STRUCTURAL FLEXIBILITY IN SUPPLY CHAINS - A SELECT DIAGNOSTIC ANALYSIS

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Abstract: *Since the evolution of concept of Supply Chain in early 1980s, it has drawn attention of several researchers and practitioners for further study on the related aspects of Supply Chains (SCs) and Supply Chain Management. Of all, flexibility aspects in supply chains has gained more popularity as "Flexibility" supports a firm's supply chain to be more 'Responsive to change'. In the context of supply chains, Flexibility is defined in terms of 'the ability of the SC to respond rapidly to demand changes in volume or mix for products (Christopher, 2011). The supply side also calls for ability of SCs to respond for rapid changes in the demand. 'Structural flexibility' reflects on the ability of SC to adapt or reconfigure its architecture in response to major changes in the demand side and/or supply sides (Christopher, 2011). This paper has explored the key structural elements that support Flexibility in the Supply Chain of the firm. The paper also represents the results of research undertaken which is diagnostic in nature.*

Keywords: Supply Chains, Structural Flexibility, Network Orchestration, Inter-operability of processes, ISM.

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Introduction

In the changing scenarios, the markets are becoming hyper competitive with dominating driving powers of the customers. The rapid changes in the customer's priorities have made ways for faster delivery, product variety, high quality of the product and services etc. Several firms have already identified the importance of these factors and trying to re-design their Supply Chains. With the help of advent of new technologies, firms are accelerating innovations in products and processes resulting in flexibility in all the channel members of their Supply Chains. Supply Chain as the name indicates is a virtual chain linking customers to suppliers. A flexibility aspect of supply chain is an area of high levels of interest among the modern researchers and practitioners. The unwanted turbulences in the business systems and processes, the strength of the firm for its sustainability is its effective Supply Chain. Developing a competence in the area of Supply Chain Management is expected to have a long term impact on the SC Competitiveness and Business performance (Rao, Wadhwa, 2002). Flexibility is an alternative means of coping with demand uncertainty (Garves & Tomlin, 2003). Flexibility in turn makes the chain more vulnerable to the rapidly changing industrial environments which ultimately make it more robust and sustainable. While observing the tremendous benefits of flexible supply chains, more research has taken place in that field in the recent scenario. In continuation to this most of the manufacturing sectors adopted these strategies for flexible systems management which in succession got dittoed to various service sectors. For a firm to be successful, it must be able to elevate the 'flexibility' from an operational perspective to 'cross-organisational perspective'. This evolution from individual organisation flexibility to cross-firm flexibility results in the requirement that entire Supply Chains be "flexible" (Duclos et al., 2003).

1. Methodology

The research undertaken is diagnostic in nature. The scope of the study was confined to select Indian firms (irrespective sector of operation) in and around select major cities in the state of A.P. The selection criterion for including a firm in to the sample is that the firm should well defined Supply Chains Systems in place and manage all the activities that are essentially involved in an effective Supply Chain.

The qualitative data for the study was collected through (i) study of various available documents in the select firms and (ii) semi-structured interviews with the Supply Chain Managers of the firms. Interpretive Structural Modeling (ISM) methodology was used. The

objectives of the study required qualitative data. The qualitative data was collected through semi-structured interviews with SC Managers in the select firms. The selection of firms into the sample is based on “Random Sampling”. In Random sampling which is also known as “Probability sampling” or “Chance sampling”, every item of the universe has an equal chance to be included in the sample. The results obtained by random sampling can be assured in terms of probability. Random Sampling ensures the law of Statistical Regularity which states that “if on an average the sample chosen is a random one, the sample will have the same composition and characteristics as of the universe” (Kothari, 1990).

2. Analysis using Interpretive Structural Modelling

ISM supports group judgment on the extent and nature of relationship among elements. The interpretations of the group were used to draw and overall structure from the complex set of elements. The final structure has been portrayed in a diagraph model (Sage, 1977). Identification of structure with in a system is of great value in dealing effectively with the system and better decision-making. (Sxena et. al., 2006). According to them the ISM can be defined as a process that transforms unclear and poorly articulated mental models of a system in to visible, well-defined models useful for many purposes.

3.1 *ISM Methodology*

In the present study, Interpretive Structural Modelling (ISM) is used to achieve the research objectives. ISM is an interactive learning process (Pramod and Banwet, 2010). In this a set of different directly and indirectly related elements are structured into a comprehensive systemic model (Warfield, 1974; Sage, 1997). The model so formed portrays the structure of a complex issue, a system of a field of study, in a carefully designed pattern employing graphics as well as words (Thakkar et al, 2008). ISM methodology helps to understand the order and direction on the complexity of relationships among elements of a problem under study (Sage, 1977). The direct and indirect relationships among various elements depict the situation more accurately than the case when an individual factor is considered in a stand-alone mode. ISM develops insights into the collective understanding of these relationships.

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 a complex set of variables. It is a modelling technique as the specific relationships and overall

structure are portrayed in a graphical model. It is primarily intended as a group learning process but can also be used individually.

3.2 *Structural Self-Interaction Matrix (SSIM)*

The scenario was discussed in detail with reference to the study with the concerned experts in the select firms, and also expert opinion was sought from the experts from the academia. ISM methodology suggests use of expert opinions using brain storming, nominal group techniques etc. (which are some of the management techniques for developing the contextual relationship). For analysing the barriers in developing SSIM the following four symbols have been used to denote the direction of relationship between the elements (I and J):

V – Variable i will help achieve variable j

A – Variable j will help achieve variable i

X – Variables i and j will help each other

O – Variables i and j are unrelated

Through detailed discussions with senior mangers of select banks, the following list of key elements was identified for understanding the objectives:

1. Visibility
2. Information flow
3. Information sharing
4. Access to capacity
5. Inter-Operability of processes
6. Network orchestration
7. Structural flexibility
8. Access to Knowledge & talent

These elements were subjected to approval of the interviewees for representation of the study variables in this study. Considering these elements, a Structural Self-Interaction Matrix (SSIM) was developed by determining a contextually relevant subordinate relation among the select elements. Following the consultation and approval of interviewed experts from select firms, the final SSIM representing the pair wise comparison of the elements was developed. The development of SSIM requires depicting dependence among all possible pairs of elements by choosing a contextual relationship showing which elements lead to which other element. Also the derived SSIM was subjected to the consensus of interviewed experts of

banks under the population. Based on their feedback, the SSIM was modified and is shown in Table.1.

Table.1: Structural Self-Interaction Matrix (SSIM)

		8	**7**	**6**	**5**	**4**	**3**	**2**
1	Visibility	O	V	V	V	V	A	A
2	Information flow	V	V	V	V	V	A	
3	Information sharing	V	V	V	V	O		
4	Access to capacity	X	V	V	V			
5	Inter-operability of processes	O	V	A				
6	Network orchestration	A	V					
7	Structural flexibility	A						
8	Access to knowledge & talent							

3.3 Reachability Matrix

(i) SSIM has been converted in to a binary matrix called “initial reachability matrix”. It is developed by substituting V, A, X, and O by 1 and 0. The substitution of 1 and 0 is as per the rules of ISM methodology.

The initial reachability matrix for the relationships among the select elements is made and is shown in Table 2.

Table 2: Initial Reachability Matrix

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	1	0	0	1	1	1	1	0
2	1	1	0	1	1	1	1	1
3	1	1	1	0	1	1	1	1
4	0	0	0	1	1	1	1	1
5	0	0	0	0	1	0	1	0

6	0	0	0	0	0	1	1	0
7	0	0	0	0	0	0	1	0
8	0	0	0	0	0	1	1	1

After incorporating the transitivities i.e., if one element A leads to element B (A => B) and element B leads to element C (B => C) then element A should also lead to element C (A => C), the final reachability matrix is developed and is shown in Table 3.

Table 3: Final Reachability Matrix with Driver power and dependence

Element	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	Driving power	Ranks
1	1	0	0	1	1	1	1	0	5	3
2	1	1	0	1	1	1	1	1	7	2
3	1	1	1	1	1	1	1	1	8	1
4	0	0	0	1	1	1	1	1	5	3
5	0	0	0	0	1	0	1	0	1	6
6	0	0	0	0	0	1	1	0	2	5
7	0	0	0	0	0	0	1	0	1	6
8	0	0	0	1	0	1	1	1	4	4
Dependence	3	2	1	5	5	6	8	4		
Ranks	5	6	7	3	3	2	1	4		

3.4. Classification of elements

Based on the dependence and driver power, the elements under study are subjected to MICMAC analysis (Duperrin and Godet, 1973) and classified into four sectors, namely autonomous, dependent, linkage and driver/independent. The driver power and dependence of the elements is indicated in Table 4.

Table 4: MICMAC Analysis

Driver Power									
	8	3							
	7		2						
	6		**IV**					**III**	
	5			1		4			
	4				8				
	3		**I**				**II**		
	2						6		
	1					5			7
		1	2	3	4	5	6	7	8

Dependence

From the table the sector classification is made and is as follows.

I – Autonomous

II – Dependent

III – Linkage

IV – Independent (Driver)

The autonomous elements have a weak driver power and weak dependence relatively disconnected from the system. These elements have few links which may be strong. The dependent elements have weak driver power but strong dependence. The linkage elements on the other hand have strong driver power and dependence. These elements are unstable due to the fact that any action on these elements will affect the other and also a feedback on themselves. The driver or Independent variables condition the rest of the system (Mandal and Deshmuk, 1994). It is observed that the key variables with strong driver power fall into the category of independent or linkage elements (Ravi and Shankar, 2005).

The key elements viz., Visibility, Information flow and Information sharing have fallen in the Independent sector in the MICMAC Analysis while Access to capacity has fallen in the

Linkage category and proven to be the conditioning elements of the rest of the elements. The linkage element such as Access to capacity has shown strong driver power and strong dependency on the other elements of the system. The element viz., Structural Flexibility has shown highest dependence on all other elements.

3.5 Level Partition

The reachability set and the antecedent set for each criteria are depicted in APPENDIX – A. The ISM methodology is adopted deliberately with an intention to study the indirect relationships of the elements. The structural model has been derived form the connective information contained in the diagraph shown at figure 1. The details of the sub-elements are indicated in the respective boxes with indicated relationships as depicted in the fig.2.

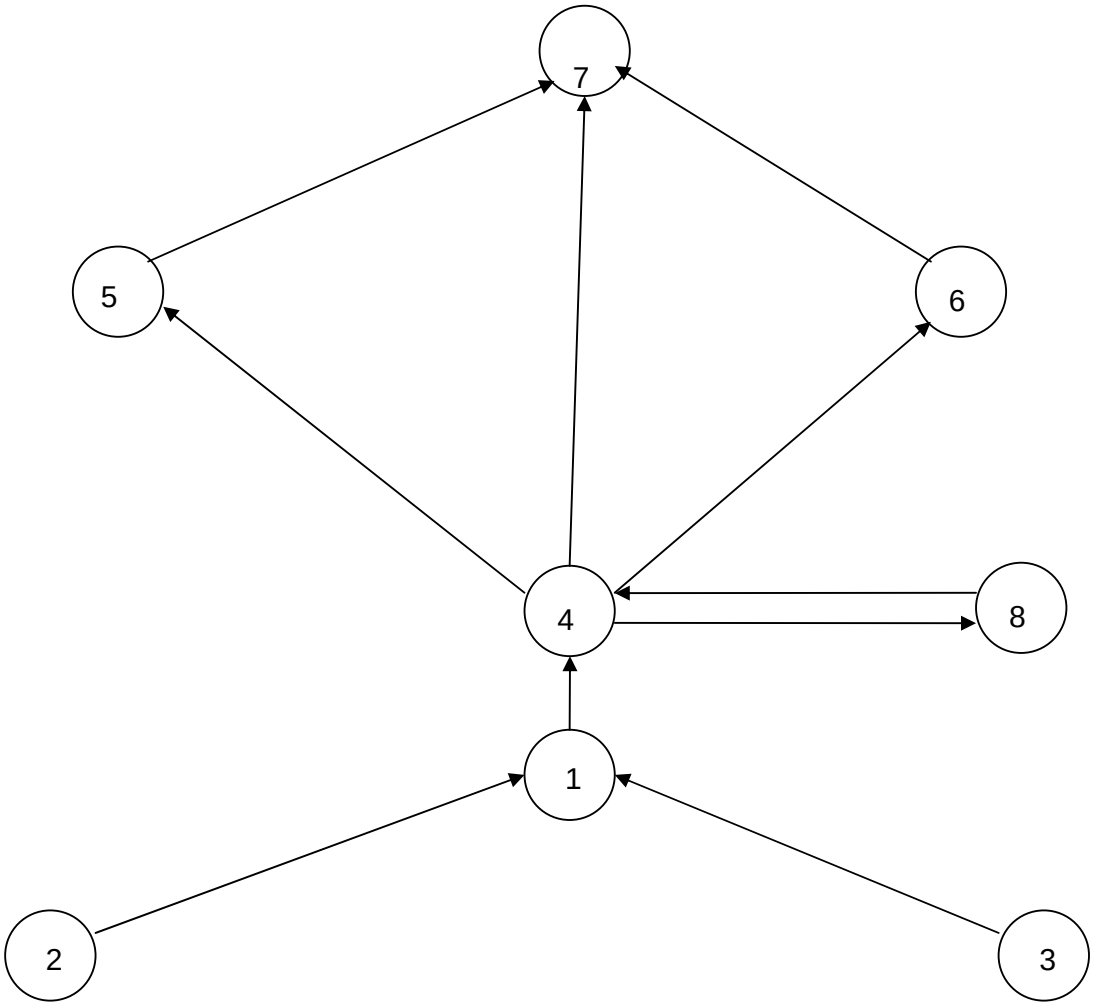

Figure 1. ISM DIAGRAPH

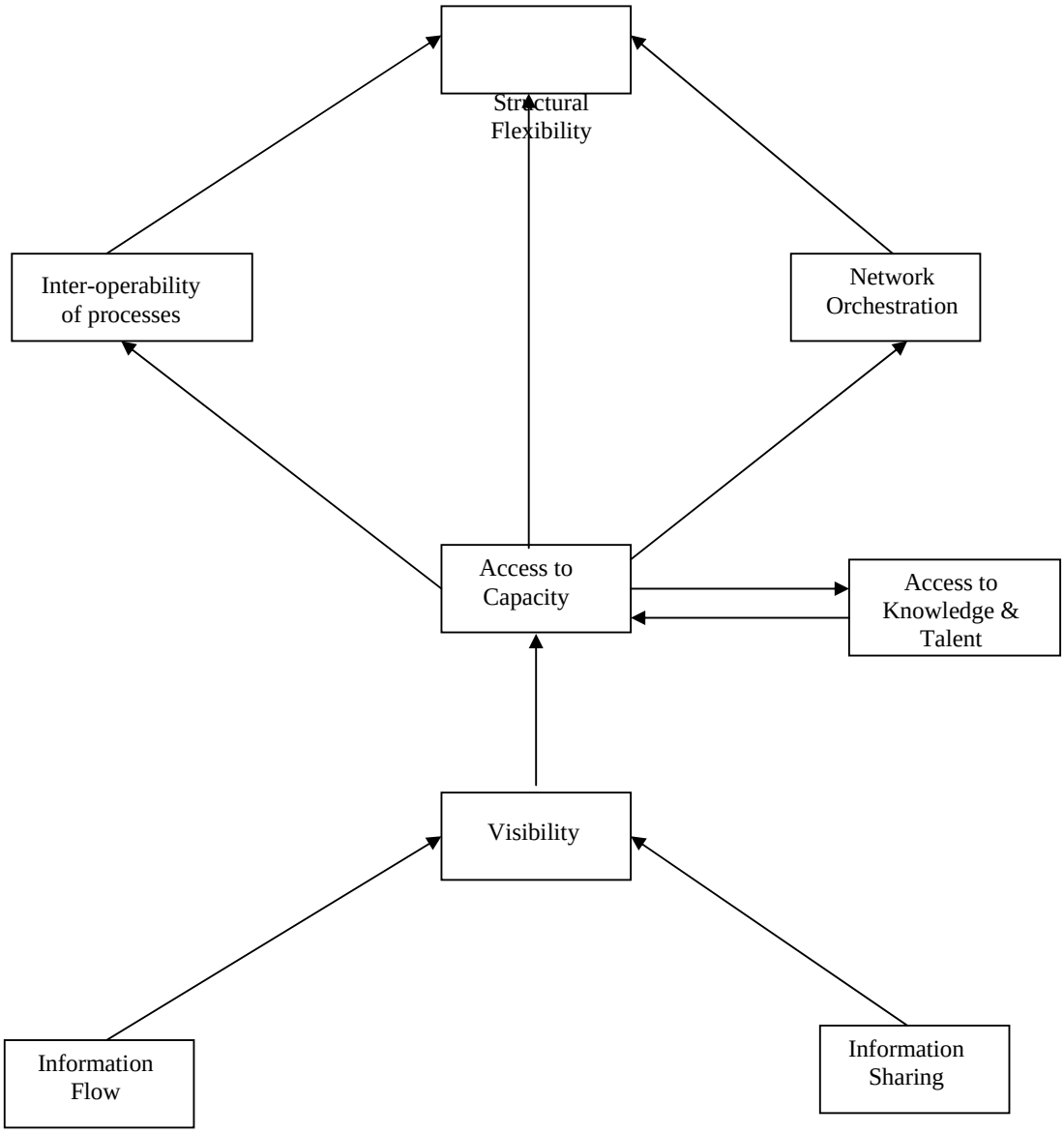

Figure 2. The element inter-relationships in digraph (ISM)

4 Results and Discussion

In the present scenario a paradigm shift has already taken place. The mass production and mass marketing strategies are getting replaced by Global customisation and one-to-one marketing strategies leading to the concept of Extended Enterprise Systems. These facts are

being validated by the structural model that has been derived from ISM in the present study. The key element Structural Flexibility has shown high dependence on the other structural elements. The information sharing among all the verticals of the given firm is the driving power of its SC and helps the firm to cope up with the demand uncertainties. For a given firm, its ability to view end-to-end of its SC (from both ends, i.e., from supplier to customer and back to supply side) is its Visibility. According to Chiristopher (2011), information sharing through the channel of information flow provides a powerful plat form for a firm on which it can build collaborative working relationships across its SC. This has been proven by the ISM model.

With the improved Visibility a firm can have an increased access to its capacity and through to its knowledge and talent resources. Visibility helps firms to evaluate its capacity in terms of capacity with every channel partner viz., Raw material procurement, manufacturing, warehousing, packing, inbound and outbound logistics, Marketing, Sales & distribution, reverse logistics etc. Access to the knowledge of the changing market trends and customer priorities is highly essential for a firm to initiate innovation on the product as well as the process using its internal talent. This will help the firm for capacity adjustments there by resulting dyadic relations between the two. The rapidly changing customer priorities call for a firm's ability to operate multiple SCs to serve for a specific market. This leads to "inter-operability" of the nodal points representing the various channel partners and their linkages with in firm's SC. As several relevant instruments are used in a way to portray any musical aspect such as melody or harmony, the orchestration of the channel partners for activity synchronisation is becoming more essential for a firm for effective SCs. The ISM Model has proven that the ability of the firm to access market knowledge and firm's capacity that support in re-engineering its SC network, orchestrating the channel partners and synchronising the activities across the SC resulting the Structural flexibility i.e., the ability of SCs to reconfigure its network design in compliance to the rapid changes on both sides of the SCs.

5 Conclusion

This research pinpoints the importance of various elements on the resulting structural flexibility. By analyzing the contributions of various elements to the overall system, it is possible for SC managers to plan their future strategies in a much precise and deterministic

manner. The research undertaken in this case revealed that Access to capacity is the most crucial element where maximum attention has to be focused. Instead of making decision by intrusions and prior judgement, a much better situation can be visualized from this research. Ultimately this study adds to the body of flexibility studies in domain of Supply Chain Management with a new insight of strategy which paves ways to the future researchers.

APPENDIX – A

Level partition of Elements

Level - 1 :				
Element	Reachability set	Antecedent Set	Intersection	Level
1	1,4,5,6,7	1,2,3	1	
2	1,2,4,5,6,7,8	2,3,	2	
3	1,2,3,4,5,6,7,8	3	3	
4	4,5,6,7,8	1,2,3,4,8	4	
5	5,7	1,2,3,4,5	7	
6	6,7	1,2,3,4,6,8	6	
7	7	1,2,3,4,5,6,7,8	7	1
8	4,6,7,8	2,3,4,8	8	

Level - 2 :				
Element	Reachability set	Antecedent Set	Intersection	Level
1	1,4,5,6	1,2,3	1	
2	1,2,3,4,5,6,8	2,3,	2	
3	1,2,3,4,5,6,8	3	3	
4	4,5,6,8	1,2,3,4,8	4	
5	5	1,2,3,4,5		2
6	6	1,2,3,4,6,8	6	2
8	4,6,8	2,3,4,8	8	

Level - 3 :				
Element	Reachability set	Antecedent Set	Intersection	Level
1	1,4	1,2,3	1	
2	1,2,3,4,8	2,3,	2	
3	1,2,3,4,8	3	3	
4	4,8	1,2,3,4,8	4	3
8	4,8	2,3,4,8	8	3

Level - 4 :				
Element	Reachability set	Antecedent Set	Intersection	Level
1	1	1,2,3	1	4
2	1,2,3	2,3,	2	
3	1,2,3	3	3	

Level - 5 :				
Element	Reachability set	Antecedent Set	Intersection	Level
2	2,3	2,3,	2	5
3	2,3	3	3	5

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