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Deployment of Interpretive Structural Modelling in knowing Discouraging Factors of Indian SMEs to Implement Supply Chain Management

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Abstract: Many researchers have applied Interpretive Structural Modeling (ISM) technique in knowing the variables of a situation and there by developing a model to prioritize the actions to address the situation. In this study, ISM is applied in understanding the Discouraging Factors (DF) of Small and Medium Scale Enterprises (SMEs) to implement SCM in their organization. Industry experts' opinion and literature is used as raw data for identifying the Discouraging Factors (DF) for adopting Supply Chain Management. Identified elements are ranked by using ISM techniques. Further, these identified variables are interrelated by using Ray Diagram & in the end an ISM model is developed. The ISM model prepared here will help the SMEs to implement SCM and prioritize their actions in implementing it. Literature review of deployment of ISM by researchers is presented in this paper. This literature review helps the researchers in using ISM in their study. Further, preparation of a ray diagram for each and every variable is demonstrated. This will help the researchers to apply transitivity tests by using ray diagram in their study.
Keyword: Interpretive Structural Modeling, Supply Chain Management, SCM, SMEs, Supply Chain Integration, Difficulty Factors.

1. Introduction

SMEs are the main drivers of the vibrant economy of India and they are the engines of development of Large and Auto Industries. Table 1 shows the key statistics of Indian SMEs. SMEs contribute 95% of total industries and give the jobs to both skilled and unskilled manpower contributing around 40% of Indian Employment.

Criteria	Numbers
SMEs in India	42.50 includes registered and non-registered
Employment Opportunity	106 Million
Products	6000+
GDP Contribution	For Manufacturing 6.11% and for Service industries its is 24.63%
SMEs Output	45% of total Manufacturing
SME Exports	40% of total exports

Table 1: Importance of SMEs: *Sources: msme.gov.in*

Supply chain consists of suppliers, industry and the customers. SMEs are the main vendors to large scale industries and are the main players of the supply chain. Growth of SMEs is very important in the interest of each and every partner of the Supply Chain. In the literature, various studies have established the correlation between the supply chain implementation and performance [1]. Lot of study is being done in developing the systems and framework for implementing the supply chain activities in large scale industries. These frameworks and processes are being implemented in large scale industries as they have sufficient skilled manpower and also rate of return on their investment in SCM. Implementation of these frameworks has helped large scale industries to gain competitive advantage [2].

In the literature, it is documented that, in SMEs, implementation of SCM is not satisfactory. SMEs, neither have the scale of business, manpower nor the money to adopt SCM in their industries. Hence this study addresses the factors or variables which discourage Indian SMEs in implementing SCM.

2. Research Agenda & Framework

Research agenda is to:

1. Identify the Discouraging Factors of SMEs in implementing the SCM activities in their industries
2. Ranking of these identified Discouraging Factors by using ISM
3. Deployment of Interpretive Structural Modeling (ISM) for developing model for the actions to be taken to implement SCM in SMEs. MICMAC analysis is done in the end for the classification of variables
4. To document the managerial implications of the research

Organization of this paper with different sections and methodology adopted is summarized figure 1 as flow chart.

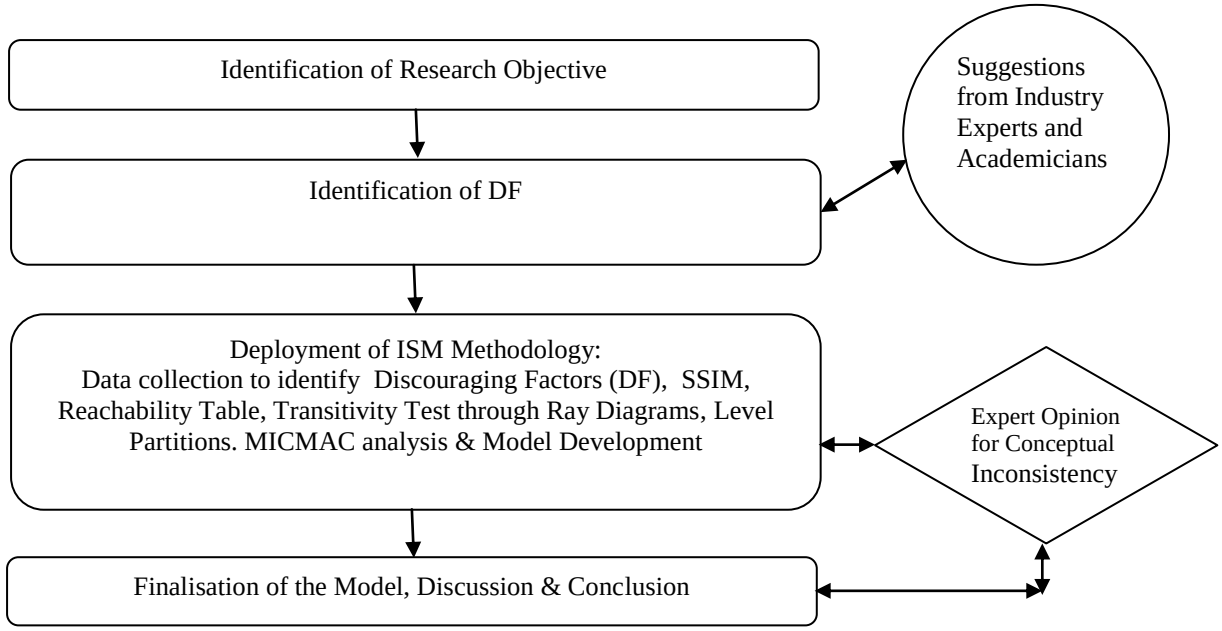

Figure 1: Research Methodology

3. ISM as a modeling tool: Literature Review

Researchers have applied Analytical Hierarchy Process (AHP), Analytic Network Process (ANP) and also Interpretive Structural Modeling (ISM) in modeling the variables of SCM. ANP is unmanageable, inconvenient & burdensome because of pair wise comparison Matrix. [3] & AHP are poor in capturing real life situations and complex variables [4]. In comparison to AHP & ANP, ISM is suitable for transforming invisible and poorly segmented variables into a well-defined model for complex decisions [5]. Warfield first introduced ISM in 1973. In the interpretive nature of ISM where a group of experts decides the nature of relationships from a complex set of items and extracts an overall structure [6].

ISM is used to establish hierarchical and interrelationship among the identified elements and further these elements are grouped into autonomous, dependent, linkage and independent variables [7].

The Modelling part of ISM depicts the particular relations and total structure in directed graph [6]. The correct order and complexity of relationships among the variables is found by graph theory and ray diagram [8]. In ISM, ray diagram is used for transitivity check among the variables. Many researchers like [7], [8], [9], [10], [11] and [12] have applied ISM methodology for developing a model in their research. Literature review is done to know the application of ISM in the research and is listed Table 2.

S. No	Main Authors	Year of Publication	Area of ISM Application
1	Malone	1975	Introductory paper about ISM
2	Warfield	1976	Introduced detailed Procedure for applying the ISM
3	Linstone H	1979	Proposed that ISM is good tool to model the subjective elements and variables
4	Lendris G B	1980	Modeling of a large number of variables can be done by using ISM.
5	Anukul M	1994	Used ISM to study the variables of Vendor selection
6	Jharkharia S	2004	IT enablers are studied by ISM
7	Sanjay J	2005	Studied the barriers for IT enabled Supply Chains
8	Sunil Luthra	2011	Applied ISM to variables of Green Supply Chain Management
9	Pramod Shahabadkar	2013	Conducted the literature review of use of ISM by researchers in their study. 42 articles related to deployment of ISM are reviewed in this paper.
10	Jagdish R J	2014	Lean implementation variables are identified by using Literature survey and Expert Opinion
11	Pankaj S	2015	16 barriers to implement GSCM in SMEs located in North India are identified through literature survey and ISM is applied to address these barriers by Hierarchical Modeling and MICMAC analysis
12	Rakesh K	2015	Lean manufacturing elements are analyzed by ISM
13	Devendra K	2015	11 Innovation Enablers are identified through literature. ISM -Fuzzy is applied. Data for the Study is collected from 100 manufacturing industries
14	Abhijit M	2018	Green Supply Chain barriers for Textile Industries of South Asian Countries
15	Mabrouk N	2020	Variables influencing performance of SCM for Saudi SMEs

Table 2: Application of ISM by Researchers in their Study

Steps followed for deployment of ISM in this study is as explained below:

1. Elements or variables of study should be identified. This can be done by literature survey, case study approach or from survey.
2. Study of pairwise relationship among elements and there by preparing Structural Self-Interaction Matrix (SSIM).
3. Preparing the Reachability table from SSIM by using binary values (1 and 0)
4. Initial Reachability table is transferred into the Final Reachability table by checking the transitivity test using a ray diagram.
5. Using the final Reachability matrix, for every element partitioned into levels.
6. Using the level partitions and Reachability matrix, digraph is prepared
7. From the digraph initial ISM model is developed and after checking the model for conceptual inconsistency, the final model is developed.

4. Identification of Discouraging Factors (DF) for implementing SCM in SMEs

ISM technique suggests survey, case study or brainstorming sessions as tools to identify variables for the study. Hence, in this study, SMEs are contacted through structured questionnaires to identify factors which discourage Indian SMEs in implementing the SCM activities. Data is collected from Engineers working in SMEs, Owners and Directors of SMEs. Profiles of industry experts for the study are shown in the figure 2.

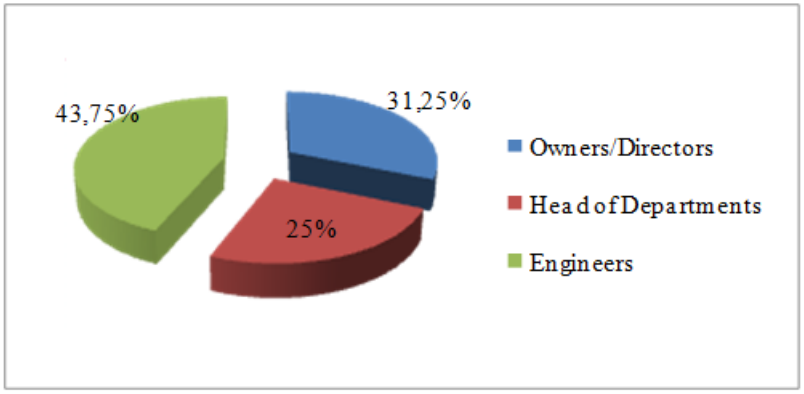

Figure 2: Profile of Industry Experts

From the discussion with the experts, eight factors which discourage the Indian SMEs are identified and are listed in the Table 3.

S No	Discouraging Factors (DF) for Indian SMEs to Implement SCM
1	Firm is small can be managed without implementing SCM
2	It is not much beneficial
3	Supply Chain Partners are not ready to implement SCM
4	Sharing of Sensitive information is not possible
5	Technical expertise required for SCM is not available
6	Implementation of SCM is expensive and time consuming
7	Competitors are not performing SCM activities
8	Not aware of this management technique

Table 3: Discouraging Factors

5. Deployment of ISM in Study

Relationship among Discouraging Factors (DF) to implement SCM in SME's is studied by ISM and its deployment in this study is explained in the following section.

5.1 Structured Self Interaction Matrix (SSIM)

For the analysis of Discouraging Factors (DF) a situational relationship- "leads to" - is selected which denotes one DF leads to other and is as below [6].

V- DF i l help to achieve DF j
A- DF j is achieved by DF i
X- DF i and j help to achieve each other
O- DF j and i are unrelated.

An SSIM model as shown in Table 4 is developed by using above concept and relationship between i and j DF are analysed by V, A, X and O notations which show the direction of relationship among i and j. Opinions of two experts are collected to understand the relationship among variables.

5.2 Reachability matrix

The developed SSIM is converted to binary matrix. This binary matrix is called initial Reachability matrix. Table 4 shows how the binary values (1 and 0) are substituted in place of V, A, X and O [7], [13].

S. No(i)	Discouraging Factors(DF) to Implement SCM (j)	8	7	6	5	4	3	2	1
01	Firm is small can be managed without implementing SCM	X	O	V	V	X	V	A	
02	It is not much beneficial	O	O	A	A	X	A		
03	Supply Chain Partners are not ready to implement SCM	X	X	O	O	O			
04	Sharing of Sensitive information is not possible	X	A	A	O				
05	Technical expertise required for SCM is not available	A	O	V					
06	Implementation of SCM is expensive and time consuming	A	O						
07	Competitors are not performing SCM activities	O							
08	Not aware of this management technique								

Table 4 Structural self – interaction matrix

5.3 Transitivity Test Using Ray Diagram

Once the initial reachability table is formed, then the transitivity test is performed. This means, if i leads to j and j leads to k, then i should lead to k and i-k in Table 5, 0 is replaced with 1 [6]. Transitivity tests for DF 1 to 8 are shown in detail through figures 3-6. For example in the initial reachability matrix for DF (1, 7) it is 0. In the transitivity test, as shown in figure 2, 1 leads to 3 and 3 leads to 7. Therefore as per the transitivity test rule 1 leads to 7. Hence in the final reachability table 6 for (1, 7), 0 is replaced by 1 as 1 leads to 7. Similarly transitivity test is done for all other DFs and final reachability Table 6 is prepared.

S. No	1	2	3	4	5	6	7	8
01	1	0	1	1	1	1	0	1
02	1	1	0	1	0	0	0	0
03	0	1	1	0	0	0	1	1
04	1	1	0	1	0	0	0	1
05	0	1	0	0	1	1	0	0
06	0	1	0	1	0	1	0	0
07	0	0	1	1	0	0	1	0
08	1	0	1	1	1	1	0	1

Table 5 Initial reachability matrix-

Note: If V- Then i-J=1, and J-i=0, If A, i-J=0, and J-i=1, If X, i-J=1, and J-i=1,If O, i-J=0, and J-i=0

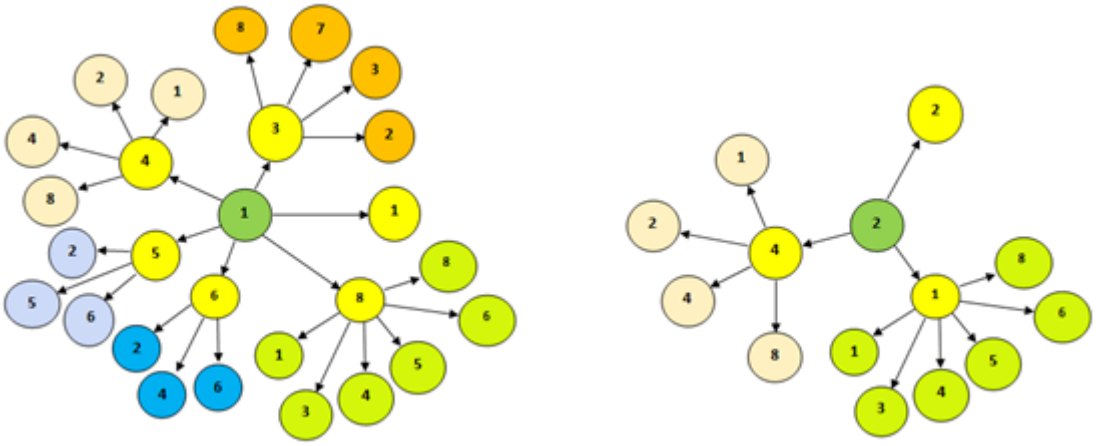

Figure 3: Ray Diagram of Transitivity Test for DF 1 & 2

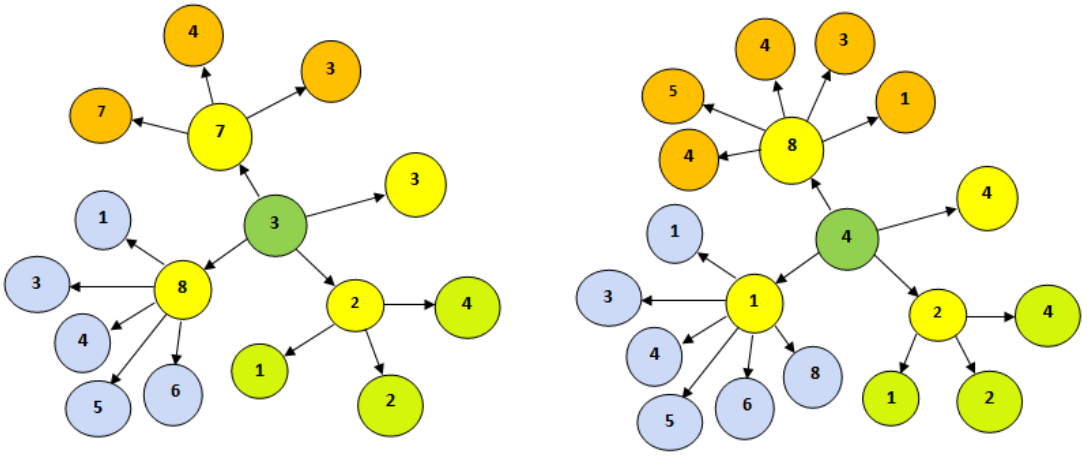

Figure 4: Ray Diagram of Transitivity Test for DF 3 & 4

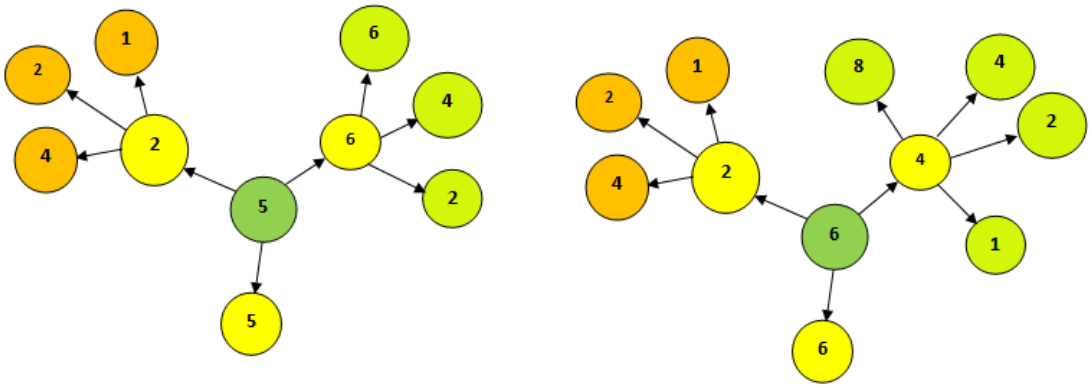

Figure 5: Ray Diagram of Transitivity Test for DF 5 & 6

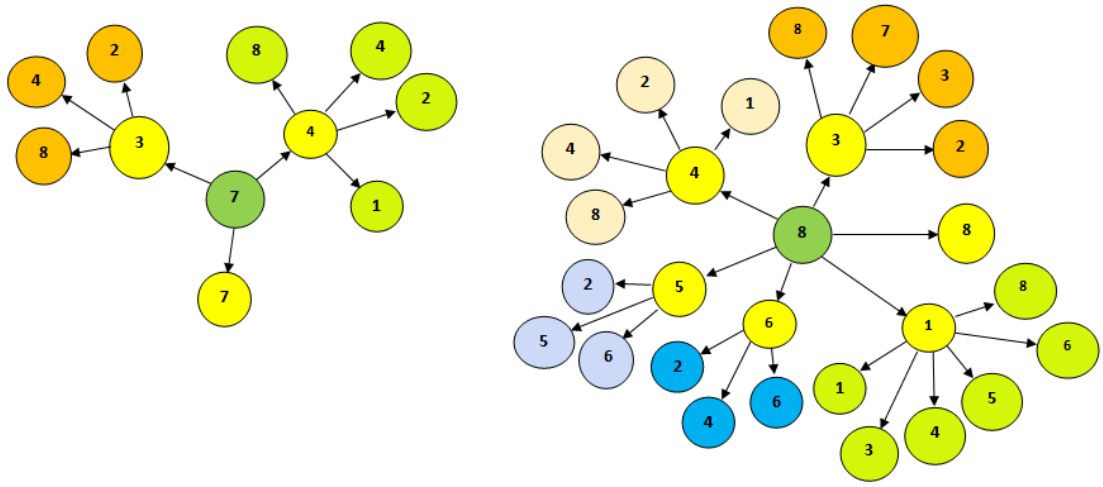

Figure 6: Ray Diagram of Transitivity Test for DF 7 & 8

Sr. No	1	2	3	4	5	6	7	8	Driving Power
01	1	1	1	1	1	1	1	1	8
02	1	1	1	1	1	1	0	1	7
03	1	1	1	1	1	1	1	1	8
04	1	1	1	1	1	1	0	1	7
05	1	1	0	1	1	1	0	0	5
06	1	1	0	1	0	1	0	1	5
07	1	1	1	1	0	0	1	1	6
08	1	1	1	1	1	1	1	1	8
Dependence	8	8	6	8	6	7	4	7	

Table 6- Final reachability matrix

Driving power of a DF is sum of all DFs which help to achieve it. Whereas, dependence is the sum of all DFs which may help in achieving it [6]. The MICMAC analysis uses these driving powers and dependencies for grouping the DFs in to four categories like autonomous, dependent, linkage and independent.

5.4 Level Partitions

Using Reachability table, for every DF, reachability and antecedent sets are obtained. Reachability set for a DF is DF itself and other DFs which help to achieve it. Likewise antecedent set for a DF is DF itself and other DF which may help achieving it. After this the intersection set for these DFs is obtained. The DF which has the same reachability and intersection sets is placed at the top level in the ISM hierarchy. These top level DFs are separated from others as they will not contribute to any other DF [12]. This process is continued till all DF levels are found. These levels will help in preparing the diagraph and final ISM model. Various iterations along with DF, reachability, antecedent and intersection sets with their levels are presented in the Table 7 to 9.

DF	Reachability Set	Antecedent set	Intersection set	Level
1	1,2,3,4,5,6,7,8	1,2,3,4,5,6,7,8	1,2,3,4,5,6,7,8	I
2	1,2,3,4,5,6,8	1,2,3,4,5,6,7,8	1,2,3,4,5,6,8	I
3	1,2,3,4,5,6,7,8	1,2,3,4,7,8	1,2,3,4,7,8	
4	1,2,3,4,5,6,8	1,2,3,4,5,6,7,8	1,2,3,4,5,6,8	I
5	1,2,4,5,6,	1,2,3,4,5,8	1,2,4,5	

6	1,2,4,6,8	1,2,3,4,5,6,8	1,2,4,6,8	I
7	1,2,3,4,7,8	1,3,7,8	1,3,7,8	
8	1,2,3,4,5,6,7,8	1,2,3,4,6,7,8	1,2,3,4,6,7,8	

Table 7: Iteration 1

DF	Reachability Set	Antecedent set	Intersection set	Rank
3	3,5,7,8	3,7,8	3,7,8	
5	5	3,5,8	5	II
7	3,7,8	3,7,8	3,7,8	II
8	3,5,7,8	3,7,8		

Table 8: Iteration 2

DF	Reachability Set	Antecedent set	Intersection set	Rank
3	3,8	3,8	3,8	III
8	3,8	3,8	3,8	III

Table 9: Iteration 3

DF	1	2	3	4	5	6	7	8	Driving Power	Rank
01	1	1	1	1	1	1	1	1	8	I
02	1	1	1	1	1	1	0	1	7	I
03	1	1	1	1	1	1	1	1	8	III
04	1	1	1	1	1	1	0	1	7	I
05	1	1	0	1	1	1	0	0	5	II
06	1	1	0	1	0	1	0	1	5	I
07	1	1	1	1	0	0	1	1	6	II
08	1	1	1	1	1	1	1	1	8	III
Dependence	8	8	6	8	6	7	4	7		

Table 10 -Levels of DFs in the ISM model

5.5 Building the ISM model

By using final reachability matrix, levels of DFs as shown in the Table 10, ISM model is generated using nodes, lines and arrows [14]. For example: relationship between i and j is shown by an arrow which points from i to j. This graph is called directed graph or digraph. Final ISM model is prepared after considering the transitivity test and is shown in the Figure 7. In the table 7, DF 1, 2, 4 & 6 are found at the level 1 and hence they are placed at the top in the ISM model. Subsequently in table 8, DF 5 and 7 are at the 2nd level and in table 9, DF 3 and 8 are at the third level and so they are placed at a lower level in the ISM Model.

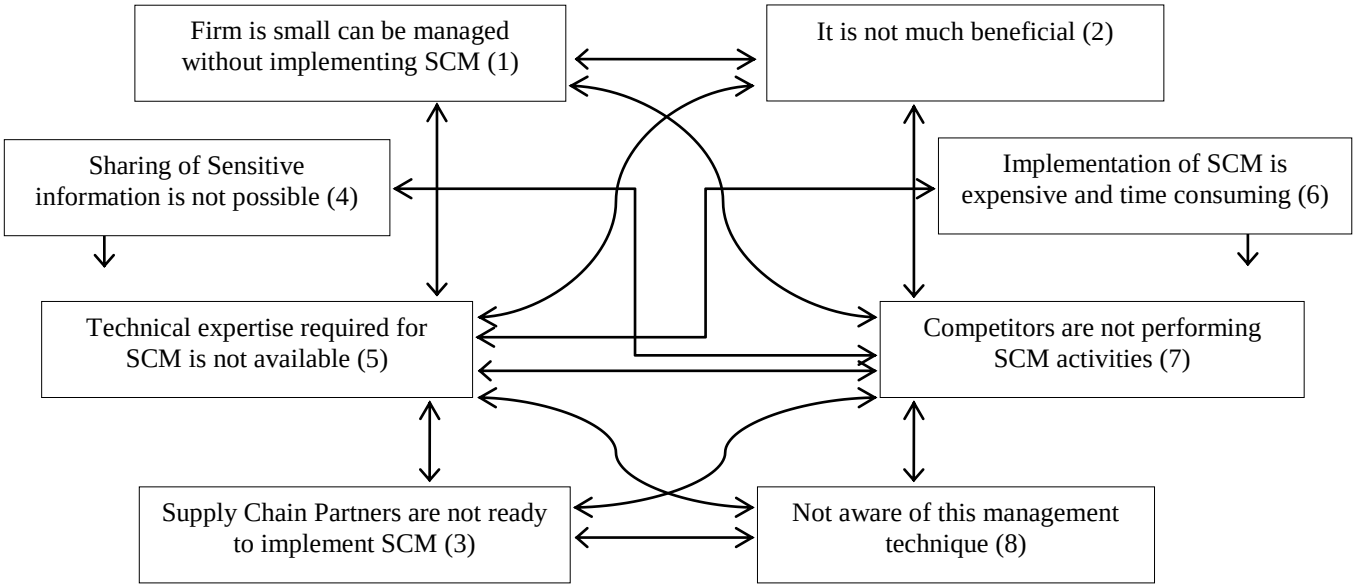

Figure 7: ISM Model

5.6 Level partitions and MICMAC analysis: Classification of Discouraging Factors

Driving power and dependence of DFs are analysed by MICMAC analysis [14]. DFs are grouped as autonomous, dependent, linkage and independent. The first group includes autonomous DFs with weak driving power and weak dependence. The dependent DFs which are grouped in second cluster are distinguished with weak driving power and strong dependence.

The linkage DFs which are in third cluster are with strong driving power and strong dependence. Independent DFs which are in fourth cluster are recognized by strong driving power with weak dependence. Each DF's driving power and dependence power are tabulated in Table 6. In the table, columns and rows where the entry is "1" indicates driving power and dependence respectively. After this, driving and dependence graph is drawn as shown in figure 8.

6. Managerial Implication and Conclusion

As shown in the ISM model Figure 6, "Firm is small can be managed without implementing SCM", "It is not much beneficial" are at the top level. Further, also from figure 8, DFs "Firm is small can be managed without implementing SCM" and "It is not much beneficial" having very high dependence and high driving power and so they are positioned at the III quarter. Hence, it is important for managers and researchers that there is a need of more studies in future to establish the quantitative relationship between SCM and performance.

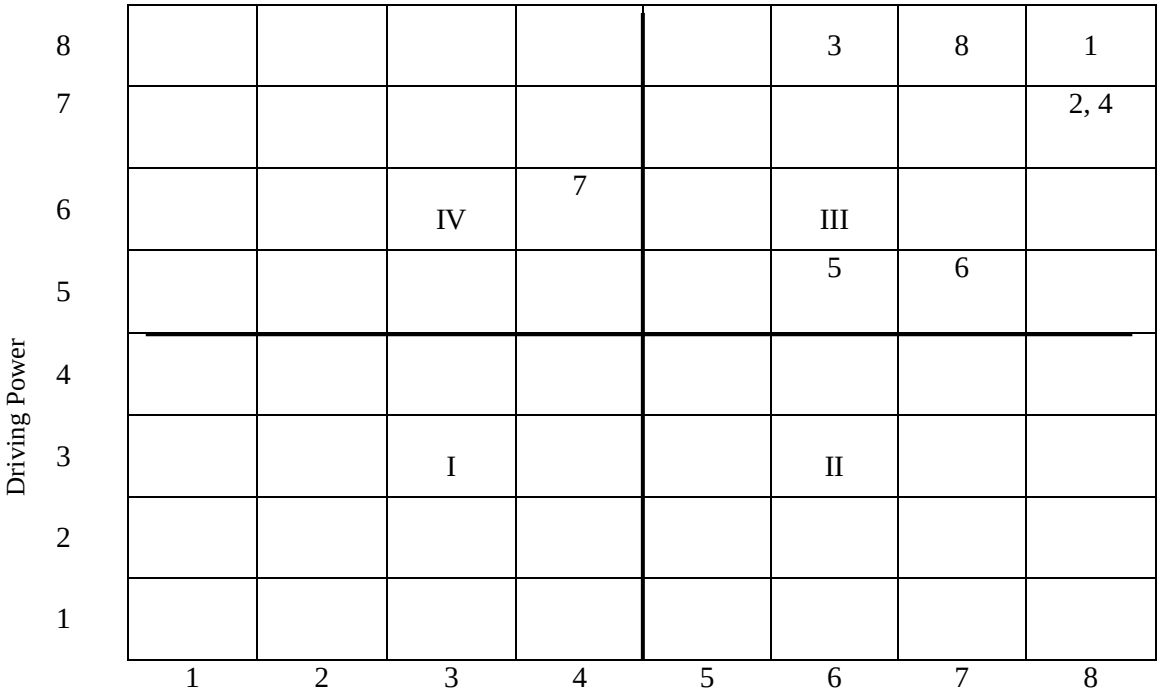

Figure 8: Driving Power V/s Dependence

I-Autonomous Barriers II-Linkage Barriers
III-Dependant Barriers IV-Independent Barriers

"We cannot share sensitive information" and "Implementation of SCM is expensive and time consuming" are at the next lower level and SMEs owners need to address these factors. Significantly, SMEs "Technical expertise required for SCM is not available" is at a lower level.

Further, from figure 8, "Technical expertise required for SCM is not available" and "Implementation of SCM is expensive and time consuming" are having moderate driving power and very high dependence on other DFs. Therefore, SME managers need to address these issues on a priority basis. "Competitors are not performing SCM activities" has a very low driving and dependence power and is a dependent DF. Managements need to address this issue. From the figure 8 it can be documented that there are no autonomous and linkage DFs.

Further, our study documents that many SMEs are aware of SCM activities and hence the DF - "Not aware of this management technique" and "Supply Chain Partners are not ready to implement SCM" are at the lowest level.

7. Scope for Future Study

As suggested in ISM technique, expert opinion was taken in identifying the variables and establishing the relationship among the identified variables. Yet, we suggest verifying this model by using statistical tools like Structural Equation Modelling (SEM) as it has capability of testing an already developed model. The ISM model developed in this study will be an initial model for further SEMs.

Biggest contribution of this study is, it demonstrates the deployment of ISM and provides valuable inputs to SME managers in implementing SCM in their organisation. This study adds on to the research in ISM, SMEs and SCM.

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