so the normalized decision matrix is obtained directly from the fuzzy decision matrix and then Construct Weighted Normalized Fuzzy Decision Matrix. Fuzzy positive ideal solution and Fuzzy negative ideal solution is calculated by using vertex method. The final solutions are given below.

Fuzzy positive ideal solution:

$A^+$= ( (0.8,0.8,0.8), (0.9,.0.9,0.9) , (0.52,0.52,0.52), (0.52,0.52,0.52 (0.64,0.64,0.64)

, (0.52,0.52,0.52) (0.52,0.52,0.52) , (0.9,.0.9,0.9) , (0.52,0.52,0.52) (0.52,0.52,0.52) )

Fuzzy Negative Ideal Solution:

$A^-$ = ( (0.07,0.07,0.07) (0.12,0.12,0.12), (0.24,0.24,0.24) , (0.19,0.19.0.19 (0.07,0.07,0.07) ,

(0.07,0.07,0.07) , (0.14,0.14,0.14) , (0.29,.0.29,0.29), (0.07,0.07,0.07) , (0.02,0.02,0.02) )

Calculating distances between Fuzzy positive ideal solution and suppliers' ratings and in similar way the distances between Fuzzy negative ideal solution and suppliers' ratings are calculated.

Closeness coefficients between the supplier is calculated by using the following equation

$$C_{ci} = \frac{d^+_i}{d^+_i + d^-_i}$$

Where,

$$d^+_i = \Sigma^n_{j=1} \ d_i(\tilde{v}_{ij}, \tilde{v}_j^*), \quad i=1,2,....,m,$$

$$d^-_i = \Sigma^n_{j=1} \ d_i(\tilde{v}_{ij}, \tilde{v}_j^-), \quad i=1,2,....,m,$$

Based on the closeness coefficients for the five alternatives considered, the best among the five alternatives will be selected, as the higher the closeness coefficient, the best is the supplier.

In this hypothetical example, closeness coefficients ($C_c$) for the alternatives $A_1$ ,$A_2$, $A_3$, $A_4$, $A_5$ are $C_{c1}$=0.434, $C_{c2}$=0.460,$C_{c3}$=0.491,$C_{c4}$=0.493,$C_{c5}$=0.463,respectively.The prioritization of the suppliers are $A_4$,$A_3$,$A_5$,$A_2$,$A_1$ and $A_4$ is the best among all the five alternatives.

## 3. CONCLUSION

Initially, fuzzy TOPSIS method has been tested hypothetically to E-manufacturing unit of foundry type, as there is no E-manufacturing unit at present in the world, we have taken from Nelcast Ltd., with the choice of preferences given in the context of e-manufacturing and method results are tabulated in table

| | di* | di- | di* + di- | Cci |
|---|---|---|---|---|
| **A1** | 2.99 | 2.3 | 5.29 | 0.434 |
| **A2** | 2.9 | 2.48 | 5.38 | 0.460 |
| **A3** | 2.76 | 2.67 | 5.43 | 0.491 |
| **A4** | 2.7 | 2.63 | 5.33 | **0.493** |
| **A5** | 2.76 | 2.67 | 5.43 | 0.463 |

One of the strengths of the fuzzy TOPSIS method is the ability to measure the closeness coefficient Based on the closeness coefficients for the five alternatives considered ,the best among the five alternatives will be selected as the higher the closeness coefficient ,the best is the supplier.

Coming to the hypothetical example, closeness coefficients ($C_c$) for the alternatives $A_1$ ,$A_2$, $A_3$, $A_4$, $A_5$ are $C_{c1}$=0.434,$C_{c2}$=0.460,$C_{c3}$=0.491,$C_{c4}$=0.493,$C_{c5}$=0.463,respectively.The prioritization of the suppliers are $A_4$,$A_3$,$A_5$,$A_2$,$A_1$.

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