# Selection of Supplier's Criteria by Using Interpretive Structural Modeling

Rachit Kumar Verma[1], Manish Kumar Sagar[2]
[1,2]*Department of Mechanical engineering, Madhav Institute of Technology and Science Gwalior M.P-474005, India*
Rachit_kr_verma@ymail.com
Manishsagar@gmail.com

*Abstract-*

**In the rapid changing business there is a need of developing their original strength to outlive under the complicated and unrest business environment. Supplier selection is a key to success of fast moving business organization. The objective of this paper is an approach for selection of best supplier by tracing the dynamics between supplier selection criteria's (SSCs). Developing interpretive structure modeling (ISM) methodology, the research presents mutual relationships among SSCs. ISM is a method that uncertain and poorly pronounced mental prototypes of systems into noticeable well-defined models useful for various purposes. The paper suggests a calculated explanation created on interpretive structural modeling and graph theory matrix to control selection of criteria index for supplier. This paper is also helpful to understand mutual influences of criteria's and to identify those criteria's which support driving criteria and also those criteria's which are most influenced by dependent criteria. The criteria are grouped as drivers, enablers and dependents and the hierarchically structured. An execution of such model can help the manufacturing organization to grow and survive in the fast moving environment.**

*Keyword-* **Supplier selection criteria's; Interpretive structural modeling; Driving power; Dependence power**

## I. INTRODUCTION

Supply chain management is very crucial part of any organization for their existence in rapid changing developing business policies. Supply Chain management grows weak when any one interaction efforts to enhance its own profit without taking attention for extra adjacent or semi-adjacent performer in supply chain. Supplier selection is a part of supply chain, without selection of honest supplier, supply chain cannot be survived. Therefore supplier selection is very critical issue in between practitioners and researchers. Developing a supplier selection is based on basis of different criteria's. There are many quality criteria's for developing a successful supplier. The purpose of this paper is to improve the relationships among the identified criteria's using interpretive structural modeling (ISM) and on the basis of driving power and dependence power these criterion are classified. At present, the supplier selection study is very popular in the world and it mainly includes two parts: the study of attribute system for vendor selection and the study of approaches for vendor evaluation (Liu, 2007). The selection of best criteria's is a key component for developing a successful supplier because it reduces price, increases quality, increases profit, reduces delivery time, increases performance of the product. The supplier selection is simple process if there is only single criteria is used in decision making process of supplier selection. There are several criteria's are used for supplier selection and makes more complex process. It is more difficult to take all the criteria's for supplier selection therefore researcher find a new way to solve this problem of selection of criteria for an organization by using interpretive structural modeling(ISM). Many analytical models have been proposed for supplier selection. However, interpretive structural modeling (ISM) for supplier selection has arrived at a score value, which is an objective value, used for comparisons among different supplier's selection criteria. The ideas from crowd of specialists are used in raising the relationship matrix, which was later used in the progress of the interpretive structural modeling model. The model has been considered manufacturing organization in India. This paper attempts to use our generic model to select the right suppliers for manufacturing organization's by identifying the criteria's which influence the supplier selection.

## II. LITERATURE REVIEW

If only single criteria was used in the decision making process the supplier selection would be simple. Excess of supplier should be available for the nonstop supply of product in the supply chain. To guarantee the conference of appropriate quality standards for all the incoming products, periodic evaluation of supplier's quality is carried out and the essential requirements supported for supplier's selection are quality, price, delivery and flexibility (Y.P. and Hung, 1997). The process for supplier selection in reality is a puzzle solving procedure, which covers the work of problem definition, formulation of criteria, qualification and choice (Koul, 2011). At present, the supplier selection study is very noted concept in the world and it mainly includes two parts: the study of characteristic system for supplier selection and the study of approaches for supplier diagnosis (Liu, 2007). The frontier of a supply chain, suppliers act as a key component for success because the right suppliers reduces costs, increases profit margins, improves component quality and ensures timely delivery (Lei Li, 2009). There are ranges of criteria in making their decisions during supplier selection. If several criterion are used then it is necessary to find how far each criterion influences the decision making process, whether all are to be equally weighted or the effect varies according to the type of criteria (Yahya, 1999). Supplier Selection is dealing with

various criterions which can be applied in a manufacturing organization to best leverage this resource internally and externally for selecting a suitable supplier. The concept of supplier selection is discovered by Dickson in 1966. The work of Dickson (1966) was one of the original works in the supplier selection area. Selecting the appropriate supplier is always a cumbersome task for manufacturing organizations due to various criteria are discovered in manufacturing organization. Because of this researcher discovered an easy way of selection of criteria for supplier selection. Selecting the appropriate proposal submitted by various suppliers is an important component of production and logistics management in many companies and it is further complicated by the fact that individual suppliers may have different performance characteristics for different criteria (Kirytopoulos, 2008). Researcher intellectualizes a typical supply chain of any organization as shown in Figure 1.

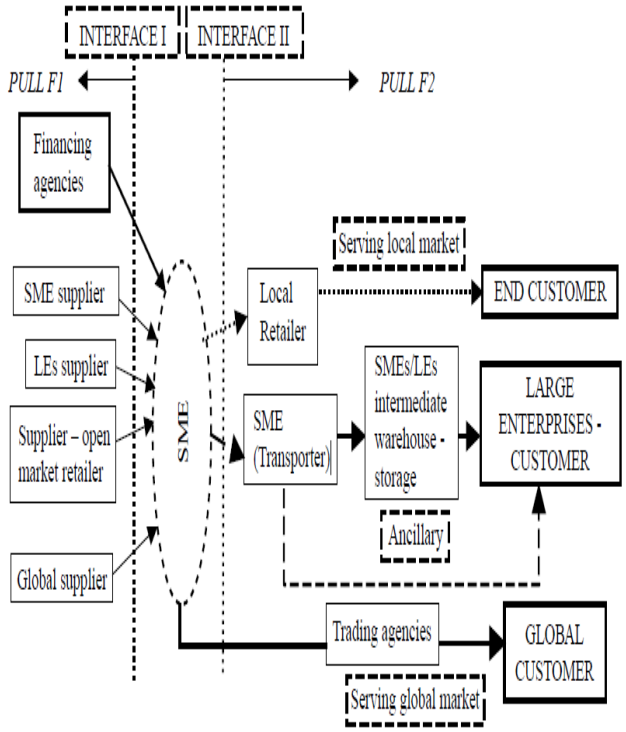


Fig. 1- Typical supply chain (S.G. Deshmukh, 2007)

## III. Interpretive Structural Modeling (ISM)

The concept of interpretive structural modeling was first discovered by J. Warfield in 1973. Warfield suggested ISM due to evaluate the complex socio-economic systems. ISM has become, since its invention in 1972, a powerful tool useful for people manipulative systems. Warfield (1982b) has described ISM as "a computer-aided education method that permits an individual or a group user to change a structure or plot viewing inter relations among formerly determined criteria according to a selected appropriate relationship". A set of different directly and indirectly related criteria are structured into an inclusive systematic model. ISM is explanatory as based on group decision and conclusion whether and how the system's criteria are connected (M.D. Singh, 2008). It is organizational as created on the connection's foundation and final structure is demoralized from difficult set of system's criteria. The ISM process transforms unclear, poorly articulated mental models of systems into visible, well-defined models useful for many purposes (A. P. Sage, 1977). ISM is explanatory as the decision of the group decides whether and how the variables are related. It is a modeling technique as the specific relationships and overall structure are portrayed in a graphical model. It has been used for over 28 years to understand complex situations and find solutions to complex problems. The various steps involved in the ISM technique are:

1. Detecting criteria which are related to the problem this could be done by survey;
2. Establishing a circumstantial relationship between criterion with respect to other criterion would be studied;
3. Emerging a structural self-interaction matrix (SSIM) of criteria which shows relationship between criteria;
4. Developing a reachability matrix from the SSIM, and testing the matrix for transitivity - transitivity of the circumstantial relation is a basic statement in ISM which states that if criteria A is related to B and B is related to C, then A is related to C;
5. Partitioning of the reachability matrix into different levels;
6. Based on the relationships given above in the reachability matrix, drawing a directed graph (digraph), and removing the transitive links;
7. Converting the resultant digraph into an ISM-based model by replacing criteria nodes with the statements;
8. Reviewing the model to check for conceptual inconsistency and making the necessary modifications.

After literature review and expert opinion of the survey response from organization following 15 criteria has been identified. The literature review, together with the experts' opinion, was used in developing the relationship matrix, which is later used in the development of an ISM model.

### *A. Criteria*

1. Quality;
2. Price;
3. Delivery;
4. Flexibility;
5. Warranties;
6. Capacity;
7. Customer services;
8. Financial position;
9. No of employees;
10. Geographical location;
11. Performance history;
12. Communication;
13. Technical capability;
14. Responsiveness;
15. Management & organization.

In the beginning a members of group of experts was assembled from Industries. ISM methodology is intelligence process by the experts using different methods for developing circumstantial relationship between different supplier selection criteria. For examining the criteria, the following four symbols have been used to denote the direction of relationship between criteria (i and j). V - Criteria i will help to achieve Criteria j; A - Criteria j will help to achieve Criteria i; X - Criteria i and j will help to achieve each other; O - Criteria i and j are unrelated.

TABLE I.
STRUCTURAL SELF-INTERACTION MATRIX

| Cr. no | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | X | X | V | X | V | O | V | V | V | O | V | V | X | V | V |
| 2 | X | X | V | V | V | O | V | X | V | V | O | V | X | V | V |
| 3 | A | A | X | X | O | V | V | A | A | V | V | V | V | V | A |
| 4 | X | A | X | X | V | V | V | X | V | O | O | V | X | X | V |
| 5 | A | A | O | A | X | O | V | A | O | O | O | O | V | V | X |

*a)The reachability matrix*

The converted ISM matrix into binary matrix (criteria are 0 and 1) (Vittal, 2005). The ISM has been converted into a binary matrix, called the initial reachability matrix by putting V, A, X and O by 1 and 0 as per given case (M. D. Singh, 2008). The replacement of 1s and 0s are as per the following rules:

If the (i, j) entry in the ISM is V, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0;

If the (i, j) entry in the ISM is A, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1;

If the (i, j) entry in the ISM is X, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 1;

If the (i, j) entry in the ISM is O, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 0.

TABLE II
REACHABILITY MATRIX

| Cr no | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Dri. P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 13 |
| 2 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 13 |
| 3 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 9 |
| 4 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 12 |
| 5 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 5 |
| 6 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 7 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 6 |
| 8 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 12 |
| 9 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 10 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 5 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 4 |
| 12 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 7 |
| 13 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 8 |
| 14 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 8 |
| 15 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 5 |
| Dep. P | 4 | 4 | 7 | 7 | 6 | 6 | 10 | 8 | 9 | 8 | 8 | 10 | 12 | 11 | 14 | |

*b) Level partition*

From the final reachability matrix, the reachability and antecedent set for each barrier is found (J. Warfield, 2005). The reachability matrix consists of the criteria itself and the other criteria which it may help achieve, whereas the antecedent set consists of the criteria itself and the other criteria which may help in achieving it. Thereafter, the intersection of these sets is derived for all the criteria. The criteria's for which the reachability and the intersection sets are the same occupy the top level in the ISM hierarchy. The top-level criteria in the hierarchy would not help achieve any other criteria above its own level. Once the top-level criteria are identified, it is separated out from the other. This process is continued until the level of each criterion is found. These levels help in building the diagraph and the final model.

TABLE III.
LEVELS OF SUPPLIER SELECTION PROCESS CRITERIA

| Cr. no | Reachability | Antecedent | Intersection | Level |
|---|---|---|---|---|
| 1 | 1,2,3,4,5,7,8,9,11,12,13,14,15 | 1,2,4,13 | 1,2,4,13 | I |
| 2 | 1,2,3,4,5,7,8,9,10,12,13,14,15 | 1,2,8,13 | 1,2,8,13 | I |
| 3 | 3,4,6,7,10,11,12,13,14 | 1,2,3,4,8,9,15 | 3,4 | V |
| 4 | 1,3,4,5,6,7,8,9,12,13,14,15 | 1,2,3,4,8,13,14 | 1,3,4,8,13,14 | III |
| 5 | 5,7,13,14,15 | 1,2,4,5,8,15 | 5,15 | XI |
| 6 | 6,7,8,10,11,13,15 | 3,4,6,9,12,14 | 6 | VIII |
| 7 | 7,8,9,10,12,15 | 1,2,3,4,5,6,7,11,12,15 | 7,12,15 | X |
| 8 | 2,3,4,5,8,9,10,11,12,13,14,15 | 1,2,4,6,7,8,9,13 | 2,4,8,9,13 | II |
| 9 | 3,6,8,9,10,11,12,13,14,15 | 1,2,4,7,8,9,13,14,15 | 8,9,13,14,15 | IV |
| 10 | 10,12,13,14,15 | 2,3,6,7,8,9,10,14 | 10,14 | XI |
| 11 | 7,11,14,15 | 1,3,6,8,9,11,12,13 | 11 | XIII |
| 12 | 6,7,11,12,13,14,15 | 1,2,3,4,7,8,9,10,12,14 | 7,12,14 | IX |
| 13 | 1,2,4,8,9,11,1 | 1,2,3,4,5,6,8, | 1,2,4,8,9,13 | VII |

| | | | | |
|---|---|---|---|---|
| | 3,15 | 9,10,12,13,14 | | |
| **14** | 4,6,9,10,12,13,14,15 | 1,2,3,4,5,8,9,10,11,12,14 | 4,9,10,12,14 | VI |
| **15** | 3,5,7,9,15 | 1,2,4,5,6,7,8,9,10,11,12,13,14,15 | 5,7,9,15 | XII |

The variables are classified into four clusters. The first cluster consists of the autonomous variables that have weak driver power and weak dependence. These variables are relatively disconnected from the system, with which they have only few links, which may be strong. Second cluster consists of the dependent variables that have weak driver power but strong dependence. Third cluster has the linkage variables that have strong driving power and also strong dependence. These variables are unstable in the fact that any action on these variables will have an effect on others and also a feedback on themselves. Fourth cluster includes the independent variables having strong driving power but weak dependence. It is observed that a variable with a very strong driving power called the key variables, falls into the category of independent or linkage variables. In this table, an entry of 1' along the columns and rows indicates the dependence and driving power, respectively. Subsequently, the driver power dependence diagram is constructed.

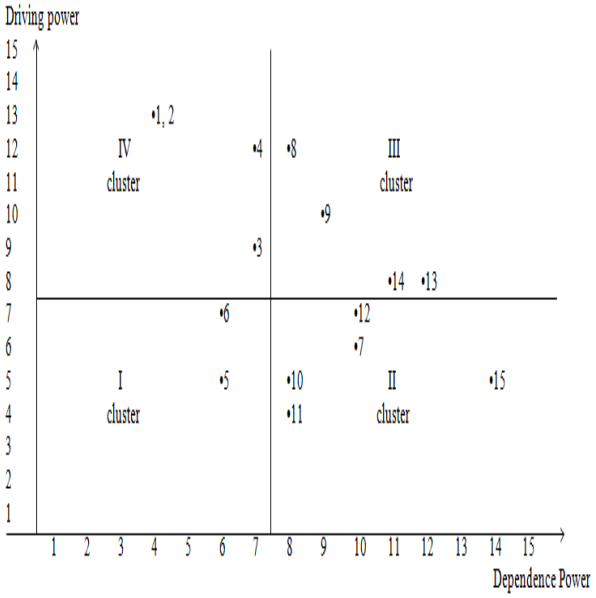


Fig 2. Cluster of criteria

*c) Formation of ISM based model*

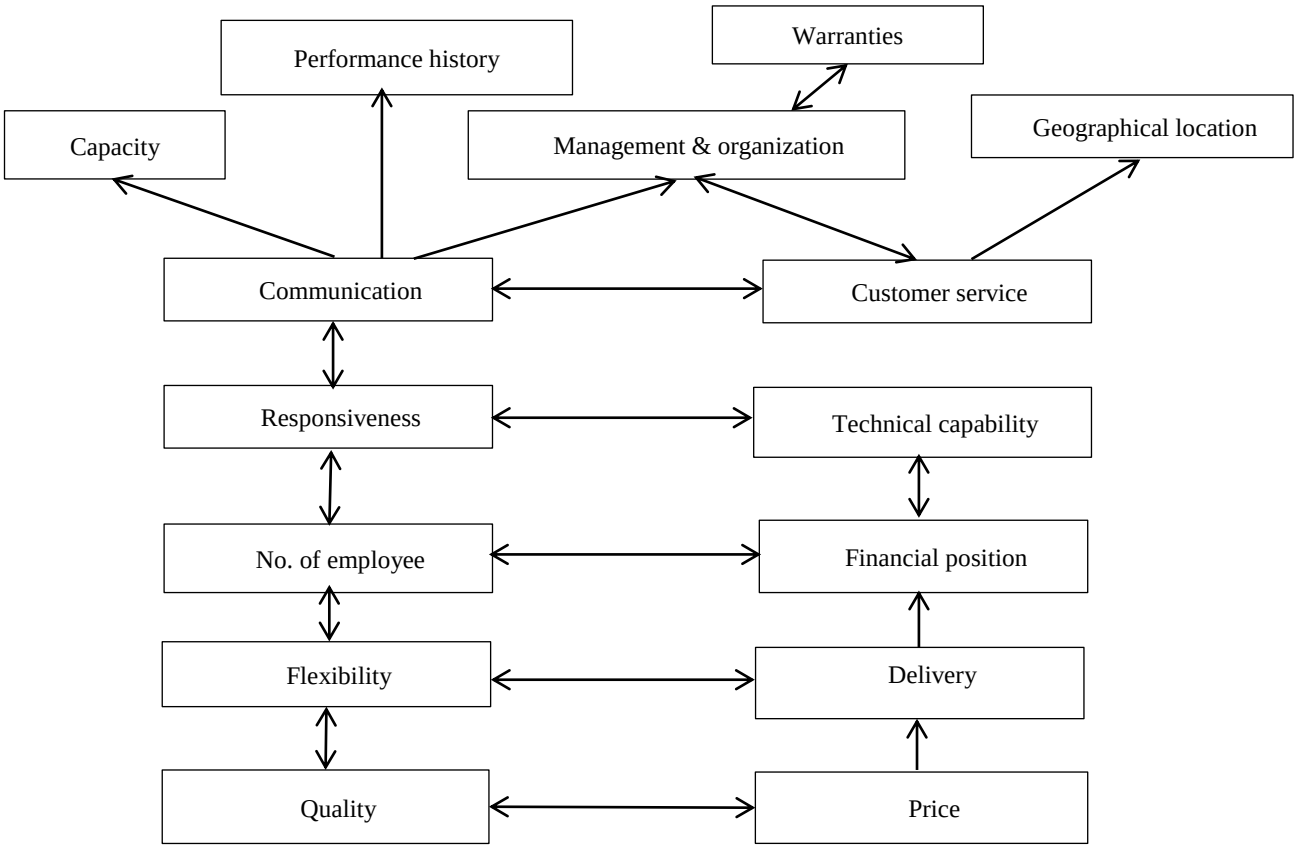


Fig.3. Interpretive Structural Modeling

From the final reachability matrix, the structural model is generated. If the relationship exists between the variables j and i, an arrow pointing from i to j shows this. This resulting graph is called a digraph. The digraph is finally converted into the ISM model.

## IV. Conclusion

The levels of criteria's are important in ISM model process. It can also be observed from fig. 1 that four criteria namely quality, price delivery and flexibility have high driving power and low dependence power. Therefore these criteria are treated as main criteria in supplier selection. On the basis of above researcher conclude that all the fifteen criteria are important for the purpose of successful selection of supplier. In this research only fifteen criteria have been used for the development of ISM model, but more supplier selection criteria can be included to develop the relationship among them using the ISM methodology. This research is beneficial in supply chain of manufacturing organization for selection of supplier by selection of criteria. This study gives knowledge of criterion and importance of each criterion for selection of supplier. Interpretive structural modeling gives the importance of each criterion on the basis of relation among them. Further research, there is a huge scope of ISM in the field of supplier selection criteria for different manufacturing organization.

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