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STATEMENT OF THE PROBLEM

OBJECTIVES

HYPOTHESES

RESEARCH METHODOLOGY

RESULTS & DISCUSSION

FINDINGS

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CONTRIBUTIONS TO BOOKS

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

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CRITICAL FACTORS FOR SUCCESSFUL SC COLLABORATION: AN INTERPRETIVE STRUCTURAL MODELING APPROACH

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ABSTRACT

Interpretive Structural Modelling (ISM) is a methodology for identifying and summarizing relationships among specific SC collaborations, which define an issue or problem. It provides a means by which order can be imposed on the complexity of such factors. In the present paper the important critical success factors have been analysed to obtain an ISM, which shows the interrelationships of the variables and their levels. These variables have also been categorized depending on their driving power and dependence. The research shows that there exists a group of enablers having a high driving power and low dependence requiring maximum attention and of strategic importance while another group consists of those variables which have high dependence and have the resultant actions.

KEYWORDS
Interpretive Structural Modelling, Supply chain Collaboration.

1. INTRODUCTION

Today the key issues in supply chain (SC) are the formation of the SC and its efficient coordination with objectives of customer satisfaction and sustaining competency. This requires complex flow of information, materials, and funds across multiple functional areas both within and among organizations. To achieve this organization must identify, evaluate, rank, and manage its SC risks. (Stevenson 2007) The leaner and more integrated SC get the more likely uncertainties, dynamics and accidents in one link affect the other links in the chain. Organizations obsession with speed and costs also causes SC to break down particularly during the launch of new products (Ravi. V, 2005). Also coordinating actions across organizations is tough because organizations have different cultures and they cannot count on shared beliefs or loyalty to motivate their partners (Yu, 2001). The benefits of SC collaboration include reduction in overall cost, improved delivery service and shorter product development cycles. Despite these benefits organizations who partner in strategic SC continue to encounter barriers. These barriers exist at multiple levels of organizations: the organizational, intra organizational and inter organizational levels. (Stanley 2008).
ISM is a well established methodology for identifying relationships among specific items which define a problem or an issue (Warfield 1974). Therefore, in this research, SC collaboration critical success factors (CSFs) have been analyzed using the ISM approach, which shows the interrelationships of various SC collaboration CSFs, their driving power and dependencies. The opinions from a group of experts were used in developing the relationship matrix, which is later used in the development of the ISM model. In this paper, thirteen CSFs have been chosen on the basis of literature review and the opinions of experts from academia (Table 1). The main objectives of this paper are to identify and rank the CSFs, to establish relationships among the identified CSFs using ISM, and to discuss the organizational implications of this research and suggest directions for future research.

2. LITERATURE REVIEW

2.1 DEFINITIONS OF SUPPLY CHAIN MANAGEMENT

Cheng (2002) defined SC as an integrative philosophy to manage the total flows of a distribution channel from suppliers level to production, distribution and the ultimately the end customer. The integrative philosophy of SC management eliminates the boundaries of the single organization and puts emphasis on the effectiveness of the SC as a whole and SC that which can quickly support new market opportunities and be synchronized and streamlined to maximize efficiency and effectiveness. (Chan, 2009). SCM is the approach to designing, organizing, and executing all the activities from planning to distribution along the entire value chain, including the network of suppliers, manufacturers and distributors. (IP W. H, 2011). It aims to procure the correct inputs (raw materials, components and capital equipment), convert them into finished products and dispatch them to their final destinations. (Barrat, 2004). Sahay (2003) defined SC management is the integration of key business processes across the SC for the purpose of creating value for customers and stakeholders and it is the management of material, information and finance through a network of organizations (i.e. suppliers, manufacturers, logistics providers, wholesales/distributors and retailers) that aims to produce and deliver products or services for the consumers. (Singh, 2003). The SC is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer. (Gunasekaran, 2004).

2.2 SC COLLABORATION CRITICAL SUCCESS FACTOR

Fawcett et al. (2010) address how organizations mitigate existing forces to achieve the SC collaboration critical success factor (CSF). Seven key theories were used to provide insight into the theoretical framework for the creation of the collaboration CSF. Organizations are beginning to pursue greater collaboration; however, managers are often stymied in their pursuit of collaborative business models. This paper focused on the mitigation of resisting forces and collaboration CSFs. Their organizational structures and cultures are two CSFs which are discussed. Improving collaborative capabilities and higher levels of customer service and productivity are those benefits which are discussed as the benefits of SC collaboration CSF. Vijayasarathy (2010) empirically examined the multi-dimensionality of supply integration and explored its relational antecedents. The research is an empirical field study and has some shortcomings but still it comes with some of the SC collaboration CSFs like information sharing, strategic planning, organization structure, trust and commitment and also discussed the positive effects of these SC collaboration CSFs as the Benefits. Siddiqi (2008) establishes the necessity for collaboration for effective SC management in the age of Internet. In a networked society where everything is connected, collaboration is the word visited and revisited every now and then. The paper shows that when a SC is CSF with the information technology then it can link with all members of the SC to the information network, which improves effectiveness, reduces paperwork and pushes down the cost. Wu and Cheng (2007) attempts to quantify the impact of information sharing on inventory and expected cost in a multiple SC under a general end demand process. This paper states inventory reduction, cost reduction as the benefits of the SC collaboration with CSFs like information sharing and inventory planning, but it is suggested that further studies consider the sensitivity of the results to the assumptions made and simulation of the proposed model using real data. Power (2004) study is a review of the sample of literature relating to the integration and implementation of SC management

practices from a strategic viewpoint. The intent of this literature review is to document and analyze literature relating to the integration and implementation of SC management practices. Customer needs or customer oriented vision, information sharing and co-operation are some of the SC collaboration enablers which are discussed in this paper with the beneficial effects of them like improved relationship, customer satisfaction with competitive advantage and added cost to business. Jonsson and Zineldin (2003) studied proposes a conceptual model including behavioral dimensions of supplier-dealer relationships and presents hypotheses about how to achieve satisfactory inter-organizational relationships. This paper represents the impact of communication, adaptation, reputation, non-coercive power, coercive power, cooperativeness, relationship bonds, dependency and objective relationship as the enablers of the SC collaboration and shows various benefits of an inter-organizational relationship. Kidd et al (2003) paper deals with the SC management practice of firms in developed nations and their capabilities to progress under the modern regime of harder and faster just in time systems. The paper deals with the leadership, trust and JIT as the enablers for SC collaboration CSF clear and common objectives are explained with these and the various beneficial effects are discussed in this paper. Stanly (2008) paper presents an approach to manage inventory decisions at all stages of the SC in an integrated manner. In this paper the SCM problem has been addressed with particular emphasis on inventory management. Also information communication discussed as an enabler for SC collaboration CSF. Yang (2001) paper studies the effects of information sharing strategies on SC performance. They first consider four common types of information sharing strategies for a SC of a single product. This paper deals with the positive and negative effects of matching the product, demand process, production and distribution process, and SC structure with the right information sharing strategies and comes up with the benefits like reduced bull whip effect.

TABLE 1: SUPPLY CHAIN COLLABORATION CRITICAL SUCCESS FACTOR (CSF)

Supply Chain Collaboration CSF Number	CSF Description	References
CSF 1	Leadership	Chan (2009)
CSF 2	Common Objectives	Simatupang et al. (2002), Janssen (2004), Barrat (2005), Fawcett et al (2010)
CSF 3	Strategic Planning	Kidd et al (2003)
CSF 4	Organization Structure	Kim (2007), Vijayasathi (2010)
CSF 5	Lead Time	Cheng et al. (2001), Barrat (2005), Lazarevic et al (2007)
CSF 6	Technology	Kollurru and Meredith (2001), Prasaad and Sounderpandian (2003), Ruppel (2004), Lazarevic et al (2007), Fasanghari (2008)
CSF 7	Information Sharing	Yu et al. (2001), Simatupang et al. (2002), Jonsson and Zineldin (2003), Simatupang and Sridharan II (2004), Wu and Cheng (2007), Kulchitsky and Larson (2008)
CSF 8	Trust	Kollurru and Meredith (2001), Agarwal and Shankar (2003), Ruppel (2004), Kwan and Suh (2005), Fawcett et al (2010)
CSF 9	Openness	Baraat (2004), Suh and Kwan (2005), Siddiqi (2008), Chen (2010)
CSF 10	Co-operation	Power (2004)
CSF 11	Benefit Sharing	Siddiqi (2008)
CSF 12	Decision Synchronization	Sridharan and Simatupang (2003), Simatupang and Sridharan II (2004), Min et al. (2005), Weingarten et al. (2010)
CSF 13	Customer Oriented Vision	Baraat (2004), Fawcett et al (2010), Lado et al. (2011)

3. INTERPRETIVE STRUCTURAL MODELING METHODOLOGY AND MODEL DEVELOPMENT

ISM starts with an identification of elements which are relevant to the problem or issue and extends with a group problem solving technique. Then a contextually relevant subordinate relation is chosen. Having decided on the element set and the contextual relation, a structural self-interaction matrix (SSIM) is developed based on pair wise comparison of elements. In the next step, the SSIM is converted into a reachability matrix and its transitivity is checked. Once transitivity embedding is complete, a matrix model is obtained. Then, ISM model is derived by the partitioning of the elements. (Suh, 2005)

The various steps involved in the ISM technique are

1. Variables are listed down, which can be objectives, actions, and individuals etc., a contextual relationship is established among variables with respect to which pairs of variables would be examined.
2. A structural self interaction matrix (SSIM) is developed for variables which indicate pair-wise relationship among variables of the system.
3. A reachability matrix is developed from the SSIM and is checked the matrix for transitivity.
4. The reachability matrix is partitioned into different levels.
5. The reachability matrix is developed in its conical form, i.e. with most zero (0) variables in the upper diagonal half of the matrix and most unitary (1) variables in the lower half.
6. Based on the above, a directed graph (Digraph) is drawn and transitive links are removed and the resultant Digraph is converted into an ISM by replaci variables nodes with statements.
7. The ISM model is reviewed to check for conceptual inconsistency and incorporate makes the necessary modifications.

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

3.1 Structural Self-Interaction Matrix (SSIM)

Keeping in the mind contextual relationship for each SC collaboration CSF, the existence of relationship between any two SC collaboration CSF (*i* and *j*) and associated direction of the relation are questioned. For developing SSIM, the following four symbols have been used to denote the direction of relationship between SC collaboration CSFs (*i* and *j*):

V for the relation from *i* to *j* but not in opposite direction;
A for the relation from *j* to *i* but not in opposite directions;
X for both direction relations from *i* to *j* and *j* to *i*; and
O if the relation between the does not appear valid.

Based on contextual relationships, the SSIM is developed (Table 2).

TABLE 2: STRUCTURAL SELF-INTERACTION MATRIX

CSF No.	13	12	11	10	9	8	7	6	5	4	3	2
CSF 1	V	V	V	V	V	V	V	V	V	V	V	V
CSF 2	V	V	V	V	V	V	V	V	V	V	V	
CSF 3	V	V	V	V	V	V	V	V	V	V		
CSF 4	V	V	V	V	V	V	V	X	X			
CSF 5	V	V	V	V	V	V	V	X				
CSF 6	V	V	O	O	O	O	V					
CSF 7	V	X	A	A	A	A						
CSF 8	V	V	X	V	V							
CSF 9	V	V	A	X								
CSF 10	V	V	A									
CSF 11	V	V										
CSF 12	V											
CSF 13												

3.2 Reachability Matrix

The SSIM has been converted into a binary matrix, called the initial reachability matrix as shown in Table 3 by substituting *V*, *A*, *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.

After incorporating the transitivity as mentioned in step (4) of the ISM technique, the final reachability matrix is shown in Table 4. In Table 4, the driving power and the dependence of each SC collaboration CSF are also shown. The driving power for each SC collaboration CSF is the total number of SC collaboration CSFs (including itself), which it may help achieve. Dependence is the total number of SC collaboration CSFs (including itself), which may help achieving it. These driving powers and dependencies are used in the classification of SC collaboration CSFs into four groups, i.e. autonomous, dependent, linkage, and driver.

TABLE 3: INITIAL REACHABILITY MATRIX

CSF No.	1	2	3	4	5	6	7	8	9	10	11	12	13
CSF 1	1	0	1	1	1	1	1	1	1	1	1	1	1
CSF 2	0	1	1	1	1	1	1	1	1	1	1	1	1
CSF 3	0	0	1	1	1	1	1	1	1	1	1	1	1
CSF 4	0	0	0	1	1	1	1	1	1	1	1	1	1
CSF 5	0	0	0	1	1	1	1	1	1	1	1	1	1
CSF 6	0	0	0	1	1	1	1	0	0	0	0	1	1
CSF 7	0	0	0	0	0	0	1	0	0	0	0	1	1
CSF 8	0	0	0	0	0	0	1	1	1	1	1	1	1
CSF 9	0	0	0	0	0	0	1	0	1	1	0	1	1
CSF 10	0	0	0	0	0	0	1	0	1	1	0	1	1
CSF 11	0	0	0	0	0	0	1	1	1	1	1	1	1
CSF 12	0	0	0	0	0	0	1	0	0	0	0	1	1
CSF 13	0	0	0	0	0	0	0	0	0	0	0	0	1

TABLE 4: FINAL REACHABILITY MATRIX

CSF No.	1	2	3	4	5	6	7	8	9	10	11	12	13	DR
CSF 1	1	0	1	1	1	1	1	1	1	1	1	1	1	**12**
CSF 2	0	1	1	1	1	1	1	1	1	1	1	1	1	**12**
CSF 3	0	0	1	1	1	1	1	1	1	1	1	1	1	**11**
CSF 4	0	0	0	1	1	1	1	1	1	1	1	1	1	**10**
CSF 5	0	0	0	1	1	1	1	1	1	1	1	1	1	**10**
CSF 6	0	0	0	1	1	1	1	1*	1*	1*	1*	1	1	**10**
CSF 7	0	0	0	0	0	0	1	0	0	0	0	1	1	**3**
CSF 8	0	0	0	0	0	0	1	1	1	1	1	1	1	**7**
CSF 9	0	0	0	0	0	0	1	0	1	1	0	1	1	**5**
CSF 10	0	0	0	0	0	0	1	0	1	1	0	1	1	**5**
CSF 11	0	0	0	0	0	0	1	1	1	1	1	1	1	**7**
CSF 12	0	0	0	0	0	0	1	0	0	0	0	1	1	**3**
CSF 13	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**
DP	**1**	**1**	**3**	**6**	**6**	**6**	**12**	**8**	**10**	**10**	**8**	**12**	**13**	

DR= Driving Power
DP=Dependence Power

3.3 Level partitions

From the final reachability matrix, the reachability and antecedent set of each SC collaboration CSFs are found (Warfield, 1974). The reachability set consists of the SC collaboration CSF itself and the other SC collaboration CSFs which it may help achieve it. Thereafter, the intersection of these sets is derived for all the SC collaboration CSFs. The SC collaboration CSFs for whom the reachability and the intersection sets are same, occupy the top level in the ISM hierarchy. The top-level CSF in the hierarchy would not help achieve any other SC collaboration CSF above its own level. Once the top-level CSF is identified, it is separated out from the other SC collaboration CSFs. It is seen from the Table 5 that Customer Oriented Vision (CSF 13) is occupied at level I. Hence, this CSF would be positioned at the top of the ISM hierarchy. After omitting the Customer Oriented Vision from Table 6, the next table is prepared. Then, the same process is repeated to find out the CSF in the next level.

In the next level i.e. II level the Information Sharing (CSF 7) and Decision Synchronizing (CSF 12), occupied the position and again omitted from the table. This process is continued until the levels of each CSF are found out. These levels (see Table 6) help in building the diagraph and the final model of ISM.

TABLE 5: PARTITIONING OF REACHABILITY MATRIX: 1ST ITERATION

CSF No.	Reachability Set	Antecedent Set	Intersection Set	Level
CSF 1	1,3,4,5,6,7,8,9,10,11,12,13	1	1	
CSF 2	2,3,4,5,6,7,8,9,10,11,12,13	2	2	
CSF 3	3,4,5,6,7,8,9,10,11,12,13	1,2,3	3	
CSF 4	4,5,6,7,8,9,10,11,12,13	1,2,3,4,5,6	4	
CSF 5	4,5,6,7,8,9,10,11,12,13	1,2,3,4,5,6	5,6	
CSF 6	4,5,6,7,8,9,10,11,12,13	1,2,3,4,5,6	5,6	
CSF 7	7,12,13	1,2,3,4,5,6,7,8,9,10,11,12	7,12	
CSF 8	7,8,9,10,11,12,13	1,2,3,4,5,6,8,11	8,11	
CSF 9	7,9,10,12,13	1,2,3,4,5,6,8,9,10,11	9,10	
CSF 10	7,9,10,12,13	1,2,3,4,5,6,8,9,10,11	9,10	
CSF 11	7,8,9,10,11,12,13	1,2,3,4,5,6,8,11	8,11	
CSF 12	7,12,13	1,2,3,4,5,6,7,8,9,10,11,12	7,12	
CSF 13	13	1,2,3,4,5,6,7,8,9,10,11,12,13	13	I

TABLE 6: LEVEL OF SC COLLABORATION CSF

CSF No.	Reachability Set	Antecedent Set	Intersection Set	Level
1	1	1	1	VII
2	2	2	2	VII
3	3	1,2,3	3	VI
4	4	1,2,3,4,5,6	4	V
5	5,6	1,2,3,4,5,6	5,6	V
6	5,6	1,2,3,5,6,7,8,9,10,11,12	5,6	V
7	7,12	1,2,3,4,5,7,8,9,10,11	7,12	II
8	8,11	1,2,3,4,5,6,8,11	8,11	IV
9	9,10	1,2,3,4,5,6,8,9,10,11	9,10	III
10	9,10	1,2,3,4,5,6,8,9,10,11	9,10	III
11	8,11	1,2,3,4,5,6,8,11	8,11	IV
12	7,12	1,2,3,4,5,6,7,8,9,10,11,12	7,12	II
13	13	1,2,3,4,5,6,7,8,9,10,11,12,13	13	I

3. 4 Formation of ISM-based model

The structural model is generated from final reachability matrix as given in Figure 1. If there is a relationship between the SC collaboration CSF *i* and *j*, this is presented by an arrow which points from *i* to *j.* This graph is called a directed graph, or digraph. It is a diagram composed of points called vertices and arrows called arcs going from a vertex to another vertex. A digraph is drawn for the results where the factors are placed according to their levels, with level I factors at the top and level IX factors at the bottom. The first level factors are the factors that do not influence any other factor but are influenced easily by other factors. Similarly the second level factors influence level I factors above it but are influenced by level III factors, below it. The initial diagraph is drawn by joining the factor's node with arrows pointing according to the direction of their antecedent. After removing the transitivity of the ISM methodology, the final digraph is formed (Figure 1) and is converted to ISM-based model by replacing variable nodes with the statements (Figure 2).

FIGURE 1: FINAL DIAGRAPH DEPICTING THE RELATIONSHIP OF SC COLLABORATION CSFs

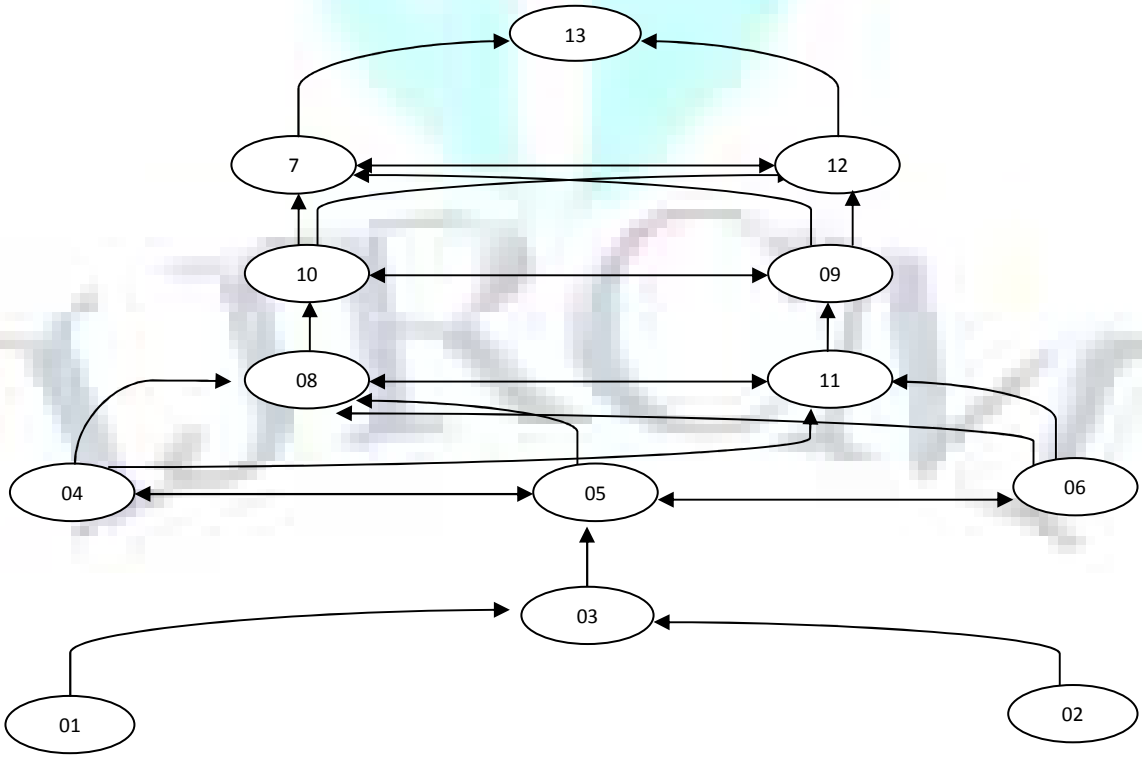
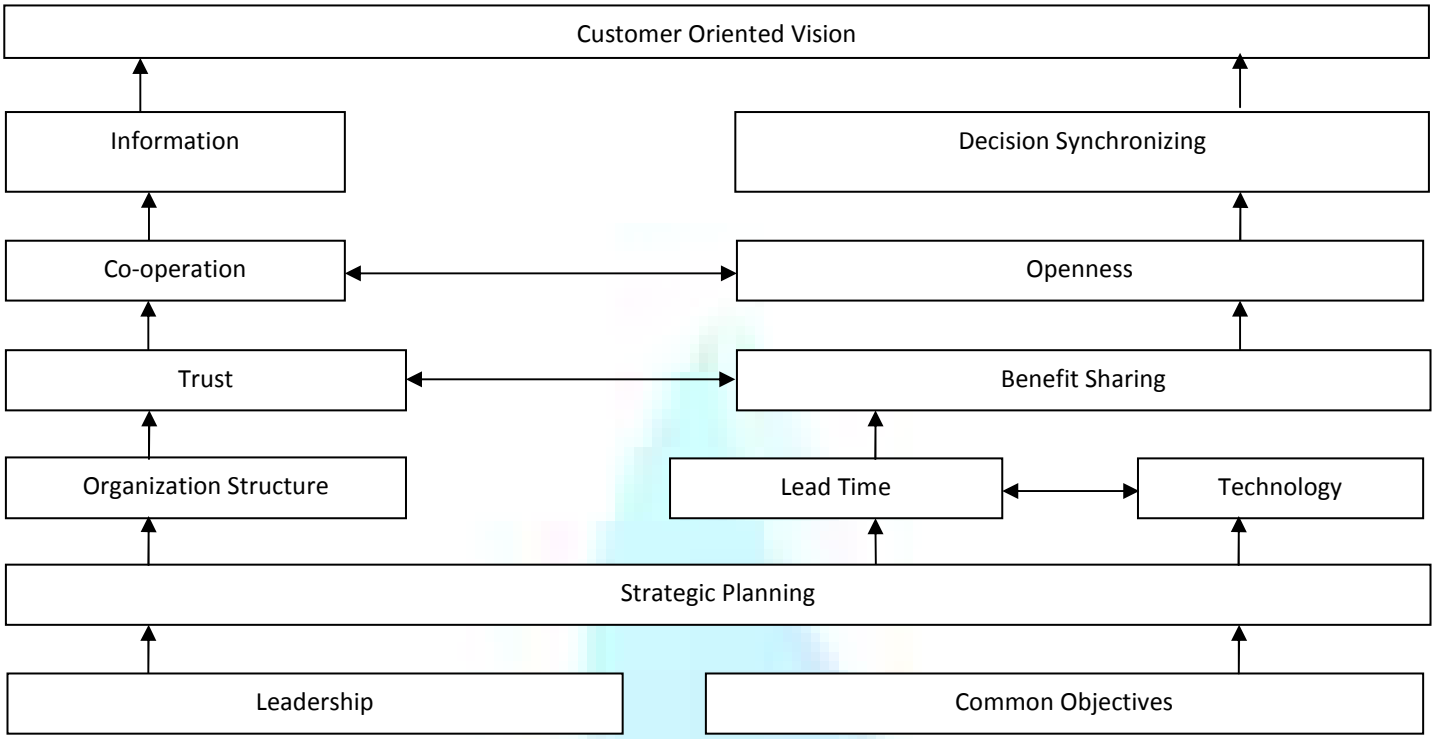


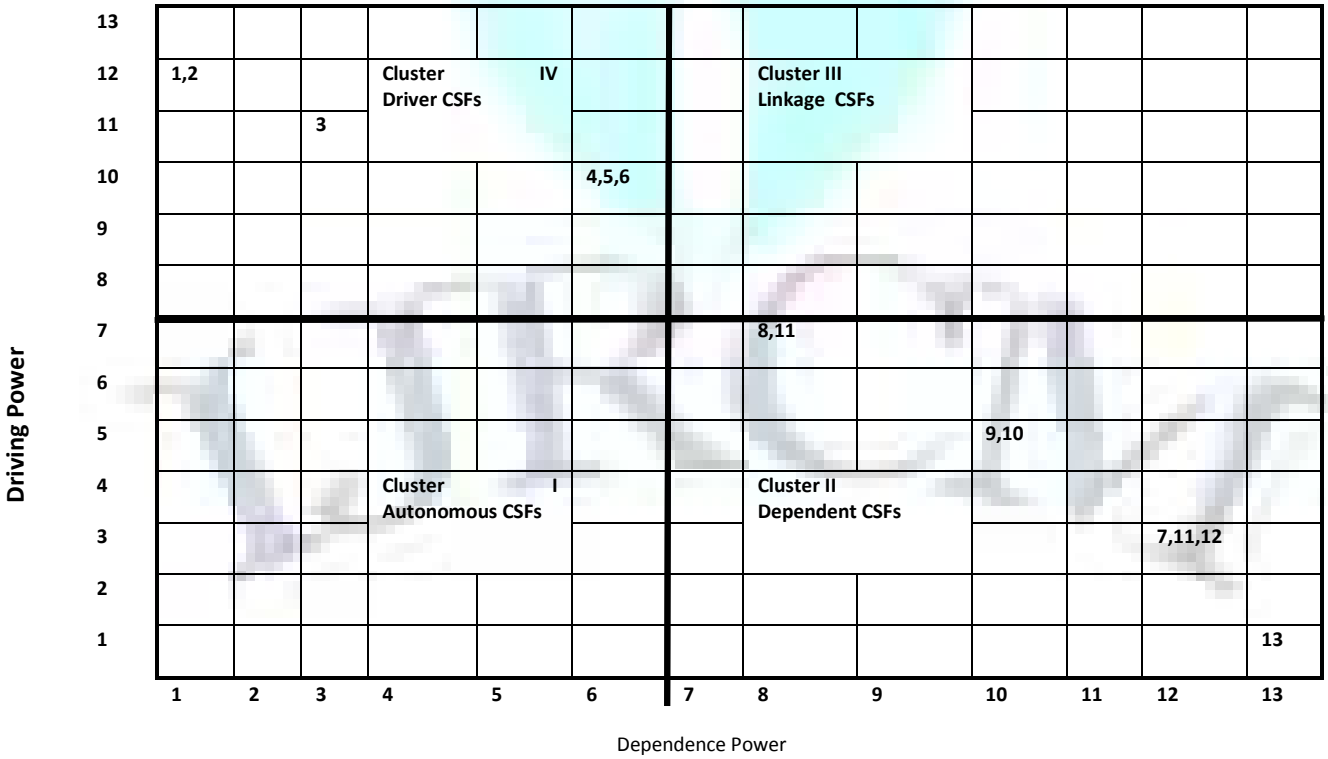
FIGURE 2: ISM BASED MODEL OF SC COLLABORATION CSFs



4. ANALYSIS OF ISM MODEL FOR SC COLLABORATION CSF

All CSF have been classified, based on their driving power and dependence power, into four categories as autonomous, dependents, linkages, and independent SC collaboration CSFs. The above classification is similar to the classification used by Mandal and Deshmukh (1994). The driving power and dependence power of each SC collaboration CSF are shown in Table 4. The driving power and dependence power diagram for SC collaboration CSFs are shown in Figure 3. It is observed from Table 4 that Lead Time (CSF 5) has a dependence power of 6 and a driving power of 10 and therefore, it is positioned at a place which corresponds to a dependence power of 6 and a driving power of 10 in Figure 3. The objective behind the classification of SC collaboration CSFs is to analyze the driving power and dependence power of the SC collaboration CSFs.

FIGURE 3: CLUSTERS OF SC COLLABORATION CSFs



5. DISCUSSIONS AND CONCLUSION

Development of ISM model (Figure 2) and categorization of SC collaboration CSFs (Figure 3) have following managerial implications:

The driving power - dependence power diagram (Figure 3) indicates that there are no autonomous CSFs in the process of SC collaboration CSF. Autonomous CSFs are weak drivers and also weak dependent. The autonomous CSFs are relatively disconnected from the system, with which they have only few links, which may

not be strong. Hence, they don't have much influence on the system. Therefore, among the thirteen selected CSFs, all the CSFs have much influence in the SC collaboration. Hence top management can't take lightly any of these CSFs, if they are very serious to make SC collaboration successful.

Information sharing (CSF 7), Trust (CSF 8), Cooperation (CSF 9), Openness (CSF 10), Benefit sharing (CSF 11), Decision synchronizing (CSF 12) and Customer oriented vision (CSF 13) are weak drivers but are strongly dependent on the others (Figure 3). They are seen at the top of the ISM hierarchy (Figure 2), therefore considered as important SC collaboration CSFs. Their strong dependence indicates that they require all the other SC collaboration CSFs to minimize the effect of these CSFs in SC collaboration. The management should therefore accord high priority in tackling these CSFs. Besides tackling these CSFs, management should also understand the dependence of these CSFs on lower level of the ISM.

There are no CSFs in the linkage category that has a strong driver power and also a strong dependence (Figure 3). Any change occurring to these CSFs will have an effect on others and also a feedback on themselves. Hence, these CSFs are unstable in nature which may affect the successful SC collaboration in the organizations either in positive or negative way. The absence of any linkage SC collaboration CSFs in this study indicates that no CSF is unstable among all the twenty CSFs chosen in this study.

The driving power and dependence diagram (Figure 3) indicates that independent CSFs such as Leadership (CSF 1), Common objectives (CSF 2), Strategic planning (CSF 3), Organization Structure (CSF 4), Lead Time (CSF 5) and Technology (CSF 6). Thus management needs to address these CSFs more cautiously and may be treated as the root causes of all the CSFs. It has been observed that these CSFs help to achieve the CSFs which appear at the top of the ISM hierarchy. Therefore, it can be anecdotal that management should work out strategies to facilitate these independent CSFs for successful SC collaboration. Those CSFs possessing higher driving power in the ISM need to be taken care on priority basis because there are few other dependent CSFs being affected by them.

ISM has capability to develop theoretical model only through managerial techniques such as brain storming, group technique, etc. It is only subjective judgment and doesn't give any weight age associated with the CSFs. The contextual relation among the SC collaboration CSFs 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 SC collaboration CSFs might influence the final result.

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