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# Evaluation of the Performance and Ranking of Suppliers of a Heavy Industry by TOPSIS Method

K Dharun Prashanth[1], P Parthiban[1]* and R Dhanalakshmi[2]

[1]National Institute of Technology, Tiruchirappalli-620015, India
[2]National Institute of Technology Nagaland, Dimapur-797103, India

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The purpose of this paper is to evaluate the performance of the suppliers of a heavy industry and to rank them based on their performance by using Multi Criteria Decision Making Tool (MCDM) – TOPSIS Method. The Criteria and Sub Criteria for the supplier performance evaluation has been decided by a team of experts from the manufacturing industry. DEMATEL is used to calculate the weightage of the criteria and TOPSIS is used to evaluate and rank the suppliers based on these criteria. This paper ranks the suppliers of the industry based on their performance. It also provides a clear picture about various factors affecting the performance of the suppliers. This research provides an insight to all the suppliers as to where they stand with respect to their performance. It helps them identify the factors in which they need to strengthen in order to improve their performance. It also provides a competitive environment for improving their performance which ultimately aids the manufacturing industry with better results from the suppliers.

**Keywords:** Supplier performance evaluation, Vendor performance, Supplier Evaluation, DEMATEL, TOPSIS, Multi Criteria Decision Making (MCDM)

## Introduction

Supplier selection and supplier performance evaluation are becoming recognized as a strategic and important component of supply chain strategy[1,2,3,7,14]. A good coordination between a manufacturer and suppliers is necessary because the failure of coordination results in excessive delays, poor-quality product and ultimately leads to poor customer services[4,5,6,8]. Since there are several factors which affects the supplier's performance, it is considered as a multi-criteria problem and it is necessary to make a trade off between conflicting tangible and intangible factors to find the best suppliers[9,10,11,12]. Multi-Criteria Decision Making (MCDM) is the most well-known branch of decision making and it support the decision makers (DMs) in evaluating a set of supplier against set of criteria[9,10,11,12,14]. This paper discusses about the evaluation and ranking of 20 suppliers of a manufacturing industry based on their performance. The performances of these suppliers are evaluated based on several criteria and sub criteria. They are classified under 3 main Criteria – Quality, Delivery and Performance History, Capacity and Capability, Responsiveness, Service, Safety and Trust.

*Author for Correspondence
E-mail: parthee_p@yahoo.com

## Methodology

This paper proposes the following methodology for evaluating the supplier performance using MCDM tools.

Step 1 - Ranking the suppliers using TOPSIS
Step 2 - Conduct Sensitivity analysis to determine the influence of criteria weights on decision making

### Identification of Criteria & Sub Criteria

In order to evaluate the performance of the suppliers of a manufacturing industry, the criteria and sub criteria were chosen by experts from the industry based their existing working environment, past experience and present business scenario. The performances of these suppliers are evaluated based on several criteria and sub criteria. They are classified under 3 main Criteria – I. Quality, Delivery and Performance History, II. Capacity and Capability and III. Responsiveness, Service, Safety and Trust. The Sub criteria chosen under the 3 main criteria are elaborated in table 1.

### TOPSIS method

TOPSIS *(the Technique for Order Preference by Similarity to Ideal Solution)* is an alternative to the ELECTRE method[13]. The basic concept of this

Table 1 — Criteria and Sub Criteria for Vendor (Performance) Evaluation

| Quality, Delivery & Performance History (QDP) | Capacity & Capability (CC) | Responsiveness, Service, Safety & Trust (RSST) |
|---|---|---|
| Quality - Product & Manufacturing | Product Range & Capacity | Discipline & Professionalism |
| Quality - Service & Working Environment | Administration Capability | Accessibility, Availability & Dependability |
| QC & QA Documentation - Certification & Validity | Technical Capability | Compliance with timeline, punctuality & rules |
| Compliance to Delivery Commitments | Financial Capability | Accidents |
| Completions - PGMA / DU / Tonnage | Infrastructure, Facilities & Layout Design | Compliance with Safety Standards & Rules |
| Past Records, Highlights, Achievements & Breakthroughs | Man Power - Skill, Qualification & Certification | Firm & Personnel Trust, Transparency with business partner |
| | Machinery, HT & NDT Facilities | Security of Materials - Risk Vendor |

method is that the selected alternative should have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution in a geometrical sense. TOPSIS assumes that each attribute has a tendency of monotonically increasing or decreasing utility. Therefore, it is easy to locate the ideal and negative-ideal solutions. The Euclidean distance approach is used to evaluate the relative closeness of alternatives to the ideal solution. Thus, the preference order of alternatives is yielded through comparing these relative distances.

**Sensitivity Analysis**

Sensitivity analysis is done in order to check the robustness of the model. It helps to determine the influence of the criteria on the decision making process. This analysis provides increased understanding of the relationships between input and output variables in the model. It helps us to identify the criteria which cause significant uncertainty in the output and therefore more focus and thrust shall be given on those criteria to increase the robustness of the model further.

## Case study

**Problem Description**

Outsourcing department in BHEL, Trichy is responsible for outsourcing various products like Pressure parts fabrication, Attachment fabrication for Shop assemblies, Part processing fabrication for Shop assemblies, Structures, Columns, Ceiling girders, Ducts, Oil Systems, Feeders, Hangers & Suspensions and other miscellaneous fabrication, punching & shearing jobs. The department functions and operates with 250 vendors located in and around Trichy. Evaluation of these vendors' performance becomes very crucial for the smooth and transparent functioning of the supply chain. This paper discusses about evaluation of 20 vendors on certain identified criteria using the MCDM tools – DEMATEL & TOPSIS.

Table 2 — Crisp Numbers

| | |
|---|---|
| Very Low importance (VL) | 0 |
| Low importance (L) | 1 |
| Equal Importance (E) | 2 |
| High Importance (H) | 3 |
| Very High Importance (VH) | 4 |

**Topsis**

In the data collection stage experts from various agencies used the crisp values mentioned in table 2 to rate the alternative with respect to various criteria and sub criteria. The decision matrix is converted to Normalized Decision Matrix. Using the Criteria Weightage from DEMATEL, Weighted Normalized Decision Matrix is computed. Then Positive and Negative Solutions are computed. Using the above values, the $Si^*$, $S_i$ & $C_i$ are computed which is used to rank the suppliers as shown in table 3.

## Results and Discussion

This paper discusses about evaluating the performance of 20 Suppliers of a manufacturing firm against a set of criteria and sub criteria using TOPSIS Method. This model has also enabled us to rank the suppliers based on their performance. The criteria and sub criteria for the supplier performance evaluation has been chosen by a team of experts from the firm. DEMATEL was used to find the weightage of these criteria and sub criteria. Using the criteria weightage from DEMATEL, the 20 suppliers were evaluated using the TOPSIS tool. As per TOPSIS methodology $Si^*$, $S_i$ & $C_i$ Values were computed for each supplier and the suppliers were ranked based on $C_i$ Values. The results shows that the suppliers V1&V6 have the highest $C_i$ value (0.642) and hence are ranked 1st amongst the 20 Suppliers. Suppliers V8 and V9 have scored the least $C_i$ value (0.505 & 0.379 respectively) and hence have been ranked the last amongst the 20 Suppliers. A graphical representation of the supplier ranking based on the $C_i$ values is shown in Figure 1.

Table 3 — $Si^*$, $S_i$ & $C_i$ Values with Vendor Ranking

| | V 1 | V 2 | V 3 | V 4 | V 5 | V 6 | V 7 | V 8 | V 9 | V 10 | V 11 | V 12 | V 13 | V 14 | V 15 | V 16 | V 17 | V 18 | V 19 | V 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Si* | 0.6655 | 0.706 | 0.7237 | 0.78701 | 0.7641 | 0.6655 | 0.7641 | 1.086 | 1.345 | 0.8979 | 0.888 | 0.724 | 0.888 | 0.7641 | 0.706 | 0.706 | 0.706 | 0.76409 | 0.7237 | 0.7237 |
| Si | 1.1928 | 1.217 | 1.2222 | 1.11015 | 1.1711 | 1.1928 | 1.1711 | 1.108 | 0.82 | 1.0692 | 1.091 | 1.222 | 1.091 | 1.1711 | 1.217 | 1.217 | 1.217 | 1.17111 | 1.2222 | 1.2222 |
| Si* + Si | 1.8583 | 1.923 | 1.9459 | 1.89716 | 1.9352 | 1.8583 | 1.9352 | 2.194 | 2.164 | 1.9672 | 1.979 | 1.946 | 1.979 | 1.9352 | 1.923 | 1.923 | 1.923 | 1.9352 | 1.9459 | 1.9459 |
| Ci* | 0.6419 | 0.633 | 0.6281 | 0.58516 | 0.6052 | 0.6419 | 0.6052 | 0.505 | 0.379 | 0.5435 | 0.551 | 0.628 | 0.551 | 0.6052 | 0.633 | 0.633 | 0.633 | 0.60516 | 0.6281 | 0.6281 |
| RANK | 1 | 2 | 3 | 5 | 4 | 1 | 4 | 8 | 9 | 7 | 6 | 3 | 6 | 4 | 2 | 2 | 2 | 4 | 3 | 3 |

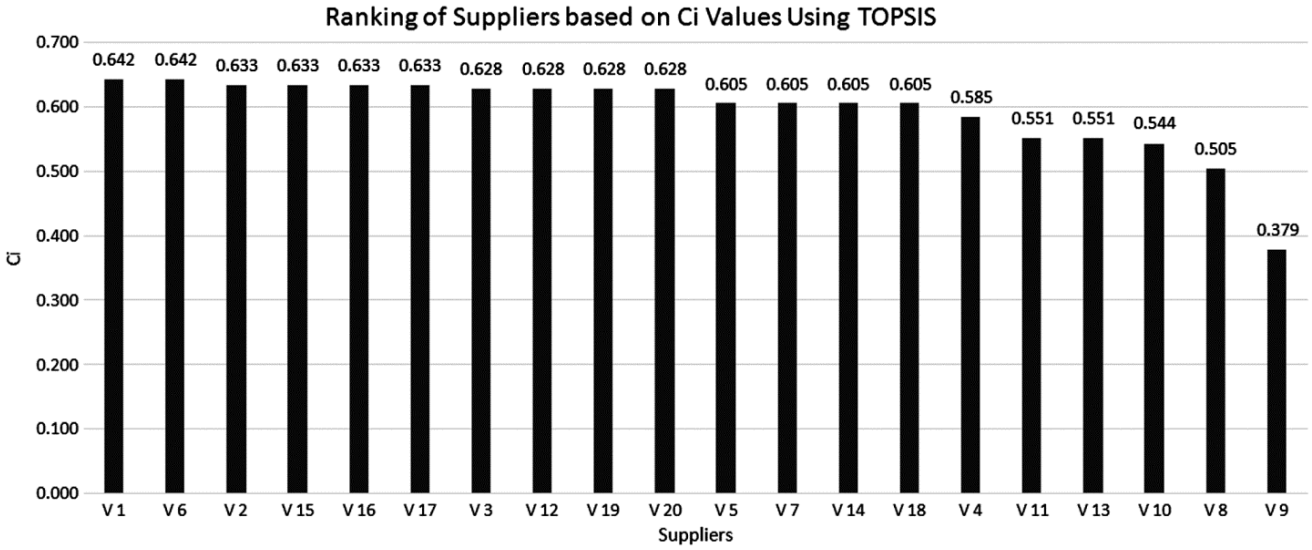


Fig. 1 — Graphical Representation of Supplier Ranking based on $C_i$ values

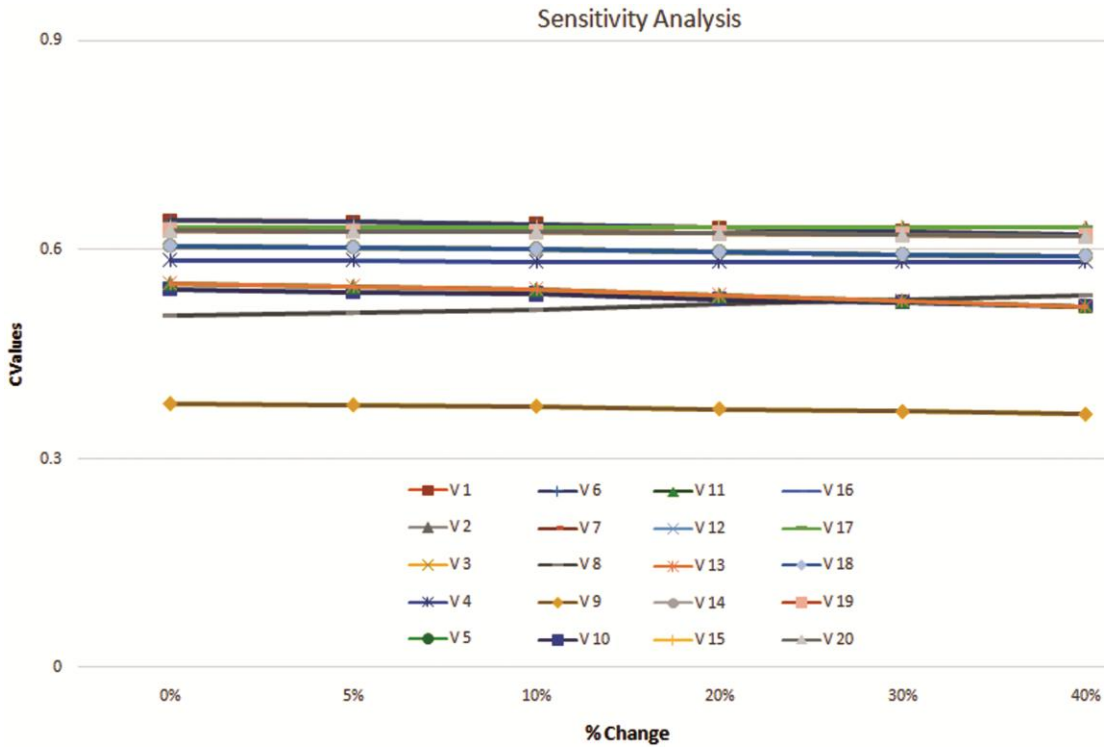


Fig. 2 — Graphical Representation of Sensitivity Analysis based on $C_i$ values

**Sensitivity Analysis**

In this paper in order to check the robustness of the model and determine the impact of the criteria on the ranking of the suppliers, sensitivity analysis is done by uniformly reducing the DEMATEL Criteria weightage value from 0% up to 40 % to determine the $C_i$ values in TOPSIS methodology. The $C_i$ values for all the suppliers corresponding to the change in DEMATEL weightage values are computed. The results are presented in graphical form in Fig 2.It is observed that the ranking of the suppliers based on $C_i$ Values is the almost the same for all the 6 experiments involving change in DEMATEL Criteria Weightage which proves that the model is robust.

## Conclusion

The objective of this research paper is to evaluate the performance of the suppliers of a manufacturing firm by integrating two of the Multi criteria decision making tools namely DEMATEL & TOPSIS. A total of 20 Suppliers were chosen at random for study purpose. The study comprises of 2 stages – Stage 1) TOPSIS was used to calculate the $C_i$ values for the 20 suppliers based on which the suppliers were ranked. DEMATEL was used to calculate the Criteria weightage. Stage 2) Sensitivity Analysis was conducted in order to determine the robustness of the model and also to determine the impact of the criteria on the supplier performance. The results shows that the suppliers V1&V6 were ranked 1$^{st}$ amongst the 20 suppliers and the suppliers V8 and V9 were ranked the least amongst the 20 suppliers.

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