MODELLING THE BARRIERS OF INTEGRATION IN AN AGILE SUPPLY CHAIN

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ABSTRACT

Integration is an important desirable characteristic of agile supply chain. The difficulty in achieving a total integration is due to dynamic and conflicting objectives employed by different supply chain partners. There are some barriers in this process. These barriers have influences on one another and also adversely affect the supply chain integration. The aim of this paper is to understand the mutual influences so that those barriers which are at the root of few more barriers (called driving barriers) and those which are most influenced by others (called dependent barriers) are identified. Interpretive structural modeling (ISM) methodology has been used to evolve such relationships. It is observed that there are some barriers, which have both high driving power and dependency and therefore need more attention. The study concludes with a discussion on these barriers and the managerial implications.

Key words: *Integration, supply chain agility, Barriers, Interpretive structural modeling (ISM)*

INTRODUCTION

The success of agile supply chain lies in the willingness of partner firms to share information for their mutual benefits. Still, many firms are reluctant to share information with their trading partners (Lee and Whang, 2000; Power et al., 2001). This reluctance acts as barrier in integration of agile supply chain. Cooper et al., (1997) have suggested that top management support, leadership, and commitment to change and innovation are important antecedents to the integration of a supply chain. Handfield and Nichols (1999) have discussed the integration risk in selecting a supply chain partner who is in poor financial condition. By integrating supply chain, the original equipment manufacturers can sharply reduce production lead-times, add flexibility in order modification, and speed the supply chain (Mason et al., 2002). Time-based competition refers to the ability to deliver products or services faster than other competitors. Management of time, specifically lead-time, can be a competitive advantage. Naylor et al., (1999) have shown the necessity for lead-time reduction and service level improvement as prerequisites to agility. Collaboration improves trust among trading partners, which motivates them to share business information and to work on the same data (Agarwal and Shankar 2003). Trust among trading partners in inter organizational relationships improves communication and dialogue and create common strategic visions (Sahay, 2003).

Reasons for the slow growth of integrated supply chain management include the lack of guidelines for creating alliances with supply chain partners, failure to develop measures for monitoring alliances, Inability to broaden the supply chain vision beyond procurement or product distribution to encompass larger business processes, inability to integrate the company's internal procedures, lack of trust inside and outside a company, organizational resistance to the concept, lack of buy-in by top managers, lack of integrated information systems and electronic commerce linking firms (Lummus and Vokurka, 1999). A framework for supply chain integration is depicted in figure 1.

< Insert Figure 1>

IDENTIFICATION OF BARRIERS IN INTEGRATION OF AGILE SUPPLY CHAIN

Growing evidence indicates that a higher level of integration with suppliers and customers is expected to gain the greater potential benefit (Shankar and Agarwal 2004, van Hoek et al., 2001; Goldman 1995; Stevens 1989). The eleven barriers considered in this study have been identified after consulting related literature and industry experts in the field of supply chain management. These are:

1. Lack of Top Management Commitment

Top management of the partner organizations in a supply chain play an important role in developing policies, which may lead to healthy and collaborative relationship between the buyers and suppliers (Akkermanns et al., 1999; LaLonde, 2000). The commitment of the top management in SCM practices (such as improved buyer-supplier relationships, information sharing etc) is a key component for the successful adoption of SCM (Moberg et al., 2002).

2. **Missing long term buyer supplier relationship (MSBSR)**

Effective supply chain integration and synchronization among partners can eliminate excess inventory, reduce lead times, increase sales, and improve customer service (Agarwal and Shankar 2002; Anderson and Lee 1999; Bal et al., 1999). Companies are now moving towards collaborative SCM in an effort to reduce the information imbalances that result in the dreaded “bullwhip effect” (Lee et al., 1997: Ellram, 1990 and 1991), while increasing their responsiveness to market demands and customer service (Mentzer et al., 2000).

The result of collaborative SCM is not only the reduction of waste in the supply chain, but increased responsiveness, customer satisfaction, and competitiveness among all members of the partnership. Thus, collaborative SCM systems allow organizations to progress beyond mere operational-level information exchange and optimization and can transform a business and its partners into more competitive organizations (Christopher and Jittner 2000).

3. Forecasting Problems

Forecasting is the art and science of making projections about what future demands and conditions will be. Obtaining forecasting information frequently means using sophisticated techniques to estimate future sales or market conditions. The forecast of demand forms the basis for all strategic and planning decisions in a supply chain. When each stage of the supply chain makes its own separate forecasts, these forecasts are often very different. The result is a mismatch between supply and demand. In an integrated supply chain, all stages of a supply chain produce a collaborative forecast, it tends to be much more accurate (Chopra and Meindl, 2004).

4. **Lack of Information Sharing (LIS)**

The use of information technology to share data between buyers and suppliers is, in effect, creating a virtual supply chain. Virtual supply chains are information based rather than inventory based. Conventional logistics systems are based upon a paradigm that seeks to identify the optimal quantities of inventory ands where it should be located. Complex formulae and algorithms exist to support this inventory-based business model.

Paradoxically, what we are now learning is that once we have visibility of demand through shared information, the premise upon which these formulae are based no longer holds. Electronic Data Interchange (EDI) and the Internet have enabled partners in the supply chain to act upon the same data (i.e. actual sales figures) rather than to rely on the distorted and noisy picture that emerges in an extended supply chain (Jharkharia and Shankar 2003; Lee et al. 2000).

5. Lack of Trust (LOT*)*

Trust is defined as the binding force in most buyer-supplier transaction (Agarwal and Shankar 2003). It is especially critical when two situational forces are present in a transaction: uncertainty; and asymmetric product information. Many researchers have proposed that trust is essential for understanding interpersonal behavior and economic exchanges. Trust is perceived as a state of readiness for unguarded interaction with someone or something (Ba 2001).

Handfield and Bechtel (2002) have stated that the primary relational requirement for improved responsiveness is the development of greater levels of trust between purchasing organizations and their suppliers. The nature of trust and the nature of business transaction often temper the relationships. Trust among trading partners in inter organizational relationships improves communication and dialogue and create common strategic visions (Heide and John 1990).

6. Lack of Flexibility

With the emergence of a global economy that embraces 'change' as one of its major characteristics, success and survival of business are becoming more and more difficult. The emphasis is on adaptability to changes in a highly competitive business environment and on proactively addressing market and customer needs. Changes in the business environment due to varying needs of the customers lead to uncertainty in the decision parameters. Flexibility is needed in the supply chain to counter uncertainty in the decision-making. A supply chain can adapt to the changes if it is flexible and agile in nature.

7. Resistance to Change and Innovation (RCI)

Resistance has been classically understood as a foundation cause of conflict that is undesirable and detrimental to the health of any enterprise (Waddell and Sohal 1998). Resistance to change has long been recognized as a critically important factor that can influence the success or otherwise of an organizational change effort.

Similarly, resistance, among trading partners of supply chain, is an expression of reservation, which normally arises as a response or reaction to change. Management of SC normally witnesses this expression, as any trading partner's actions are perceived as attempting to stop, delay, or alter change (Handfield and Bechtel 2002). Thus resistance is most commonly linked with negative trading partner attitudes or with counter-responsive behaviours. Resistance to change can be handled when there is trust development among trading partners and they are involved in the strategic planning.

8. Poor Infrastructural Facility

Infrastructure to deploy an integrated supply chain presents a set of challenges. Infrastructure includes transportation facility available in the country of trading partners of the supply chain. Legal constraints exist sometimes prevent integration of the supply chain system. Shipments may be held in customs for interminable periods for any number of reasons. Telecommunication systems are often unreliable. Workers of trading partners in the supply chain may be not familiar with the latest technology and may destroy equipment due to lack of training (Handfield R.B. and Nichols Jr. E.L, 1999).

9. Disparity in Trading Partners' Capability

Getting the products to customers when, where, , how, and in the quantity that they want, in a cost effective manner, presents a new challenge to supply chain integration. To meet this challenge, organizations are focusing on their supply base and sourcing strategy. Disparity in trading partners' capability is a major barrier in integration of agile supply chain because partnership fails due to poor capability at partner's end (Yusuf et al., 1999 and 2004, Power et al., 2001). This poor capability implies poor inventory management, poor logistics system, weak financial position, etc.

10. Non-availability of Cross Functional Work Force

Cross-functional work forces are distinguished from other working groups by their commitment to a common purpose and goals. They are recognized by their ongoing mutual accountability to achieve common goals. These cross functional groups are often organized around a product or service, and may be responsible for all aspects of that products or service from design and development to customer support.

11. Fund Non-availability

Funds availability helps finance, which provides costs forecasts related to inflation rates and growth assumptions that need to be built into the planning process to project future costs (Lockamy III and Smith, 2000),. Finance /accounting provide the cost data required to perform the cost trade-off analysis. It is also responsible for capital budgeting, which determines the availability of capital budgeting, which determines the availability of capital to finance expenditures to improve logistics equipment and infrastructure (Gunasekaran et al., 2001 and 2003). Capital budgets are used to control capital expenditures, such as long-term investments in property, facilities, and equipment. In logistics, this would include purchase of new trucks, computer equipment, material handling and warehouse equipment, the building of new distribution centres, and similar long-term investment.

QUESTIONNAIRE DEVELOPMENT

To address the issues related to integration of supply chains in Indian industry, a questionnaire-based survey was undertaken. The questionnaire was designed keeping in view the available literature and the previous surveys. The practicing managers and academicians in the area of SCM were also consulted during the development of the questionnaire.

As the response rates of such surveys are not enthusiastic and the respondents are generally reluctant to spare time in responding to these questionnaires, the questionnaire was designed as close-ended, so that lesser time and efforts are needed in filling the questionnaire. The questions were framed on a five-point Likert-scale. However, some of the questions contained an option of yes/no type. In order to perform the statistical analysis, individual responses were coded 1 through 5 accordingly. The questionnaire was divided into three sections. Section I dealt with the company’s profile, while Section II dealt with issues related to agility, flexibility, responsiveness, customer relation, supplier relation, and integration of supply chains, and Section III dealt with the performance measurement related issues in SCM.

The questionnaire was tested for two main types of validity, which are content validity, and construct validity. Content validity represents the adequacy with which a specified domain of content is sampled (Nunally, 1978) and that the instrument item has items that cover all aspects of the variables being measured. Content validity cannot be determined numerically. Its determination is subjective and judgmental. It primarily depends on an appeal to the propriety of content and the way it is presented (Nunally, 1978). The instrument developed in this study demonstrates the content validity as the selection of measurement items was based on both, an exhaustive review of the literature and evaluation by academicians and practicing managers during its pre-testing. The content validity was further tested during pilot survey as per the guidelines provide by Forza (2002). After a careful review of respondents' answers to the questionnaire during pilot survey, some questions were modified to convey their intended meaning, and few questions were deleted from the questionnaire as per the suggestions received from the respondents. The construct validity was conducted through an exploratory factor analysis. Factor analysis was conducted to test the uni-dimensionality of the multi-items perceptual measures. As per the suggestion of Kim and Muller (1978) only those items, which had a factor loading of more than 0.40 were used in the questionnaire.

QUESTIONNAIRE ADMINISTRATION

Target Industries for Questionnaire Administration

Three sectors from the Indian industry were selected for the administration of the questionnaire. These are:

(i) auto,

(ii) electrical and electronics goods, and

(iii) fast moving consumer goods (FMCG).

Improvement in Survey Instruments

Before sending the questionnaire to the companies, a pilot study was carried out in few industries. The idea behind carrying out the pilot study was to:

(i) have a fruitful feedback from the executives working in the area of supply chain management,

(ii) add missing questions,

(iii) delete any irrelevant question, and

(iv) refine/rephrase the language of the existing questions to bring in more clarity in the questionnaire.

A total of fifteen executives in the area of supply chain management were personally contacted. Accordingly the questionnaire was modified and a final questionnaire was evolved. It was then mailed to different companies.

Questionnaire Administration

A total of 760 questionnaires were mailed to different companies of the selected sectors throughout the country. These companies were carefully selected from the directory of public sector, private sector, and government companies which also include OEMs and suppliers in auto, fast moving consumer goods, and electrical and electronics goods business.

SURVEY RESPONSES AND RESPONDENTS PROFILE

Out of the 760 questionnaires, mailed to the Chief Executives/ Managing Directors, 317 responses were received. Out of this 35 responses were found incomplete and 103 responses were received with regret in filling up the questionnaire. Therefore, only 179 questionnaires were found usable. This gives an effective response rate of 23.55% (Table 1).

This survey is designed with two main objectives, which are (i) to examine the current practices and the issues related to agility and integration of Indian supply chains, and (ii) to test the validity of some hypotheses, which have been formulated in the earlier section of this paper. This is followed by the description of the methodology, adopted to achieve the survey-oriented research objectives. Subsequent to this, observations from the survey have been reported and discussed. Various other aspects of the survey such as questionnaire development, its administration, validity, descriptive statistics, and summary have been also discussed in this paper.

<Table 1>

Non-response Bias

A test of non-response bias is to compare the answers of the early and late respondents (Lambert and Harrington, 1990). The logic behind this is that the late respondents are more likely to answer the questionnaire like non-respondents than the early respondents (Armstrong and Overton, 1977). Therefore, non-response bias was assessed by comparing the responses, which were received late after sending two or more reminders (total 60 respondents in this case) with the early respondents, which were received either without a reminder or with a single reminder (119 in present case). The results from the t-test on some key variables of this study suggest that the early respondents do not significantly differ from the late responses. Therefore, non-response bias in this study is ruled out.

Reliability of the Questionnaire Survey

For question gauging the impact of barriers on supply chain integration, Cronbach's coefficient (Alpha, α) was calculated to test the reliability and internal consistency of the response (George and Mallery, 1999). Alpha, with a value of 0.88, is considered adequate for such exploratory work (Nunally, 1978). The value of α for all the questions except question 10 (d) and question 22 has been found to be more than 0.5. It implies that there is a high degree of internal consistency in the responses to the questionnaire.

OBSERVATIONS FROM THE SURVEY

Issues covered in questionnaire include issues related to agility and integration of supply chains. Questionnaire also covers issues related to market sensitiveness, centralized and collaborative planning, information sharing, flexibility, responsiveness, customer relationship, strategic partnership, supply chain performance measures, etc.

Figures 2 to 5 show the characteristics of the surveyed companies. From Figures 2 and 3, it is clear that almost half of the surveyed companies have more than ten suppliers and annual turnover of more than 100 crores.

<Figure 2>

<Figure 3>

The major portion of the respondents is from the automobile sector (47%), followed by electrical and electronics goods (28%), and fast moving consumer goods (25%) (Figure 4).

<Figure 4>

Figure 5 shows the trend in profit/loss as reported by the companies. For 21.2% of the companies, profit remained nearly the same as in the previous years, while for 25.1% of the companies, the profit was up to 10%. Of the respondents, it was found that 34.6% companies had profits more than 10%, and 12.8% companies had profit less than 10%. 6.1% of the respondents were unable to say anything regarding their profit trends.

<Figure 5>

Figure 6 shows that 90% of respondent companies believe that well integrated supply chain improves market share of the business in which supply chain is involved.

<Figure 6>

From Figure 7, it has been observed that lack of top management commitment (Mean = 4.56, Std Dev.= 0.704) is considered as the top most barrier in strengthening integration of supply chain, followed by missing long-term buyer-supplier relationship (Mean = 4.27, Std Dev.= 0.709), forecasting uncertainties (Mean = 4.26, Std Dev.= 0.886), lack of information sharing among partners (Mean = 4.21, Std Dev.= 0.916), lack of trust in supply chain linkages (Mean = 4.12, Std Dev.= 0.915), lack of flexibility (Mean = 4.06, Std Dev.= 1.06), resistance to change and adopt innovations (Mean = 3.98, Std Dev.= 0.997), poor infra structural facilities (Mean = 3.94, Std Dev.= 1.03), disparity in trading partners' capability (Mean = 3.86, Std Dev.= 1.03), non-availability of cross functional workforce (Mean = 3.85, Std Dev.= 1.01), and fund unavailability (Mean = 3.81, Std Dev.= 1.18).

<Figure 7>

From the survey, one gets information about the relative impact of barriers on supply chain integration, but one does not get information about the impact of one barrier on other. Similarly survey result does not reveal about the driving and dependence power of barriers. These barriers not only affect the process of integration but also influence one another. It is, therefore, important to understand their mutual relationship so that those barriers that are at the root of some more barriers (called driving barriers) and those which are most influenced by others (called driven barriers) are identified. After this, it is prudent for the management to accord appropriate attention to tackle these barriers.

ISM METHODOLOGY AND MODEL DEVELOPMENT

ISM is an interactive learning process whereby a set of different directly and indirectly related elements 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 employing graphics as well as words. ISM methodology helps to impose order and direction on the complexity of relationships among elements of a system (Sage, 1977; Saxena et al., 1990; Mandal and Deshmukh, 1994; Sharma et al., 1995; Singh et al., 2003). For complex problems, like the one under consideration, a number of barriers may be affecting the IT-enablement of supply chains. However, the direct and indirect relationships between the barriers describe the situation far more accurately than the individual factor taken into isolation. Therefore, ISM develops insights into collective understandings of these relationships.

The 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. It is primarily intended as a group learning process but can also be used individually. The various steps involved in the ISM technique are:

(i) identification of elements, which are relevant to the problem or issues, this could be done by survey or any group problem solving technique,

(ii) establishing a contextual relationship between elements with respect to which pairs of elements will be examined,

(iii) developing a structural self-interaction matrix (SSIM) of elements, which indicates pair-wise relationship between elements of the system,

(iv) 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 element A is related to B and B is related to C, then A is necessarily related to C,

(v) partitioning of reachability matrix into different levels,

(vi) based on the relationships given above in the reachability matrix draw a directed graph (DIGRAPH), and remove transitive links,

(vii) convert the resultant digraph into an ISM, by replacing element nodes with statements,

(viii) review the ISM model to check for conceptual inconsistency, and make the necessary modifications.

The various steps (Figure 8), which lead to the development of ISM model, are now illustrated as under.

<Figure 8>

Structural self-interaction matrix (SSIM)

In the present model, to identify relationship among supply chain integration barriers, brainstorming sessions were conducted with experts having experience in the area of materials and supply chain management.

Initial meeting was with the management of manufacturing organization. After identifying the five experts, literature related to supply chain management had been circulated among the experts. Within a period of fifteen days a brain storming session was organized to identify the variables. In all, twenty variables had been identified in this session. The number was reduced to eleven as some variables were of same nature. The literature related to these eleven variables had been circulated among the experts. After ten days, a session was organized to establish the relationship among the variables. Since the relationships among all variables could not be identified in this session, another meeting was conducted to complete this task. In this meeting experts were also asked how these variables could be benchmarked. After four days, the list of variables and diagram were circulated among the experts for any further modification. According to experts' opinion, the diagram was reconstructed. Though ISM methodology suggests the use of expert opinions alone (based on management techniques such as brain storming, nominal group technique etc) in developing the contextual relationship, the correlation coefficients as obtained from the questionnaire survey have also been used to facilitate the experts in identifying the nature of these relationships. For analyzing the barriers in developing SSIM, the following four symbols have been used to denote the direction of relationship between barriers (i and j):

V- Barrier i will help achieve barrier j;

A- Barrier j will be achieved by barrier i;

X- Barriers i and j will help achieve each other; and

O- Barriers i and j are unrelated.

The following statements explain the use of symbols V, A, X and O in SSIM.

(i) Barriers 1 and 11 are both related to each other (X)

(ii) Barrier 1 helps achieve barrier 10 (V)

(iii) Barrier 2 will be achieved by barrier 7 (A)

Based on contextual relationships the SSIM is developed (Table III)

<Take in Table II>

Reachability Matrix

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

(i) 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,

(ii) 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,

(iii) 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,

(iv) 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.

Following these rules, the initial reachability matrix for the barriers is shown in Table III.

<Take in Table III>

After incorporating the transitivities as described in step (iv) of the ISM methodology, the final reachability matrix is shown in Table IV. In the Table IV the driving power and dependence of each barrier are also shown. Driving power for each barrier is the total number of barriers (including itself), which it may help achieve. On the other hand dependence is the total number of barriers (including itself), which may help achieving it. These driving power and dependencies will be later used in the classification of barriers into the four groups of autonomous, dependent, linkage and independent (driver) barriers.

<Take in Table IV>

Level partitions

From the final reachability matrix, the reachability and antecedent set (Warfield, 1974) for each barrier are found. The reachability set consists of the element itself and other elements, which it may help achieve, whereas the antecedent set consists of the element itself and the other elements, which may help achieving it. Then the intersection of these sets is derived for all elements. The element for which the reachability and intersection sets are same is the top-level element in the ISM hierarchy. The top-level element of the hierarchy would not help achieve any other element above their own level. Once the top-level element is identified, it is separated out from the other elements. Then, the same process finds the next level of element. This process continues till the levels of each element are found. These identified levels help in building the digraph and final model. In the present case the barriers along with their reachability set, antecedent set, intersection set and the levels are shown in Tables V to XII. The process is completed in seven iterations (Table V to XI) as follows.

In table V, the barrier 3 (Forecasting Problems) and barrier 6 (Lack of Flexibility) are found at the level I. Thus, it will be positioned at the top of the ISM model.

<Take in Table V>

In table VI, the barrier 4 (Lack of information sharing) and barrier 10 (Non availability of cross functional work forces) are found at the level II.

<Take in Table VI>

In table VII, the barrier 8 (Poor Infrastructure) is found at the level III.

<Take in Table VII>

In table VIII, the barrier 11 (Fund non-availability) is found at the level IV.

<Take in Table VIII>

In table IX, the barrier 5 (Lack of trust) and barrier 9 (Disparity among trading partners' capability) are put at level V.

<Take in Table IX>

<Take in Table X>

Levels of eleven barriers are indicated in table XI.

<Take in Table XI>

A conical matrix is developed by clustering elements at the same level, across rows and columns of the final reachability matrix, as shown in Table XII.

<Take in Table XII>

Driving Power and Dependence Power of barriers on the basis of one entry have been calculated and shown in Table XIII.

<Take in Table XIII>

Classification of barriers

Based on the driver power and dependence, different barriers have been classified into four clusters namely autonomous, dependent, linkage, and independent (Mandal and Deshmukh, 1994). The driver power and dependence of each of the barrier are shown in table V. Thereafter, the driver power-dependence diagram is shown in figure 9. To illustrate this figure, it is observed from table V that the barrier one is having a driver power of eight and dependence of one, therefore in figure 9 it is positioned at a place which corresponds to driver power of eight and dependency of one. The objective behind the classification of the barriers is to analyze the driver power and dependency of the barriers.

<Take in Figure 9>

The first cluster includes ‘autonomous barriers’ that have weak driver power and weak dependence. These barriers are relatively disconnected from the system. The second cluster consists of the dependent variables that have weak driver power but strong dependence. Third cluster has the linkage variables that have strong driver power and dependence. Any action on these variables will have an effect on the others and also a feedback effect on themselves. Fourth cluster includes independent variables with strong driver power and weak dependence.

Formation of ISM-based model

From the final reachability matrix (Table V), the structural model is generated by means of vertices or nodes and lines of edges. If there is a relationship between the barriers i and j, this is shown by an arrow which points from i to j. This graph is called a directed graph or digraph. After removing the transitivities as described in ISM methodology, the digraph is finally converted into ISM as shown in Figure 10.

<Take in Figure 10>

DISCUSSION AND CONCLUSION

One of the major objectives of this study was to identify the barriers that significantly affect the integration of a supply chain so that management may effectively deal with these barriers. The results of the survey indicated that lack of top management commitment, missing long term buyer-supplier relationship, and resistance to change and innovation are among the first level barriers. Disparity in trading partners' capabilities, lack of trust, and fund non-availability are the second level barriers which are present due to first level of barriers. These barriers result in to lack of information sharing, poor infrastructure and non-availability of cross functional work forces as reflected in the model. Lack of flexibility and forecasting problems are the depending barriers resulting from driving barriers. These two barriers are at the lower level both in the survey as well as in the model however, ISM model suggests that it has a very high depending power. With reference to the disparity of trading partners' capabilities, which has emerged as the one of the important barrier in the survey, it is observed that it finds a low level in the hierarchy of the ISM model. It could be attributed to the reason that disparity in trading partners' capabilities is caused by many socio-economic factors, which are not covered in this research. Yet we get the insight through ISM approach that "disparity in trading partners' capability" has a high driving power. This may be the reason why most respondents regarded it as significant barrier.

It is further observed from the ISM-based model that infrastructure issues such as lack of top management commitment, missing long term buyer-supplier relationship, resistance to change and innovation, and disparity in trading partners' capabilities in supply chains are at the bottom of the model with greater driving power. Therefore, the management of the companies belonging to a supply chain should collectively develop strategies to have long term buyer-supplier relationship. Top management of trading partners should create awareness about the common objective of the supply chain to minimize the resistance to change and innovation. Top management commitment help in handling the disparity among trading partner' capability by providing technological aids and financial aids to their trading partners.

It is observed from Figures 9 and 4 that the barriers nos. 5, and 11 namely lack of trust, and fund non-availability have strong driver power and dependence. Therefore, these barriers are having a significant influence in integration of supply chain. These barriers lie in the middle level, both in terms of rankings based on the results of questionnaire survey and also on the basis of ISM. Further, these barriers influence other barriers such as lack of information sharing, poor infrastructure and non availability of cross functional work force as can be seen in the final ISM model (Figure 10). Barriers lack of information sharing, and non availability of cross functional work force will effect flexibility of the supply chain and result into forecasting inaccuracy. This has strong implications for both managers as well as researchers. The managers need to address these barriers more carefully in their supply chains. On the other hand, researchers may be prompted to identify various other issues, which are significant in addressing these barriers.

This study has some other implications for the practicing managers. The identified barriers need to be overcome by the management of the supply chain partner companies. The driver power dependence diagram gives some valuable insights about the relative importance and interdependencies of the barriers. The managerial implications as emerging from this study are as under.

- The driver power dependence figure (Figure 9) indicates that there are two autonomous variables in the process of supply chain integration. Autonomous variables are weak drivers and weak dependents and do not have much influence on the system. The presence of autonomous variables (barriers) in this study indicates that barriers poor infrastructure and non availability of cross functional work force influence the process of supply chain integration and management should pay attention to these barriers.
- From driver power and dependence figure it is observed that forecasting problems and lack of flexibility are weak drivers but strongly dependent on the other barriers. These two barriers are at the top of the ISM hierarchy, therefore considered as the important barriers. The management should therefore accord high priority in tackling these barriers. Besides tackling these barriers, management should also understand the dependence of these barriers on lower

level barriers in the ISM. Fund non availability coming under this group has higher driving power hence is kept in the middle level of the ISM model.

- Barrier namely lack of information sharing is the linkage variable and has strong driver power as well as strong dependence. Though the lower level barriers induce this barrier, this also have some driver power to influence some other barriers, which are at the top of the model. The regular joint meetings of the supply chain partners and developing IT network may help in overcoming this barrier.
- From Figure 9 it is observed that five barriers namely lack of top management commitment, missing long term buyer-supplier relationship, resistance to change and innovation, disparity among trading partners' capability, and lack of trust have strong driver power and are less dependent on other barriers. Therefore, these are strong drivers and may be treated as the root causes of all the barriers. As these barriers involve all the entities of a supply chain therefore, the major stakeholder in the supply chain (normally original equipment manufacturer, OEM) should take the initiative to address these. The joint meetings of all the entities of supply chain at regular interval may prove to be useful in this regard.

At the end, it would be interesting to examine the scope of future research. In this research, through ISM, a relationship model among the barriers has been developed. This model has been developed on the basis of input from two sources (i) discussion with the experts as suggested in the ISM technique, and (ii) results of a questionnaire survey. Yet, this model has not been statistically validated. Structural equation modeling (SEM), also commonly known as linear structural relationship approach, has the capability of testing the validity of such hypothetical model. Therefore, it may be applied in the future research to test the validity of this model. It is to be mentioned here that while comparing ISM and SEM, though SEM has the capability of statistically testing an already developed theoretical model, it cannot develop an initial model for testing. On the other hand, ISM has the capability to develop an initial model through managerial techniques such as brain storming, nominal group techniques (NGT) etc. Normally, in many situations the management may not have enough time to conduct a survey and therefore, scope to have a statistically validated model to understand a problem. ISM is a supportive analytic tool for this situation. However, it may be suggested that due to complimentary nature of both of these techniques, the future research may be directed in first developing an initial model using ISM and then testing it using SEM.

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References:

Agarwal A., and Shankar R., (2002), "Analyzing alternatives for improvement in supply chain performance", Work-Study, Vol. 51 No.1, pp.32-37.

Agarwal A., and Shankar R., (2003), "On-line trust building in e-enabled supply chain", Supply Chain Management: An International Journal, Vol. 8 No.4 pp.324-334.

Aitken J., Christopher M., and Towill D., (2002), "Understanding, implementing and exploiting agility and leanness", International Journal of Logistics: Research and Applications, Vol. 5 No.1, pp.59-74.

Akkermans, H., Bogerd, P. and Vos, B., 1999, Virtuous and vicious cycles on the road towards international supply chain management, International Journal of Operations and Production Management, 19, 5, 565-582.

Anderson D.L., and Lee H.L., (1999), "Synchronized supply chains: the new frontier, achieving supply chain excellence through technology", Montgomery Research, San Francisco, CA.

Armstrong, J. S., and Overton, T.S., 1977, Estimating non-response bias in mail surveys, Journal of Marketing Research, 14, 3, 396-402.

Ba S., (2001), "Establishing on-line trust through a community responsibility system", Decision Support System, Vol. 31 No.3, pp.323-36.

Bal J., Wilding R., and Goundry J., (1999), "Virtual teaming in the agile supply chain", International Journal of Logistics Management, Vol. 10 No.2, pp.71-83.

Beamon B. M., and Ware T.M., (1998), "A process quality model for the analysis, improvement and control of supply chain systems", Logistics Information Management, Vol. 11 No.2, pp.105-113.

Chopra, S. and Meindl, P. 2001, Supply chain management: Strategy, planning and operations, 2nd Edition, Prentice Hall, Upper Saddle River, NJ.

Christopher M., (2000), "The agile supply chain, competing in volatile markets", Industrial Marketing Management, Vol. 29, pp.37-44.

Christopher M., and Towill D.R., (2001), "An integrated model for the design of agile supply chains", International Journal of Physical Distribution and Logistics, Vol. 31 No.4, pp.235-246.

Christopher M., and Jittner U., (2000)., "Developing strategic partnerships in the supply chain: a practitioner perspective", European Journal of Purchasing and Supply Chain Management, Vol. 6 No.2, pp.117-127.

Christopher M., Lowson R., and Peck H., (2004), " Creating agile supply chains in the fashion industry", International Journal of Retail and Distribution Management, Vol. 32 No. 8, pp. 367-376.

Cooper R., and Slagmulder R., (1998), "Cost management beyond the boundaries of the firm", Management Accounting, pp.18–20.

Cooper, M.C., Lambert, D.M., and Pagh J.D., 1997, Supply chain management-more than a new name for logistics, International Journal of Logistics Management, 8, 1, 1-14.

Ellram L.M., (1990), "The supplier selection decision in strategic partnerships", Journal of Purchasing and Materials Management, Vol. 26 No.4, pp.8-14.

Ellram L.M., (1991), "A managerial guide for the development and implementation of purchasing partnerships", International Journal of Purchasing and Materials Management, Vol. 27 No.3, pp.2-8.

George D., and Mallery P., (1999), SPSS for Windows Step by Step: A Simple Guide and Reference, Allyn and Bacon, Massachusetts.

Goldman S., Nagel R., and Preiss K., (1995), "Agile Competitiors and Virtual Organizations, Van Nostrand Reinhold, New York.

Gunasekaran A., Patel C., and Tirtiroglu E., (2001), "Performance measures and metrics in a supply chain environment", International Journal of Operations and Production Management, Vol. 21 No.1/2, pp.71-87.

Gunasekaran A., and McGaughey R. E., (2003), "TQM is supply chain management", The TQM Magazine, Vol. 15 No.6, pp.361-363.

Handfield R.B., and Bechtel C., (2002), "The role of trust and relationship structure in improving supply chain responsiveness", Industrial Marketing Management, Vol. 31, pp.367– 382.

Handfield R.B. and Nichols Jr. E.L, (1999), "Introduction to Supply Chain Management", Prentice Hall ,New Jersey, N.J..

Handfield R.B., and Pannesi R.T., (1992), "An empirical study of delivery speed and reliability", International Journal of Operations and Production Management; Vol. 12 No.2, pp.58-72.

Heide J.B., and John G., (1990), "Alliances in Industrial Purchasing: The Determinants of Joint Action in Buyer-Supplier Relationship", Journal of Marketing Research, Vol. 27, pp.24-36.

Jayaram J., Vickery S.K., and Droge C., (1999), "An empirical study of time-based competition in the North America automotive supplier industry", International Journal of Operations and Production Management, Vol. 19 No.10, pp.1010-1033.

Jharkharia S., and Shankar R., (2003), "IT-enablement of supply chains: Understanding the barriers", Accepted: Logistics Information Management.

Kim, J.Q. and Mueller, C.W. 1978, Factor analysis: statistical methods and practical issues, Sage publications, London.

LaLonde, B.J., 2000, The Gap Creep, *Supply Chain Management Review*, 3, 4, 7-9.

Lau H.C.W., Wong C.W.Y., Pun K.F., and Chin K.S., (2003), "Virtual agent modeling of an agile supply chain infrastructure", Management Decision, Vol. 41 No.7, pp.625-634.

Lambert, D. M., and Harrington, T.C., 1990, Measuring non-response bias in customer service mail surveys, Journal of Business Logistics, 11,2, 5-25.

Lee H.L., and Billington C., (1992), "Managing supply chain inventory: pitfalls and opportunities", Sloan Management Review, pp.65-73.

Lee H.L., Padmanabhan V., and Whang S., (1997), "Information distortion in a supply chain: The bull whip effect", Management Science, Vol. 43 No.4, pp.546-558.

Lee H.L., So K.C., and Tang C. S., (2000), "Value of information sharing in a two level supply chain", Management Science, Vol. 46 No.5, pp.626-643.

Lee H.L., and Whang S., 2000, Information sharing in a supply chain, International Journal of Technology Management, 20, 3/4, 373-387.

Lockamy III A., and Smith W. I., (2000), "Target costing for supply chain management: criteria and selection", Industrial Management and Data Systems, Vol.100 No.5, pp.210-218.

Lummus, R.R. and Vokurka, R.J., 1999, Defining supply chain management: a historical perspective and practical guidelines, Industrial Management and Data Systems, 99, 1,11-17.

Malhotra M.K., and Grover V., (1998), "An assessment of survey research in POM: from constructs to theory, Journal of Operations Management", Vol. 16 No.4, pp.407-425.

Mandal A., and Deshmukh S.G., (1994), "Vendor Selection Using Interpretive Structural Modeling (ISM)", International Journal of Operations and Production Management, Vol. 14 No.6, pp.52-59.

Mason S.J., Cole M.H., Ulrey B.T., and Yan L., (2002), "Improving electronics manufacturing supply chain agility through outsourcing", International Journal of Physical Distribution and Logistics Management, Vol. 32 No.7, pp.610-620.

Mason-Jone R., Naylor B., and Towill D.R., (2000), "Engineering the Leagile Supply Chain", International Journal of Agile Management Systems, Vol. 2 No.1, pp.54-61.

Mason-Jones R., and Towill D.R., (1999), "Total cycle time compression and the agile supply chain", International Journal of Production Economics, Vol. 62, pp.61-73.

Mentzer J.T., Foggin J.H., and Golicic S.L., (2000), “Collaboration: the enablers, impediments, and benefits”, Supply Chain Management Review, September/October, pp.52-58.

Moberg, C. R., Cutler, B. D., Gross, A. and Speh, T. W., 2002, Identifying antecedents of information exchange within supply chains, International Journal of Physical Distribution and Logistics Management, 32, 9, 755-770.

Naylor J.B., Naim M. M., and Berry D., 1999, Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain, International Journal of Production Economics, 62, 107-118.

Nunally, J. C. 1978, Psychometric Methods, McGraw Hill, NewYork.

Power D.J., Sohal A.S., and Rahman S., (2001), “Critical success factors in agile Supply chain management: an empirical study”, International Journal of Physical Distribution and Logistics, Vol. 31 No.4, pp.247-265.

Sage A.P., (1977), “Interpretive structural modeling: methodology for large-scale systems”, McGraw-Hill, New York, NY.

Sahay B.S. and Mohan, R., 2003, Supply chain management practices in Indian industry, International Journal of Physical Distribution and Logistics Management, 33,7, 582-606.

Saxena J. P., Sushil, and Vrat P., (1990), “The impact of indirect relationships in classification of variables- a MICMAC analysis for energy conservation”, System Research, Vol. 7 No.4, pp.245-253.

Saxena J. P., Sushil, and Vrat P., (1992), “Scenario building: a critical study of energy conservation in the Indian cement industry”, Technological Forecasting and Social Change, Vol. 41, pp.121-146.

Shankar R., and Agarwal A., (2004), “Designing agile and responsive supply chain”, Winning Strategies of Supply Chains, ASSOCHAM, New Delhi, India. pp.12-22.

Sharma H. D., Gupta A.D., and Sushil, (1995), “The objectives of waste management in India: a future inquiry”, Technological Forecasting and Social Change, Vol. 48, pp.285-309.

Singh, M.D. Shankar R., Narain R., and Agarwal A., (2003), “Knowledge Management in engineering industries – An Interpretive Structural Modeling”, Journal of Advances in Management Research, Vol. 1 No.1, pp.27-39.

Stevens G., 1989, Integrating the supply chain, International Journal of Physical Distribution and Materials Management, 19, 1, 3-8.

Stevens G. C., (1990), “Successful supply-chain management”, Management Decision, Vol. 28 No.8, pp.25-30.

Tolone W.J., (2000), “Virtual situation rooms: connecting people across enterprises for supply chain agility”, Computer Aided Design, Vol. 32, pp.109-117.

Van Hoek R. I., Harrison A., and Christopher M., (2001), “Measuring agile capabilities in the supply chain”, International Journal of Operations and Production Management, Vol. 21 No.1/2, pp.126-148.

Waddell D., and Sohal A.S., (1998), “Resistance: a constructive tool for change management”, Management Decision, Vol. 36 No.8, 543-548.

Warfield J.W., (1974), “Developing Interconnected Matrices in Structural Modeling”, IEEE Transcript on Systems, Men and Cybernetics, Vol. 4 No.1, pp.51-81.

Yusuf Y. Y., Gunasekaran A., Adeleye E. O., and Sivayoganathan K., (2004), "Agile supply chain capabilities: determinants of competitive objectives", European Journal of Operational Research, Vol. 159, pp. 379-392.

Yusuf Y. Y., Sarhadi M., and Gunasekaran A., (1999), "Agile manufacturing: The drivers, concepts and attributes", International Journal of Production Economics, Vol. 62 No.1/2, pp.33-43.

Table 1: Description of Respondents

		Auto-Sector		FMCG		Electrical and Electronics	
		Manufacturer	**Supplier**	**Manufacturer**	**Supplier**	**Manufacturer**	**Supplier**
Sample size	760	170	217	73	78	81	141
Responded	214	40	55	29	33	21	36
Rejected due to incomplete	35	05	07	09	08	03	03
Qualified respondents	179	35	48	20	25	18	33
Percentage (%)	23.55	20.58	22.12	27.4	32.05	22.22	23.4

Table II: Structural Self-interaction Matrix (SSIM)

Elements	11	10	9	8	7	6	5	4	3	2
1	X	V	O	V	O	O	O	V	O	V
2	O	O	V	O	A	O	X	X	V	
3	O	O	O	A	O	O	A	A		
4	O	O	O	A	X	V	X			
5	O	O	O	O	X	V				
6	A	A	A	A	A					
7	V	O	O	O						
8	A	O	O							
9	V	O								
10	A									

Table III: Initial Reachability Matrix

Elements	1	2	3	4	5	6	7	8	9	10	11
1	1	1	0	1	0	0	0	1	0	1	1
2	0	1	1	1	1	0	0	0	1	0	0
3	0	0	1	0	0	0	0	0	0	0	0
4	0	1	1	1	1	1	1	0	0	0	0
5	0	1	1	1	1	1	1	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0	0
7	0	1	0	1	1	1	1	0	0	0	1
8	0	0	1	1	0	1	0	1	0	0	0
9	0	0	0	0	0	1	0	0	1	0	1
10	0	0	0	0	0	1	0	0	0	1	0
11	1	0	0	0	0	1	0	1	0	1	1

Table IV: Final Reachability Matrix

Elements	1	2	3	4	5	6	7	8	9	10	11
1	1	1	1*	1	1*	1*	1*	1	1*	1	1
2	0	1	1	1	1	1*	1*	0	1	0	1*
3	0	0	1	0	0	0	0	0	0	0	0
4	0	1	1	1	1	1	1	0	0	0	0
5	0	1	1	1	1	1	1	0	0	0	1*
6	0	0	0	0	0	1	0	0	0	0	0
7	1*	1	0	1	1	1	1	0	0	0	1
8	0	0	1	1	0	1	0	1	0	0	0
9	1*	0	0	0	0	1	0	1*	1	1*	1
10	0	0	0	0	0	1	0	0	0	1	0
11	1	0	0	0	0	1	0	1	0	1	1

Table V: Levels of SC Integration Barriers

Element (P_i)	Reachability Set: R (P_i)	Antecedent Set: A (P_i)	Intersection R (P_i) A (P_i)	Level
1	1,2,3,4,5,6,7,8,9,10,11	1,7,9,11	1,7,9,11	
2	2,3,4,5,6,7,9,11	1,2,4,5,7	2,4,5,7	
3	3	1,2,3,4,5,8	3	I
4	2,3,4,5,6,7	1,2,3,4,5,7,8	2,4,5,7	
5	2,3,4,5,6,7,11	1,2,3,4,5,7	2,4,5,7	
6	6	1,2,3,4,5,6,7,8,9,10,11	6	I
7	1, 2,4,5,6,7,11	5,6,7	1,2,4,5,7	
8	3,4,6,8	1,8,9,11	8	
9	1,6,8,9,10,11	1,2,9	1,9	
10	6,10	1,9,10,11	10	
11	1,6,8,10,11	1,2,5,7,9,11	1,11	

Table VI: Levels of SC Integration Barriers

Element (P_i)	Reachability Set: R (P_i)	Antecedent Set: A (P_i)	Intersection R (P_i) A (P_i)	Level
1	1,2,4,5,7,8,9,10,11	1,7,9,11	1,7,9,11	
2	2,4,5,7,9,11	1,2,4,5,7	2,4,5,7	
4	2,4,5,7	1,2,4,5,7,8	2,4,5,7	II
5	2,4,5,7,11	1,2,4,5,7	2,4,5,7	
7	1, 2,4,5,7,11	5,7	1,2,4,5,7	
8	4,8	1,8,9,11	8	
9	1,8,9,10,11	1,2,9	1,9	
10	10	1,9,10,11	10	II
11	1,8,10,11	1,2,5,7,9,11	1,11	

Table VII: Levels of SC Integration Barriers

Element (P_i)	Reachability Set: R (P_i)	Antecedent Set: A (P_i)	Intersection R (P_i) A (P_i)	Level
1	1,2,5,7,8,9,11	1,7,9,11	1,7,9,11	
2	2,5,7,9,11	1,2, 5,7	2,5,7	
5	2,5,7,11	1,2,5,7	2,5,7	
7	1, 2,5,7,11	5,7	1,2,5,7	
8	8	1,8,9,11	8	III
9	1,8,9,11	1,2,9	1,9	
11	1,8,11	1,2,5,7,9,11	1,11	

TableVIII: Levels of SC Integration Barriers

Element (P_i)	Reachability Set: R (P_i)	Antecedent Set: A (P_i)	Intersection R (P_i) A (P_i)	Level
1	1,2,5,7,9,11	1,7,9,11	1,7,9,11	
2	2,5,7,9,11	1,2, 5,7	2,5,7	
5	2,5,7,11	1,2,5,7	2,5,7	
7	1, 2,5,7,11	5,7	1,2,5,7	
9	1,9,11	1,2,9	1,9	
11	1,11	1,2,5,7,9,11	1,11	IV

Table IX: Levels of SC Integration Barriers

Element (P_i)	Reachability Set: R (P_i)	Antecedent Set: A (P_i)	Intersection R (P_i) A (P_i)	Level
1	1,2,5,7,9	1,7,9	1,7,9	
2	2,5,7,9	1,2, 5,7	2,5,7	
5	2,5,7	1,2,5,7	2,5,7	V
7	1, 2,5,7	5,7	1,2,5,7	
9	1,9	1,2,9	1,9	V

Table X: Levels of SC Integration Barriers

Element (P_i)	Reachability Set: R (P_i)	Antecedent Set: A (P_i)	Intersection R (P_i) A (P_i)	Level
1	1,2,7	1,7	1,7	VII
2	2,7	1,2, 7	2,7	VI
7	1, 2,7	7	1,2,7	VI

Table XI: Levels of SC Integration Barriers

Element (P_i)	Reachability Set: R (P_i)	Antecedent Set: A (P_i)	Intersection R (P_i) A (P_i)	Level
1	1,2,3,4,5,6,7,8,9,10,11	1,7,9,11	1,7,9,11	V
2	2,3,4,5,6,7,9,11	1,2,4,5,7	2,4,5,7	III
3	3	1,2,3,4,5,8	3	VI
4	2,3,4,5,6,7	1,2,3,4,5,7,8	2,4,5,7	II
5	2,3,4,5,6,7,11	1,2,3,4,5,7	2,4,5,7	VIII
6	6	1,2,3,4,5,6,7,8,9,10,11	6	VIII
7	1, 2,4,5,6,7,11	5,6,7	1,2,4,5,7	IX
8	3,4,6,8	1,8,9,11	8	IV
9	1,6,8,9,10,11	1,2,9	1,9	II
10	6,10	1,9,10,11	10	I
11	1,6,8,10,11	1,2,5,7,9,11	1,11	I

Table XII: Conical Form of Reachability Matrix

Elements	**1**	**2**	**5**	**7**	**4**	**9**	**11**	**8**	**10**	**3**	**6**
1	1	1	1*	1*	1	1*	1	1	1	1*	1*
2	0	1	1	1*	1	1	1*	0	0	1	1*
5	0	1	1	1	1	0	1*	0	0	1	1
7	1*	1	1	1	1	0	1	0	0	0	1
4	0	1	1	1	1	0	0	0	0	1	1
9	1*	0	0	0	0	1	1	1*	1*	0	1
11	1	0	0	0	0	0	1	1	1	0	1
8	0	0	0	0	1	0	0	1	0	1	1
10	0	0	0	0	0	0	0	0	1	0	1
3	0	0	0	0	0	0	0	0	0	1	0
6	0	0	0	0	0	0	0	0	0	0	1

Table XIII: Driving power and Dependence in Reachability Matrix

Element	**1**	**2**	**5**	**7**	**4**	**9**	**11**	**8**	**10**	**3**	**6**	Driving power	Ranks
1	1	1	1*	1*	1	1*	1	1	1	1*	1*	2	V
2	0	1	1	1*	1	1	1*	0	0	1	1*	2	V
5	0	1	1	1	1	0	1*	0	0	1	1	2	V
7	1*	1	1	1	1	0	1	0	0	0	1	2	V
4	0	1	1	1	1	0	0	0	0	1	1	2	V
9	1*	0	0	0	0	1	1	1*	1*	0	1	3	IV
11	1	0	0	0	0	0	1	1	1	0	1	6	III
8	0	0	0	0	1	0	0	1	0	1	1	8	II
10	0	0	0	0	0	0	0	0	1	0	1	8	II
3	0	0	0	0	0	0	0	0	0	1	0	11	I
6	0	0	0	0	0	0	0	0	0	0	1	11	I
Dependence Power	4	5	5	5	6	3	6	4	4	6	10		
Ranks	VII	VI	III	III	IV	III	II	IV	IV	V	I		

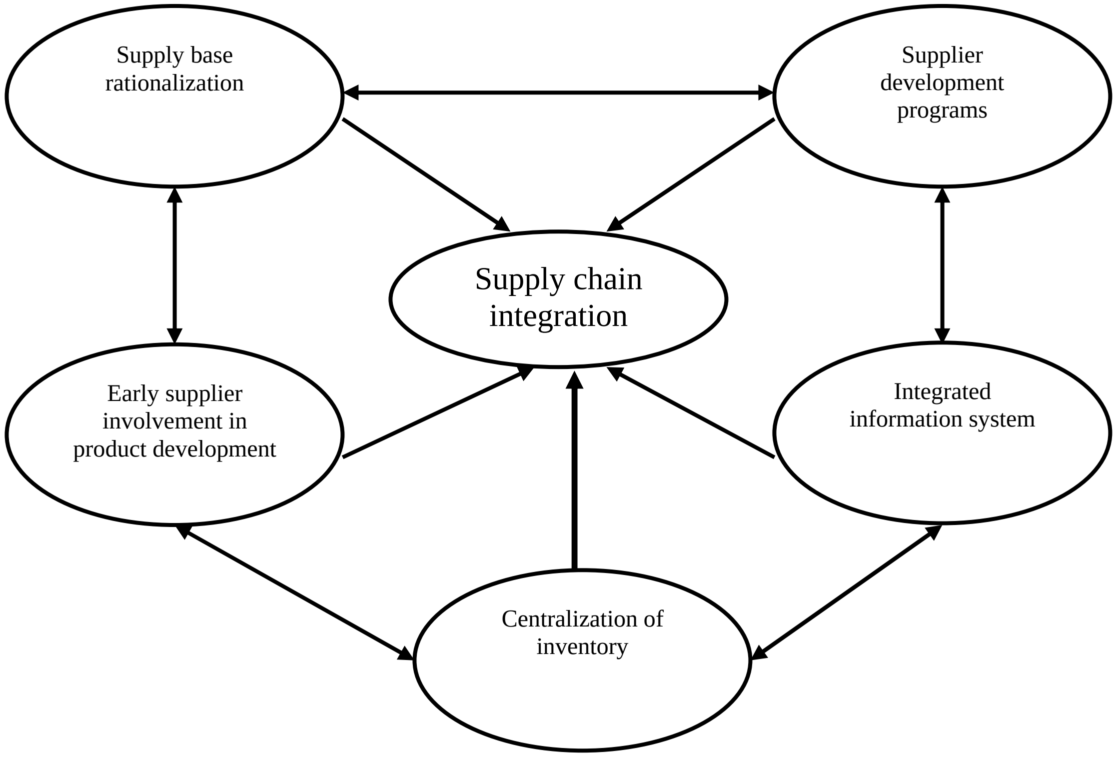

Figure 1: Framework for supply chain integration (modified from Christopher, 1998)

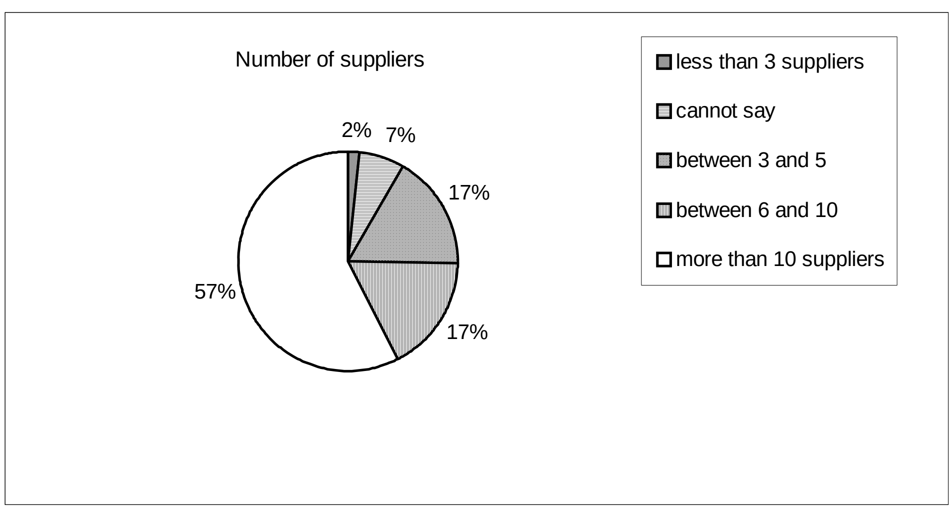

Figure 2: Percent of Respondent Firms Employing Different Number of Suppliers

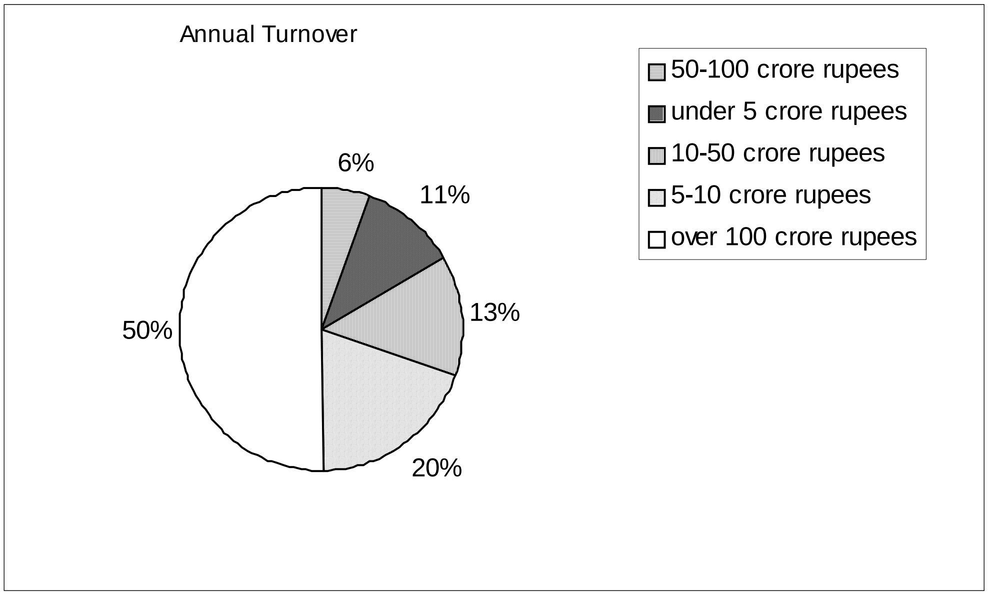

Figure 3: Break-up of the Companies Participated in the Survey

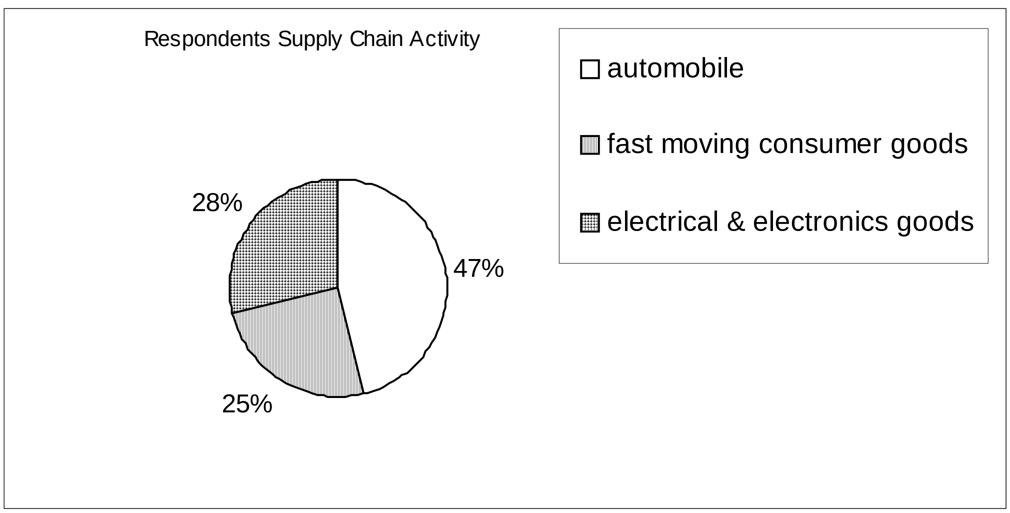

Figure 4: Percent of Respondents of the Survey across Different Sectors

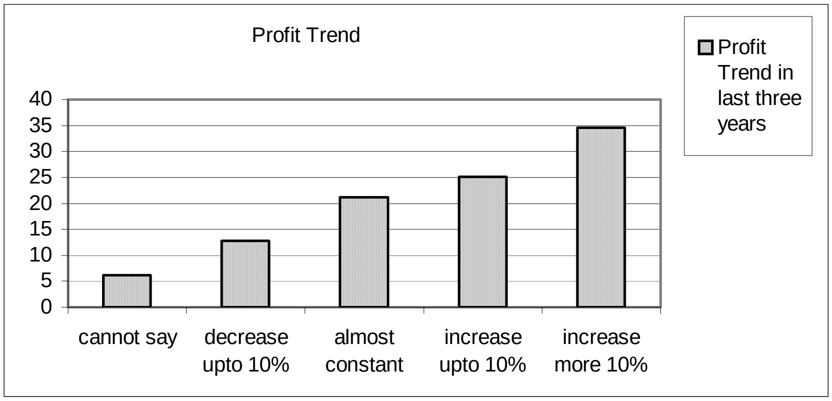

Figure 5: Profit Trend of Respondent Companies During Last Three Years

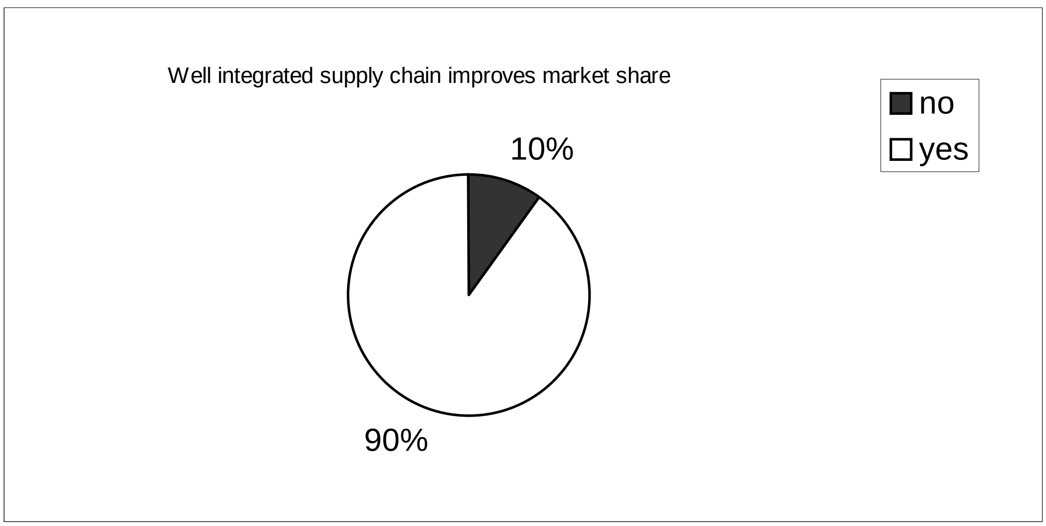

Figure 6: Respondent Companies believe that a well-integrated Supply Chain improves Market Share

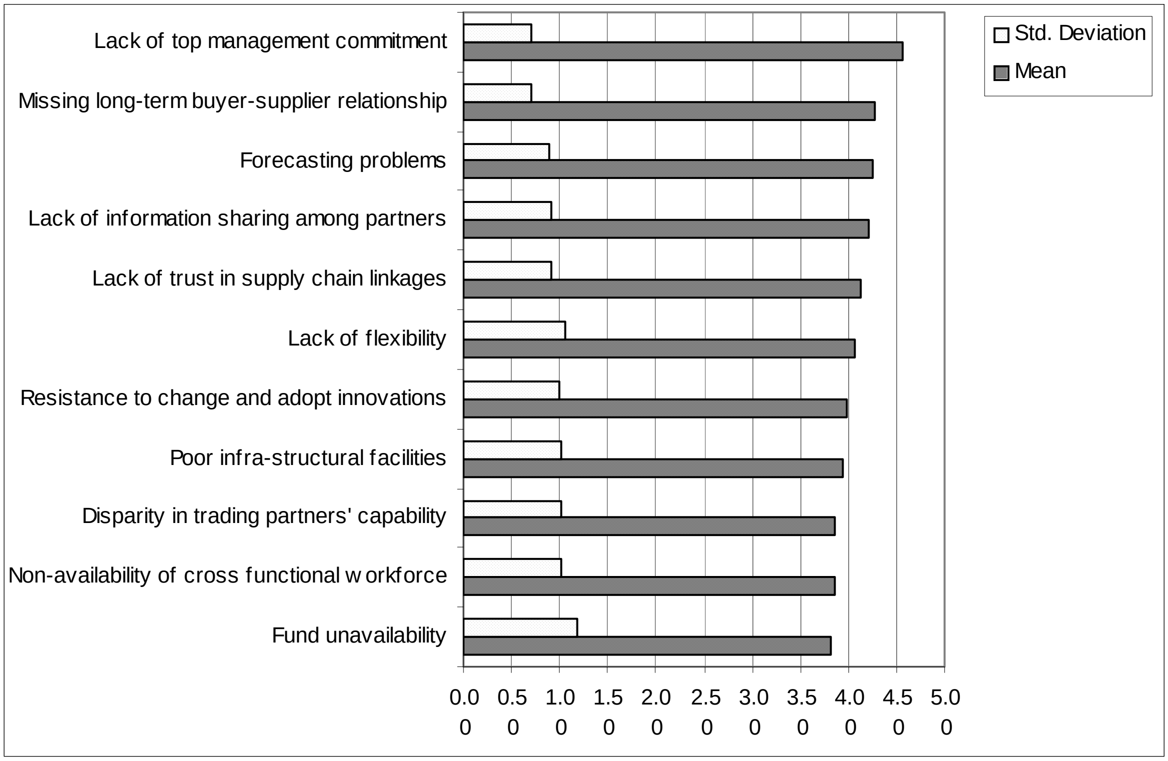

Figure 7: Barriers in Supply Chain Integration

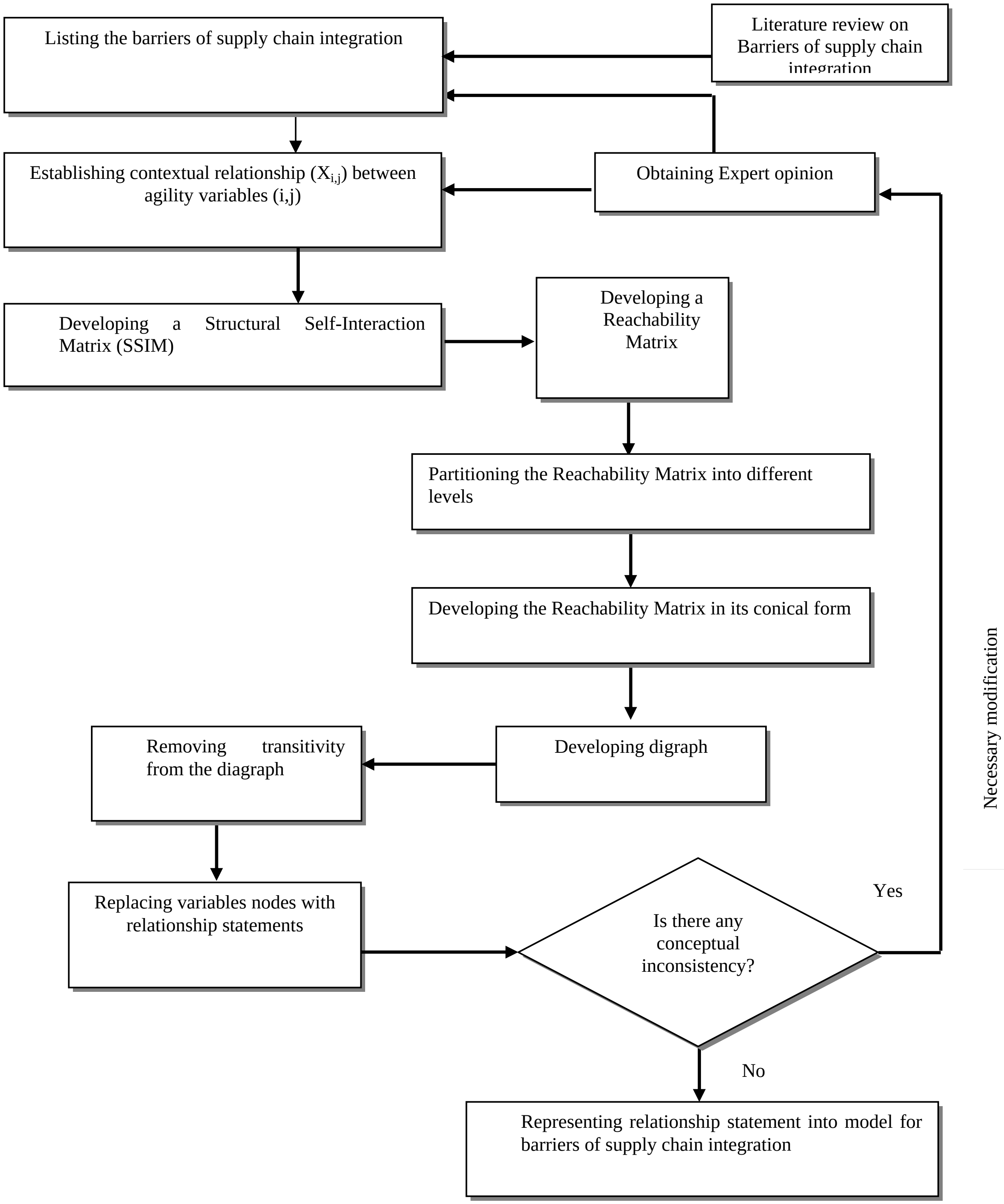

Figure 8: Flow diagram for preparing ISM

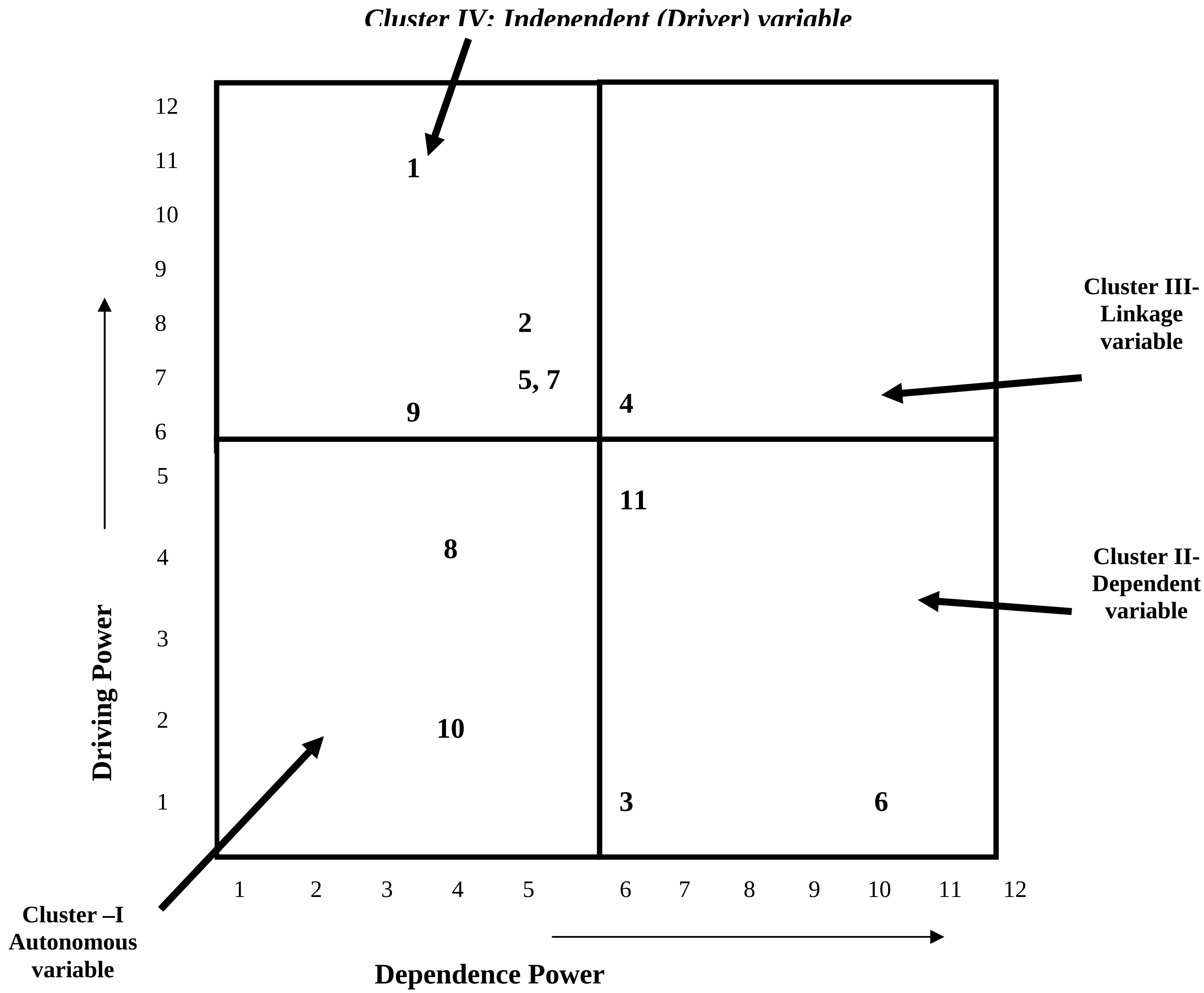

Figure 9: **Cluster of variables for improving supply chain agility**

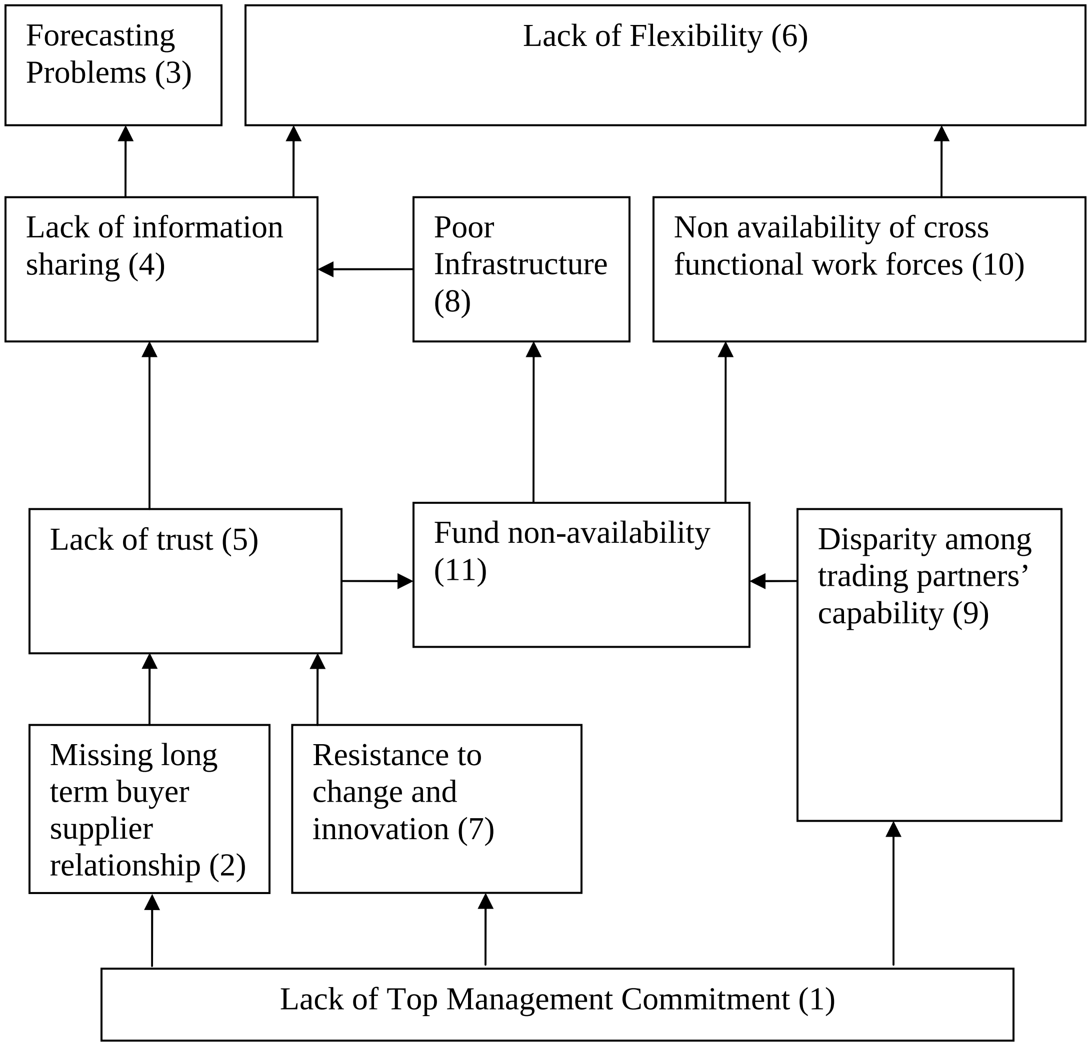

Figure 10: ISM-based model of barriers for supply chain integration barriers after removing indirect links

Vitae

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