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# SUPPLIER SELECTION PROCESS ENABLERS: AN INTERPRETIVE STRUCTURAL MODELING APPROACH

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**Abstract-** The objective of this paper is to present an approach for successful supplier selection process by understanding the dynamics between Supplier selection process enablers (SSPEs). Using Interpretive structure modeling (ISM) methodology, the research presents a Hierarchy-based model and mutual relationships among SSPEs. The paper also shows that there is a group of SSPEs having a high driving power & low dependency and high dependency & low driving power. This categorization acts as a useful tool for Managers to differentiate between independent and dependent SSPEs which ensures the selection of suitable supplier by focusing on the key enablers.

**Keywords -** enabler, driving power, dependency power, interpretive structural modeling

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## I. INTRODUCTION

In the globalization of business, organizations are more focused on developing their core competencies to survive under the complex and turbulence business environment. Hence, Supplier Selection has become the critical issue among the practitioners and researchers. The process for supplier selection is indeed a problem-solving process, which covers the work of problem definition, formulation of criteria, qualification and choice [1]. At present, the vendor (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 [2]. The frontier of a supply chain, suppliers act as a key component for success because the right choice of suppliers reduces costs, increases profit margins, improves component quality and ensures timely delivery [3].

The supplier selection process would be simple if only one criterion was used in the decision making process. There are ranges of criteria in making their decisions during supplier selection. If several criteria are used then it is necessary to determine how far each criterion influences the decision making process, whether all are to be equally weighted or whether the influence varies accordingly to the type of criteria [4]. In order to ensure the uninterrupted supply of items in a Supply Chain, more than one supplier or supplier should be available for each item. Periodic evaluation of supplier's quality is carried out to ensure the meeting of relevant quality standards for all the incoming items, and the essential requirements advocated for suppliers' selection are quality, cost, delivery, flexibility, and response [5]. Supplier Selection is dealing with various enablers which can be applied in an organization to best leverage this resource internally and externally for selecting a suitable supplier. The concept of Supplier Selection is

not a new one but there is no clear guideline on its - implementation in the organizations. Selecting the suitable supplier is always a difficult task for organizations. Selecting the best offer 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 [6].

The identification of SSPEs plays an important role in the success of Supplier Selection.

## II. SUPPLIER SELECTION PROCESS ENABLERS

SSPEs are critical success factors which allow for selecting a suitable supplier in organization, have been identified from various authors who have researched and written directly and indirectly on this issue.

### A. Top management commitment:

Senior managers actively encourage change and implement a culture of trust, involvement and commitment in moving towards "best practice" [7-14].

### B. External environment:

From the conventional viewpoint, cost is the predominant criterion for buyers in the decision-making process because keen competition forces organizations to do their best to reduce purchasing costs. Along with the development of economic globalization and management internationalization, the market competition has become intensified day by day. [10, 12, 14, 15]

*C. Long term strategic goals:*

Long-term and trust-based relationships and win-win partnerships must be based on the agreed rules for sharing risks and benefits, rather than price-based competition for good supply chain management practices [7-11],[14, 15, 16, 17]

*D. Training:*

Management should provide proper training to cultivate individual's competence and develop proficient employees to work within a supply chain philosophy [9].

*E. Information Technology:*

The technology needed to promote and support change may be large or small, strategic or operational – but, used appropriately, it offers the chance to improve the supply chain in order to increase productivity and profitability [6-12], [16,18]

*F. Network relationship:*

Network can be considered as the chain of organization operating within the same market to satisfy a variety of customers and coordination of customers, suppliers, manufactures result in improved Supplier selection process [6, 7, 9, 12, 13, 19, and 20]

*G. Supplier involvement:*

The enterprise should let supplier participate in the design process of evaluation as far as possible. Information provides real time for communication and real time transactions thereby making the principle of developing relationships with the customers much easier than ever before [9-11], [20].

*H. Information sharing:*

Information provides real time for communication and real time transactions thereby making the principle of developing relationships with the customers much easier than ever before. Supply chain encompasses all activities associated with the flow and transformation of goods from the raw material stage (extraction), through to the end user as well as all information flows [7-9],[11,12,20].

*I. Vendor managed inventory:*

The company has adopted and continues to refine the concept of jointly managed inventory, a variant of vendor-managed inventory that involves sharing inventory risks with dealers [18, 19].

*J. Innovative design:*

Deploying global supply chain innovations poses many challenges because of regulatory, normative and cultural elements of the international relationship. Quality and low cost have been served by a policy of global sourcing and innovative product design [6,7,10, 12, 14,16,17,21].

*K. Agility:*

Agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile marketplace [8, 11 and 12].

*L. Service quality:*

Develop and validate a supplier selection construct and demonstrate that underlying the documented supplier selection criteria there is need to assess a supplier's quality and service capabilities as well as its strategic and managerial alignment with the buyer [10,20,22].

Based on the literature review, the authors have identified twelve SSPEs to supplier selection process in the organization (see Table I). The aim of this paper is to develop the relationships among the identified SSPEs using ISM and classify these SSPEs depending upon their driving and dependency power. These SSPEs are derived from various literature sources and expert's discussion. Some are extracted from the work of those who have explored supplier selection process in detail. In addition, they have also been mentioned in the literature directly or indirectly with a mixed extent of emphasis and coverage.

### III. ISM METHODOLOGY AND MODEL DEVELOPMENT

The ISM process transforms unclear, poorly articulated mental models of systems into visible, well-defined models useful for many purposes [23]. A set of different directly and indirectly related variables are structured into a comprehensive systemic model. The model so formed portrays the structure of a complex issue, a system of a field of study, in a carefully designed pattern implying graphics as well as words. ISM is interpretive as the judgment of the group decides whether and how the variables are related. It is structural as on the basis of relationship, an overall structure is extracted from the complex set of variables. It is a modeling technique as the specific relationships and overall structure are portrayed in a graphical model. The various steps involved in the ISM technique are:

1. Identification of variables which are relevant to the problem or issues – this could be done by survey;
2. Establishing a contextual relationship between variables with respect to which pairs of variables would be examined;
3. Developing a structural self-interaction matrix (SSIM) of variables which indicates pair-wise relationship between variables of the system;
4. Developing a reachability matrix from the SSIM, and checking the matrix for transitivity – transitivity of the contextual relation is a basic assumption in ISM which states that if variable 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 variable nodes with the statements; and
8. Reviewing the model to check for conceptual inconsistency, and making the necessary modifications

The various steps, which lead to the development of ISM model, are illustrated as given below.

#### A. Structural Self-Interaction Matrix (SSIM)

ISM methodology suggests the use of expert opinions based on management techniques such as brain storming, nominal group technique, etc in developing the contextual relationship among the enablers. Group of experts, four each from industries and academics were consulted in identifying the nature of contextual relationships among the SSPEs. For analyzing the enablers following four symbols have been used to denote the direction of relationships between enablers (i and j):

V for the relation from i to j;

A for relation from j to i;

X for both direction relation from I to j and j to i; O if the relation between enablers are not valid.

Based on contextual relationships, the SSIM is developed (see Table II)

#### B. Reachability Matrix

The SSIM has been converted into a binary matrix, called the initial reachability matrix as shown in Table 4 by substituting V, X and O by 1 and 0 as per given case. The substitution of 1s and 0s are as per the following rules:

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

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

Since, there is no transitivity in this case; hence initial reachability matrix (see Table III) will be used for further calculations. The driving power and dependence power is shown in Table III. The driving

power for each enabler is the total number of SSPEs (including itself), which it may help achieve. Dependence is the total number of SSPEs (including itself), which may help achieving it.

TABLE I  
SUPPLIER SELECTION PROCESS ENABLERS

SSPEs Number	SSPEs Description	References
1.	Top Management Commitment	[7-14]
2.	External Environment	[10], [12], [14],[15]
3.	Long Term Strategic Goals	[7-11], [14-17]
4.	Training	[9]
5.	Information Technology	[6-12],[16], [18]
6.	Network Relationship	[6],[7],[9],[12],[13],[19],[20]
7.	Supplier Involvement	[9-11],[20]
8.	Information Sharing	[7-9],[11],[12],[20]
9.	Vendor Managed Inventory	[18],[19]
10.	Innovative Design	[6],[7],[10],[12],[14],[16],[17],[21]
11.	Agility	[8],[11],[12]
12.	Service Quality	[10],[20],[22]

#### C. Level Partitions

From the final reachability matrix, the reachability and antecedent set for each SSPEs are found [24]. The reachability set consists of the SSPE itself and the other SSPEs which it may help achieve, whereas the antecedent set consists of the SSPE itself and the other SSPEs which may help in achieving it. Thereafter, the intersection of these sets is derived for all the SSPEs. The SSPEs for whom the reachability and the intersection sets are same, occupy the top level in the ISM hierarchy. The top-level SSPE in the hierarchy would not help achieve any other SSPE above its own level. Once the top-level SSPE is identified (see Table IV), it is separated out from the

other SSPEs. Then, the same process is repeated to find out the SSPEs in the next level. This process is continued until the levels of each SSPE are found out. These levels (see Table V) help in building the diagraph and the final model of ISM.

**IV. CLASSIFICATION OF ENABLERS**

Enablers have been classified, based on their driving power and dependence power, into four categories as autonomous, dependent, linkages, and independent SSPEs. The above classification of enablers is similar to the classification used by Mandal and Deshmukh [25]. The driving power and dependence power diagram for SSPEs are shown in Fig. 1. It is observed that SSPE 5 has a dependence power of 5 and a driving power of 8 and therefore, it is positioned at a place which corresponds to a dependence power of 5 and a driving power of 8 in Fig. 1. The objective behind the classification of SSPEs is to analyze the driving power and dependence power of the SSPEs. In this classification of SSPEs, the first cluster is of autonomous SSPEs that have a weak driving power and weak dependence power. Autonomous SSPEs are relatively disconnected from the system, with which they have only few links may not be strong. The second cluster consists of dependent SSPEs that have weak driving power and strong dependence power. Here we have enablers 7,8,9,10,11 and 12 in the category of dependency enablers.

**TABLE II  
STRUCTURAL SELF-INTERACTION MATRIX (SSIM)**

Number /SSPEs	12	11	10	9	8	7	6	5	4	3	2
1. Top management commitment	v	v	v	v	v	v	v	v	v	v	o
2. External environment	v	v	v	v	v	v	v	v	v	v	v
3. Long term strategic goals	v	v	v	v	v	v	v	v	v	v	v
4. Training	v	v	v	v	v	v	v	v	x		
5. Information technology	v	v	v	v	v	v	v				
6. Network relationship	v	v	v	v	v	v					
7. Supplier involve	v	v	v	x	x						

Number /SSPEs	12	11	10	9	8	7	6	5	4	3	2
8. Information sharing	v	v	v	x							
9. Vendor management inventory	v	v	v								
10. Innovative design	x	x									
11. Agility	x										
12. Service quality											

The third cluster consists of linkage SSPEs that have strong driving and dependence power. Linkage SSPEs are unstable in nature and any change occurring to any of SSPEs will have an effect on other and also a feedback on themselves. The fourth cluster includes independent SSPEs that have strong driving power and weak dependence power. Here we have enablers 1,2,3,4,5 and 6 in the category of driving enablers.

**TABLE III  
INITIAL REACHABILITY MATRIX**

SSPEs	1	2	3	4	5	6	7	8	9	10	11	12	Driving power
1	1	0	1	1	1	1	1	1	1	1	1	1	11
2	0	1	1	1	1	1	1	1	1	1	1	1	11
3	0	0	1	1	1	1	1	1	1	1	1	1	10
4	0	0	0	1	1	1	1	1	1	1	1	1	9
5	0	0	0	0	1	1	1	1	1	1	1	1	8
6	0	0	0	0	0	1	1	1	1	1	1	1	7
7	0	0	0	0	0	0	1	1	1	1	1	1	6
8	0	0	0	0	0	0	0	1	1	1	1	1	5
9	0	0	0	0	0	0	0	0	1	1	1	1	4
10	0	0	0	0	0	0	0	0	0	1	1	1	3
11	0	0	0	0	0	0	0	0	0	0	1	1	2
12	0	0	0	0	0	0	0	0	0	0	0	1	1
Dependency power	1	1	3	4	5	6	7	8	9	10	11	12	

**TABLE IV  
PARTITION OF REACHABILITY MATRIX: FIRST ITERATION**

SSPEs	Reachability set	Antecedent set	Inters action set	Level
1	1,3,4,5,6,7,8,9,10,11,12	1	1	
2	2,3,4,5,6,7,8,9,10,11,12	2	2	

3	3,4,5,6,7,8,9,10,11,12	1,2,3	3
4	4,5,6,7,8,9,10,11,12	1,2,3,4	4
5	5,6,7,8,9,10,11,12	1,2,3,4,5	5
6	6,7,8,9,10,11,12	1,2,3,4,5,6	6
7	7,8,9,10,11,12	1,2,3,4,5,6,7	7
8	8,9,10,11,12	1,2,3,4,5,6,7,8	8
9	9,10,11,12	1,2,3,4,5,6,7,8,9	9
10	10,11,12	1,2,3,4,5,6,7,8,9,10	10
11	11,12	1,2,3,4,5,6,7,8,9,10,11	11
12	12	1,2,3,4,5,6,7,8,9,10,11,12	12

TABLE V  
LEVELS OF SUPPLIER SELECTION PROCESS ENABLERS

SS PE S	Reachability set	Antecedent set	Intersection set	Level
1	1,3,4,5,6,7,8,9,10,11,12	1	1	XI
2	2,3,4,5,6,7,8,9,10,11,12	2	2	XI
3	3,4,5,6,7,8,9,10,11,12	1,2,3	3	X
4	4,5,6,7,8,9,10,11,12	1,2,3,4	4	IX
5	5,6,7,8,9,10,11,12	1,2,3,4,5	5	VI II
6	6,7,8,9,10,11,12	1,2,3,4,5,6	6	VI I
7	7,8,9,10,11,12	1,2,3,4,5,6,7	7	VI
8	8,9,10,11,12	1,2,3,4,5,6,7,8	8	V
9	9,10,11,12	1,2,3,4,5,6,7,8,9	9	IV
10	10,11,12	1,2,3,4,5,6,7,8,9,10	10	III
11	11,12	1,2,3,4,5,6,7,8,9,10,11	11	II
12	12	1,2,3,4,5,6,7,8,9,10,11,12	12	I

V. FORMATION OF ISM DIGRAPH AND MODEL

The structural model is generated from final reachability matrix (see Table III). If there is a relationship between the SSPE i and j, this is presented by an arrow which points from i to j. This graph is called a digraph. After removing the transitivities the final digraph is formed (see Fig. 1). This final digraph is converted to final ISM based model (see Fig. 3).

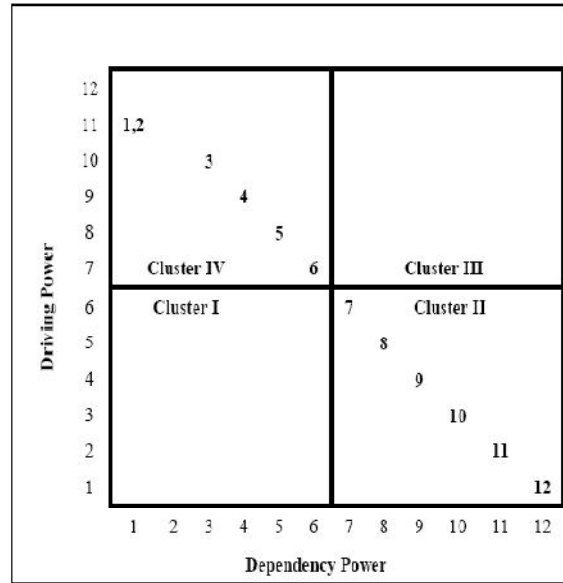


Fig. 1. Cluster of SSPEs

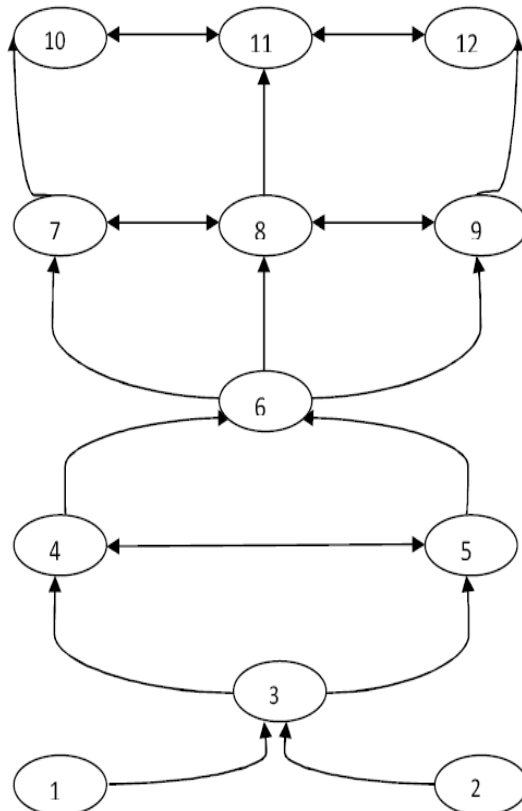


Fig. 2. Final digraph depicting the relationship among SSPEs.

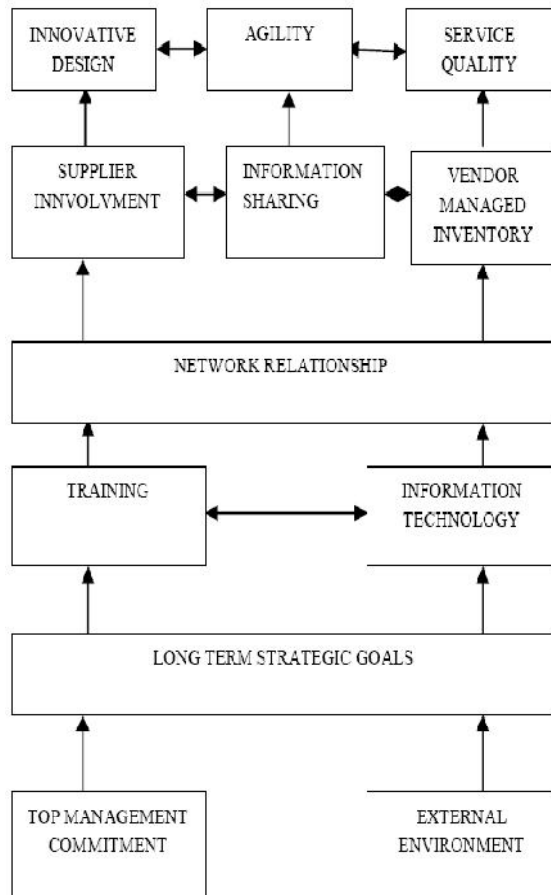


Fig.3. ISM based Model

## VI. DISCUSSION

Supplier selection has become life line of the business organization. Top management commitment and external environment have high driving power and low dependency, placed at lowest level in the hierarchy of ISM-based model. These enablers act as a base for supplier selection process. Innovative design, agility and service quality are at highest level in the hierarchy of ISM-based model having high dependency and low driving power. Long term strategic goals at tenth level influence the other identified SSPEs above it in the hierarchy but influenced by the SSPEs below it in the hierarchy but influenced by the SSPEs below it in ISM-based model. Supplier involvement and information sharing at fifth and sixth level plays a key role in supplier selection process.

Therefore, they require more attention from top management. The driving power and dependency diagram ( Fig. 1) indicate that there is no autonomous SSPEs in the process of successful supplier selection process. Autonomous SSPEs are weak drivers and weak dependents. They do not have much influence in supplier selection process. The absence of autonomous SSPEs in this study indicates that all the identified SSPEs influence the process of successful supplier selection process. Therefore, it is suggested that management should pay attention to all SSPEs.

## VII. CONCLUSION

Those SSPEs possessing higher driving power in the ISM-based model need to be taken care on priority basis there are few other dependent SSPEs being affected by them. Top management commitment, External environment and Long term strategic goals have high driving power and less dependency power. Therefore, these SSPEs can be treated as Key enablers. From discussion we can conclude that all the twelve identified SSPEs are important for successful supplier selection process.

In this research only twelve SSPEs have been used to develop the ISM model, but more SSPEs can be included to develop the relationship among them using ISM methodology. The contextual relation among the SSPEs always depends on the user's knowledge and familiarity with the organization, and its operation. Therefore, any biasing by the person who is judging the SSPEs might influence the final result. A questionnaire survey can be conducted to catch the insight on these SSPEs from more industries. Further, structural equation modeling (SEM) can be used for the statistical validation of developed hypothetical model. Hence, it has been suggested that future research may be targeted to develop the initial model through ISM and then testing it using SEM.

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