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Minimizing supply chain risk factors using interpretive structural modeling (ISM)

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Abstract

Singling out of supply chain risks is the prior stage in the risk management process. To understand and manage risk of supply chain is a significant concern of business and a compounded problem. There exists a variety of standard for risk minimizing in supply chain management. Interpretive Structural Modeling(ISM) tactic initiates with an identification of variables, which is applicable to the problem or an issue. In this research, these variables were taken under a company as risk factors whereas Structural Self-Interaction Matrix (SSIM) is converted into a Reachability Matrix (RM) and its transitivity has also been seasoned. Once transitivity has been checked, a contextually applicable subordinate relation is being chosen. Having decided the contextual relation, a Structural Self-Interaction Matrix (SSIM) is established based on pair wise comparison of variables. In this paper the elements (also referred as variables) for the implementation of RM in a warehouse has been analyzed to find an ISM which indicates the interrelationships of the elements and also their levels. These elements have also been categorized according to their driving power and dependency. This research work has been done with twenty factors, also the percentage of the drivers, linkages, autonomous along with the independent variables have been found.

Keywords: ISM, SSIM, RM, risk minimization, variables, MICMAC.

Introduction

Generally it is sensed that individuals or groups encounters trains in dealing with complex systems. A large number of elements presence and interactions amongst these elements the complexity arises in the systems. Due to the presence of directly or indirectly related elements the construction of the system becomes complicated which may or may not be segmented in a clear fashion. It becomes difficult to deal with such a system in which structure is undefined. Hence forth, it necessitates the progress of a approach which aids in identifying a structure within a system. Interpretive structural modeling is such a methodology[1,2]. Singling out of supply chain risks is the prior step in the risk management process. But transparency across the risk potential along the supply chain is not the only required condition for a successful (in the sense of effective) risk management. The selection of appropriate (minimization or prevention) measures builds on the structural assessment and the "impact area" of the various types of risks[3]. Moreover there are a huge no. of research that deals with supply chain management and the risk involved[4-7] and the literature which are conceptual deals with the fresh idea of supply chain management and the risk involved, minor study has been done on the inter connectedness involved in the risks of supply chain[8-13]. Supply chain management, organizations can more effectively ensure the proficient delivery of products and services, while taking into account the possibilities of costly delays and stoppages by adopting a risk-adjusted approach.

In the early years in Bangladesh, production was guileless, moving from raw material suppliers to manufacturers and then to markets with single flow of products. At the present time, smaller product lifecycle and growing demand among all have led to a complex supply chain. Owing to cost burden and competitive advantages, companies are attaining globalization and outsourcing policies. Though the sector is highly fragmented, Bangladesh also being a rising destination for the retail business, the risk is to be studied from supply chain perspective. Selective disturbance factors in the field of study will be discovered and explored by this paper. By analyzing the interdependencies between them the study also proposes a procedure to rank risks. For insight of study variables this appropriate relationship is established through a skill called Interpretive Structural Modeling (ISM) and followed by a (MICMAC) analysis. It is the base of the proposed model that each risk is associated with multiple ones in a way that either it drives them or is dependent on them. Designing the modification strategies is the very first step to identify and analyze the risk in terms of its frequency of happening, severity in terms of cost and what other disruptions it could lead. By proposing a methodology based on MICMAC analysis to analyze and prioritize the supply chain risks an appropriate strategy can be designed to improve the business efficiency.

The unique contribution of the model is a new formula that is proposed for prioritizing the risks based on the structural model.

The structure of the paper starts with the introduction about the supply chain risk management then comes with the literature review on supply chain risk and Bangladeshi retail industry. Next, the discussions on establishing the variables have been done after that Interpretive Structural Model formulation and MICMAC analysis. With the discussions on the new risk assessment framework, managerial implications and future possibility it ends. The main purpose of the paper is to develop supply chain risk management and identify risk factors co-relationship. Again, by finding driving power of the variables industrial obstacles can be minimized. By the help of this model the factors can be into different levels. And also, it can be found out which factor emphasize whom in the process. This study is now very much familiar in different industries across the whole country like Ananta Group, Incepta Pharmaceutical Ltd, Beximco group. A feasibility study was done on their present network whether this is sufficient to meet the risk minimizing systems in terms of MICMAC analysis. Therefore, the rational of the study is to realize the supply chain risk factors of Ananta Group in Bangladesh in terms of the viability study of the different risk factor co-relationships.

Methodology

Numerous steps involved in Interpretive Structural Modeling (ISM) system are given below:

Selecting the elements: An identification of elements is initial point which is related to the problem. The research can be done in both way secondary or primary research techniques such as desk research (secondary), survey, group problem solving (primary).

Establishment of contextual relation: Establishing a possible statement of relationship amongst the elements which intensely stated by this contextual relation. Several types of contextual relations are comparative, influence, neutral or temporal relations[15,16].

Building (SSIM) structural self-interaction matrix: The most tiring and important phase is phase, iii. During this phase the participants have to decide upon the relationship which are pair wise between the elements during this phase. For each element after establishing the contextual relationship, the existence of a relation between any two sub-elements (i and j) and the direction which is associated by the relation is interrogated. There are four symbols which are (V,A,X and O) used that show the directions of the relationship. First symbol (V) is used for showing the relation from i › j but not in both directions; second symbol (A) is used for representing the relation from j › i but they don't represent the both directions; third symbol(X) denotes for both direction relations from i › j and j › i; and the fourth one (O) is denoted for invalid relation between the elements.

Development of reachability matrix: For developing reachability matrix and for checking transitivity Structural Self-Interaction Matrix is formed. For the construction of the reachability matrix (RM) this phase (4) is concerned. Reachability matrix which is binary because the entry V, A, X and O of the Structural Self-Interaction Matrix are transformed into 1 and 0 as per the following rules: i. In the Structural Self-Interaction Matrix if the (i, j) entry is V, then in the reachability matrix (i, j) entry becomes 1 and the (j, i) entry becomes 0. ii. In the Structural Self-Interaction Matrix if the (i, j) entry is A, then in the reachability matrix (i, j) entry becomes 0 and the (j, i) entry becomes 1. iii. In the SSIM if the (i, j) entry is X, then the (i, j) and (j, i) both the entries of the conical shaped matrix become 1. iv. In the SSIM if the (i, j) entry is O, then (i, j) and (j, i) both the entries of the conical shaped matrix become 0.

In Interpretive Structural Modeling transitivity is an important supposition which leads to the final conical shaped matrix. In this situation it may be presumed that element A,B,C are interrelated. From element i to element j there will not be any direct other than indirect relationships if the element (i, j) of the final reachability matrix is 0. As there is no direct but an indirect relationship from element i to, the initial reachability matrix may not have this attribute so, entry (i, j) is also zero. Indirect relationships can be found by rising the initial reachability matrix (with diagonal entries set to 1) to successive powers until no new entries are obtained[17].

Level partitioning of conical matrix: By level partitioning the 5th phase maintains the ordering into hierarchical process from the conicalmatrix[18]. For the simplification and construction of the digraph from the reachability matrix this 5th phase is important.

Digraph drawing along with the transitivity links that is removed: An initial digraph including transitivity links is achieved from the reachability matrix which is conical shaped. The conical matrix is achieved by reorganizing the elements according to their level that are partitioned in reachability matrix., that means all the elements that have the same level are pooled.

The digraph being altered into the Interpretive Structural Modeling, conceptual variation has been checked. From step (6) final digraph has been found which is transformed into Interpretive Structural Modeling by switching the nodes of the element along with statements. Eventually, to check for incompatibilities the ISM model is studied.

Creation of SSIM: An "affects" type contextual relation is chosen, that means the risks affects one another. For instance, capacity variances have an adverse effect of on the supply on the production sector of companies and for this short time production downtimes may occurred. It should be kept in mind that for each risk, the contextual relationship can be questioned on the existence of a relation. Through group discussions between the researchers the inter-relationships are analyzed.

Reachability matrix along with level partitioning: In step (4) it has been described that the SSIM is transformed into a reachability matrix of the Interpretive Structural Modeling methodology. The final (RM) reachability matrix is reached after incorporating the transitivity (*1 indicates transitivity in the table). By the final reachability matrix the driving and dependence power of each risk is characterized. The sum of interactions of the rows affect by the driving power of each risk is the total no. of risks. Conversely, the sum of interactions of the columns affect by the dependence power of each risk is the total no. of risks. Four types of risks are autonomous, linkage, dependent and independent risks depending on their dependence and driving power. The final (RM) reachability matrix directs to the antecedent set and reachability for each risk. The element si is the set of elements of the reachability set R(si) which is defined in the row si and columns. Correspondingly, in the rows that contain 1 in the column si defines the antecedent set A(si) of the element si is the set of elements.

Formation of ISM and Development of digraph: Based on reachability matrix as per their levels a conical matrix which is in lower triangular format established through arrangement of the elements. The initial digraph including transitive links is gained that based on the conical reachability matrix. The final digraph is obtained after eliminating indirect links. Finally the elements descriptions are written in the digraph to call it the Interpretive Structural Modeling. The Interpretive Structural Modeling which has established has no feedbacks. In pure hierarchical pattern Elements are interrelated[14].

MICMAC analysis: For various supply chain risks identification and grouping are essential to develop the Interpretive Structural Modeling under study. The order of risks which are classified into direct, indirect, potential are compared, are the rich source of information. Analyzing MICMAC (an indirect classification method) critically for the scope of each element. MICMAC analysis has the necessity for the evaluation of the driving power and dependence of supply chain risks[19,20]. The driving power and dependence are respectively indicated by the summation along the rows and the columns. Elements are separated into four groups of risks which are autonomous, dependent, linkage and independent elements. In Group I autonomous elements are included that have weak driver power and weak dependence. Dependent elements are involved into Group II that have weak driver power and strong dependence. Group III includes linkage elements have Interpretive Structural Modeling of supply chain risks for both strong driving and dependence power. In group IV all independent elements are clustered that have strong driving power, but poor dependence power[14].

Results and discussion

This section describes computational experiments carried out to a Bangladeshi industry named Ananta Group, Incepta Pharmaceutical Ltd, Beximco group. Supply chain risk factors refers to everyday and exceptional risk along with the supply chain based on vulnerability and discontinuity. The risk factors of supply chain are summarized in Table-1.

Table-1: Risk factors of Ananta Group.

Risk No	Risk Name
R_1	Long term availability down times
R_2	Capacity bottlenecks on supply market
R_3	Dependency on supplier
R_4	Poor performance of subcontractors
R_5	Delay in delivery
R_6	Insufficient Inventory
R_7	Wrong SKU
R_8	Wrong inventory record
R_9	Natural disasters
R_{10}	Wrong order entry
R_{11}	IT break down
R_{12}	Mispackaging
R_{13}	Lack of wrong time study
R_{14}	Supplier flexibility
R_{15}	Long lead time
R_{16}	Improper forecasting
R_{17}	Poor distribution network
R_{18}	Irregular payment
R_{19}	Poor delivery quality
R_{20}	Lack of sufficient transport capacities

Structural Self-Interaction Matrix: This matrix is formed as a table (Table-2) where the risk factors are being put through rows and columns. And also, after arranging them into row and column the relation between them is being found out such as, which factor depending on whom according to the expert opinions.

Table-2: Structural Self-Interaction Matrix.

Elements	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	V	V	O	O	V	X	O	O	O	O	O	O	A	A	V	A	O	A	O	O
2	A	V	A	A	O	V	O	O	A	O	O	O	A	A	A	A	A	A	O	O
3	V	V	V	X	V	V	O	O	A	O	O	O	O	X	V	V	O	X	O	O
4	V	V	A	V	V	V	O	O	A	O	A	O	A	V	V	A	O	A	A	A
5	A	O	A	A	V	A	A	A	A	A	A	A	A	A	O	O	A	O	X	A
6	A	X	O	O	V	V	A	X	O	O	O	O	O	A	O	A	O	A	O	O
7	O	O	O	O	V	V	V	X	O	X	O	X	O	O	O	O	O	O	O	O
8	X	O	O	O	V	V	X	V	O	A	A	O	O	O	O	O	O	O	O	O
9	V	V	O	V	V	V	O	O	V	O	V	O	O	V	V	O	O	O	O	O
10	O	O	O	O	V	X	O	V	O	V	O	O	O	O	O	O	O	O	X	O
11	V	V	O	V	V	O	O	V	A	V	V	O	O	O	O	O	O	O	O	O
12	O	X	O	X	V	O	O	V	O	A	O	V	A	O	O	O	O	O	O	O
13	O	X	O	O	V	O	O	O	O	A	O	A	V	O	X	O	O	O	O	O
14	A	X	V	X	V	V	O	O	A	O	O	O	O	V	X	O	O	X	V	O
15	A	A	A	A	V	V	O	O	A	O	O	O	O	A	V	O	A	X	O	A
16	X	V	O	O	V	O	O	O	O	O	O	O	O	V	O	V	O	O	O	O
17	O	V	A	X	V	O	O	O	A	O	O	O	O	X	V	O	V	O	O	A
18	V	V	O	V	X	O	O	O	A	O	O	A	O	A	A	O	O	V	A	O
19	O	X	O	O	V	O	O	O	O	O	O	A	O	O	A	O	O	A	V	A
20	O	O	A	V	V	O	O	O	A	O	O	O	O	V	V	O	V	O	V	V

Initial Reachability Matrix: Hereby, the dependency of the factors on each other from the table have been drawn above. From the table of SSIM we found the relations that refers to - If the (i, j) entry in the SSIM is V, then in the reachability matrix the (i, j) entry becomes 1 and the (j, i) entry becomes 0.And if the (i, j) entry in the SSIM is A, then in the reachability matrix the (i, j) entry is 0 and the (j, i) entry is 1. In addition to if the (i, j) entry in the SSIM is X, then in the reachability matrix the (i, j) entry becomes 1 and the (j, i) entry also becomes 1. Again, if the (i, j) entry in the SSIM is O, then in the reachability matrix the (i, j) entry becomes 0 and the (j, i) entry also becomes 0.

Table-3: Initial Reachability Matrix.

Elements	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	1	0	1	0	0
4	1	1	0	1	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
6	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0
8	1	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
9	1	1	0	1	1	1	0	0	1	0	1	0	0	1	1	0	0	0	0	0
10	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0
11	1	1	0	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0
12	0	1	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
13	0	1	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
14	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	0	1	1	0
15	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0
16	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
17	0	1	0	1	1	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0
18	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
19	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
20	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	O	1	0	1	1

Final Reachability Matrix: Final Reachability Matrix has been attained from Initial Reachability Matrix. Hereby through the Final Reachability Matrix the transitivity has been checked. For building up if 'A' is being related to 'B' and 'B' is being related to 'C' then there must have been a relation between 'A' and 'C'. And for representing this 1* entries are comprised to incorporate transitivity for filling the gap if any in the opinion collected during development of structural self-instructional matrix.

Table-4: Final Reachability Matrix.

Elements	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	1	0	0	1	1	0	1*	0	0	0	0	0	0	1	0	1*	0	1*	0
2	0	1	0	0	1*	1	0	1*	0	0	0	0	0	0	0	0	0	0	0	0
3	1	1	1	1	1	1	0	1*	0	0	0	0	0	1	1	1	0	1	1*	0
4	1	1	1*	1	1	1	0	1*	0	0	0	0	0	1	1	0	1*	1*	1*	0
5	0	1*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
6	1*	1	0	0	1	1	1*	1	0	0	0	0	0	0	0	0	0	0	1*	0
7	1*	1*	0	1*	1	1	1	1	0	1	0	1	0	0	0	0	0	0	1*	0
8	1	1*	0	0	1	1	1	1	0	0	0	0	0	0	1*	0	0	0	1*	0
9	1	1	1*	1	1	1	0	1*	1	1*	1	0	0	1	1	0	0	1*	1*	0
10	1*	1*	0	0	1	1	1*	1	0	1	0	0	0	0	0	0	0	0	1	0
11	1	1	0	1	1	1*	0	1	0	1	1	0	0	1*	1*	0	0	0	1*	0
12	1*	1	0	1	1	1*	0	1	0	0	0	1	0	1*	1*	0	0	0	0	0
13	1*	1	0	0	1	1*	0	0	0	0	0	0	1	0	1	0	1*	0	1*	0
14	1	1	1	1	1	1	0	1*	0	0	0	0	0	1	1	1*	1*	1	1	0
15	1	1*	0	1*	1	1	0	1*	0	0	0	0	0	1*	1	0	0	1	1*	0
16	1	1	1*	1*	1	1*	0	0	0	0	0	0	0	1	1*	1	0	1*	1*	0
17	1	1	1*	1	1	1*	0	0	0	0	0	0	0	1	1	0	1	1*	1*	0
18	1	1	0	1	1	1*	0	0	0	0	0	0	0	1*	1*	0	0	1	1*	0
19	0	1	0	0	1	1*	0	0	0	0	0	0	0	0	0	0	0	0	1	0
20	1*	1*	1*	1	1	1*	0	0	0	0	0	0	0	1	1	0	1	1*	1	1

The diagraph obtained from Table-3 is represented as Figure-1. This figure is being drawn in accordance with the direct dependency of the risk factors.

The diagraph obtained from Table-4 is represented as Figure-2. This figure is being drawn in accordance with both the direct and indirect dependency of the risk factors. In short, this diagraph shows the transitivity. From the figure there are two types of line are being indicated. One is denoted by blue and the other one is denoted by green color. The green color refers the indirect relationship whereas the blue ones refer the direction relation between the risk factors.

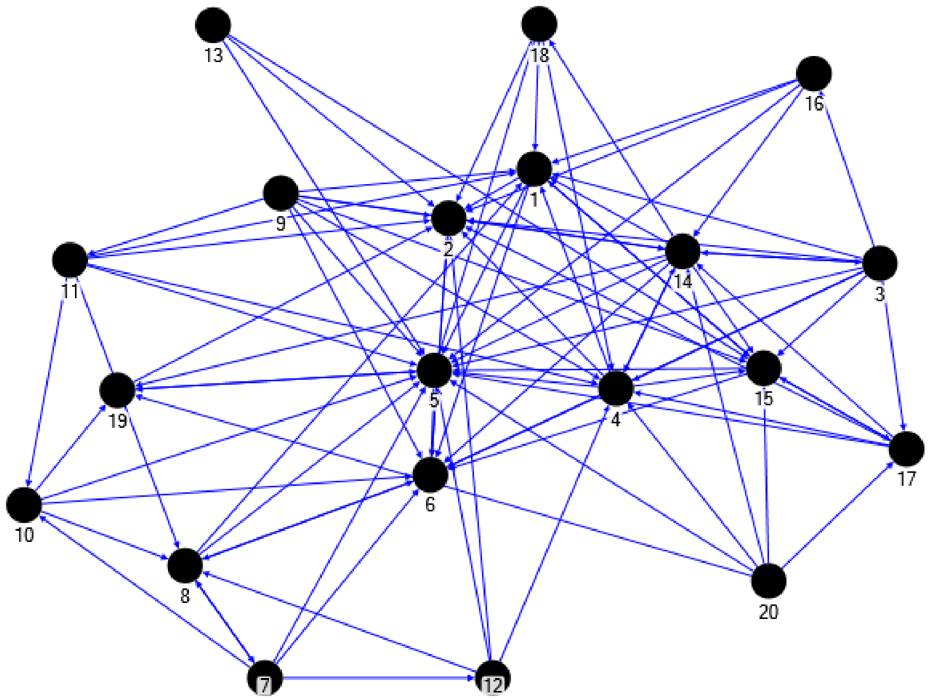

Figure-1: Diagraph depicting the relationships among the variables.

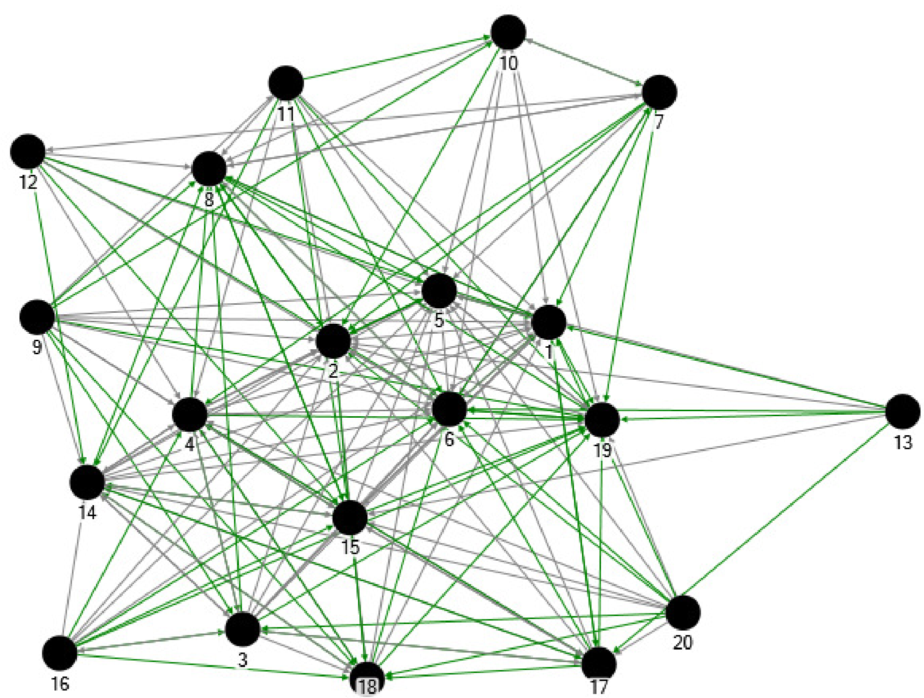

Figure-2: Final diagraph depicting the relationships among the variables.

Table-5: Levels of Risk factors.

Element (P)	Reachability Set: R (Pi)	Antecedent Set : A (Pj)	Intersection R (Pi) A (Pj)	Level
1	1,2,5,6,8,15,17,19	1,3,4,6,7,8,9,10,11,12,13,14,15,16,17,18,20	1,6,8,15,17	I
2	2,5,6,8	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19	2,5,6,8	II
3	1,2,3,4,5,6,8,14,15,16,17,18,19	3,4,14,20	3,4,14	I
4	1,2,3,4,5,6,8,14,15,17,18,19	3,4,9,11,12,14,15,16,17,18,20	3,4,14,15,17,18	I
5	2,5,19	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20	2,5,19	I
6	1,2,5,6,7,8,19	1,2,3,4,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20	1,2,6,7,8,19	I
7	1,2,4,5,6,7,8,10,12,19	6,7,8,10	6,7,8,10	II
8	1,2,5,6,7,8,15,19	1,2,3,4,6,7,8,9,10,11,12,14,15	1,2,6,7,8,15	II
9	1,2,3,4,5,6,8,9,10,11,14,15,18,19	9	9	III
10	1,2,5,6,7,8,10,19	7,9,10,11	7,10	II
11	1,2,4,5,6,8,10,11,14,15,19	9,11	11	III
12	1,2,4,5,6,8,12,14,15	7,12	12	IV
13	1,2,5,6,13,15,17,19	13	13	V
14	1,2,3,4,5,6,8,14,15,17,18,19	3,4,9,11,12,14,15, 16,17,18,20	3,4,14, 15,17,18	I
15	1,2,4,5,6,8,14,15,17,18,19	1,3,4,8,9,11,12,13,14,15,16,17,18,20	1,4,8,14, 15,17,18	I
16	1,2,3,4,5,6,14,15,16,18,19	3,14,16	3,14,16	I
17	1,2,3,4,5,6,14,15,17,18,19	1,4,13,14,17,20	1,4,14,17	I
18	1,2,4,5,6,14,15,18,19	3,4,9,14,15,16,17,18,19,20	4,15,18,19	I
19	2,5,6,19	1,3,4,5,6,7,8,9,10,11,13,14,15,16,17,18,19,20	5,6,19	I
20	1,2,3,4,5,614,15,17,18,19,20	20	20	III

Hereby Table-5 is created through the Reachability set, Antecedent set and Intersection of them. The relations between the factors through rows in case of Reachability set is being found out. Then the relations between the factors through the columns in case of Antecedent set is being formed and the Intersection set could also be found out from both sets. Finally, arrangement them into different levels for building them into Conical Form. This table is obtained from the Table-5. In this table rearrangement the risk factors according to their level through row and column is being formed. For example, elements no: 1,3,4,5,6,14,15,17,18,19 from level I that's why these variables are placed here first. Then come the elements from level II, level III, level IV and V respectively. Then again, the relation between them from the reachability matrix is being formed.

Table-6: Conical form of Reachability Matrix.

Elements	1	3	4	5	6	14	15	17	18	19	2	7	8	10	16	9	11	20	12	13
1	1	0	0	1	1	0	1	1	0	1	1	0	1	0	0	0	0	0	0	0
3	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	0	0	0	0
4	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0
5	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
6	1	0	0	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
14	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0
15	1	0	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0
17	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
18	1	0	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0
19	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
2	0	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
7	1	0	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0	0	1	0
8	1	0	0	1	1	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0
10	1	0	0	1	1	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0
16	1	1	1	1	1	1	1	0	1	1	1	0	0	0	1	0	0	0	0	0
9	1	1	1	1	1	1	1	0	1	1	1	0	1	1	0	1	1	0	0	0
11	1	0	1	1	1	1	1	0	0	1	1	0	1	1	0	0	1	0	0	0
20	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0
12	1	0	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0
13	1	0	0	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	1

Diagraph Development: On the basis of conical form of reachability matrix, transitive links is obtained by the initial diagraph as shown in Figure-3. The final diagraph is obtained after removing indirect links, as shown in Figure-4.

Figure-4 is being obtained from the figure above. In this only the direct relation is being formed between the variables. Thus, the interpretive Structural model is being showed with the levels of the variables.

Table-7 is formed from the table above. This table has shown both the driving power as well as the depending power. The driving power is being found from the summation of the factors through rows. Again, the depending power is being found from the summation of the factors through columns. Then both the driving power and depending power is being ranked. The highest summation is being ranked as I. Then the others are also being ranked respectively in order to summation.

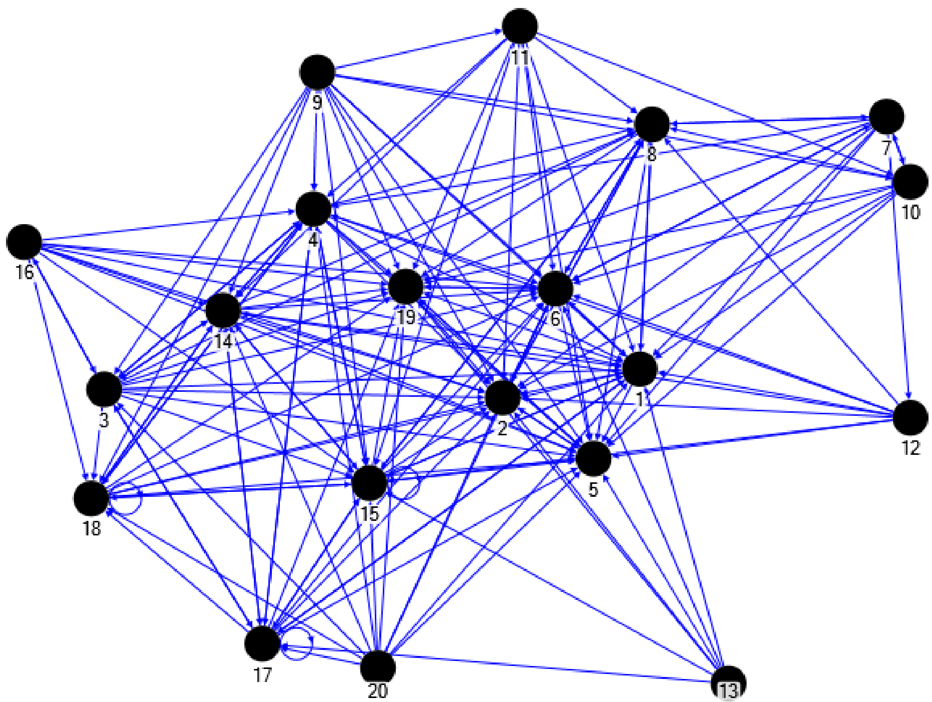

Figure-3: Diagraph showing the levels of the variables.

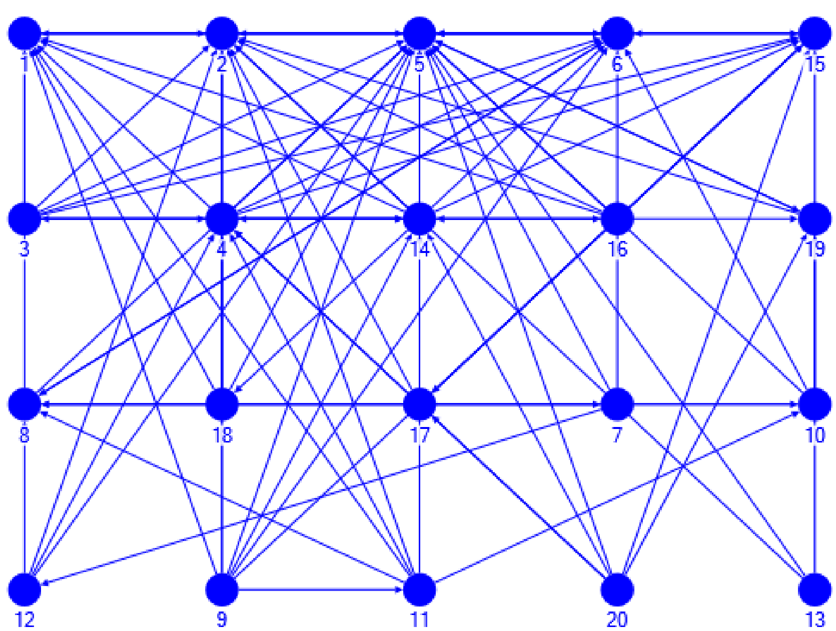

Figure-4: Interpretive Structural model showing the levels of the variables.

Table-7: Driving power and dependence in Reachability Matrix.

Elements	1	3	4	5	6	14	15	17	18	19	2	7	8	10	16	9	11	20	12	13	Driving power	Ranks
1	1	0	0	1	1	0	1	1	0	1	1	0	1	0	0	0	0	0	0	0	8	VII
3	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	0	0	0	0	13	II
4	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	12	III
5	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	3	X
6	1	0	0	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	7	VIII
14	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	12	III
15	1	0	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	11	IV
17	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	11	IV
18	1	0	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	9	VI
19	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	4	IX
2	0	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	4	IX
7	1	0	1	1	1	0	0	0	0	1	1	1	1	1	0	0	0	0	1	0	10	V
8	1	0	0	1	1	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	8	VII
10	1	0	0	1	1	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	8	VII
16	1	1	1	1	1	1	1	0	1	1	1	0	0	0	1	0	0	0	0	0	11	IV
9	1	1	1	1	1	1	1	0	1	1	1	0	1	1	0	1	1	0	0	0	14	I
11	1	0	1	1	1	1	1	0	0	1	1	0	1	1	0	0	1	0	0	0	11	IV
20	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	0	0	12	III
12	1	0	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0	9	VI
13	1	0	0	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	1	8	VII

Table-8: Dependence Ranks.

17 IV	7 X	12 VII	19 II	11 VII	14 V	8 IX	9 VIII	18 III	21 I	4 XI	13 VI	4 XI	2 XII	1 XIII	2 XII	1 XIII	2 XII	2 XII	1 XIII

MICMAC Analysis: For analyzing the driving power and dependence power of the variables MICMAC analysis has great impact. The variables are classified into four clusters.

First cluster includes "Autonomous variables" which have weak dependence and driver power. These are relatively disconnected from the system, with which they have only few strong links.

The second one consists of the dependent variables that have strong dependence but weak driver power. The third one which has the linkage variables that have both the strong driving power and dependence. These v are unstable variables. Any action on these variables will not only have an effect on others but also a feedback effect on themselves.

Fourth cluster includes independent variables having strong driving power but weak dependences. It is observed that a variable with the very strong driving power, called as the key variables false into the category of independent or linkage variables.

An entry of "1" in table 6 the dependence and driving power respectively indicated along the columns and rows.

The variables which are categorized into ranks. For example, element 4 has VII rank in dependence and III in driving power while element 2 has IX rank in dependence and IX rank in driving power.

Four categories are presented in Figure-5. Risk factors 3,8,9,10,11,12,13,15,17,16,20 comes under category IV and therefore categorized as independent drivers. Risk factors 1,4,7,14,18 comes under category III and therefore categorized as linkage variable. Risk factors 5, 19 come under category III and therefore categorized as Dependent variable. Risk factor 1 comes under category I and therefore categorized as Autonomous variable.

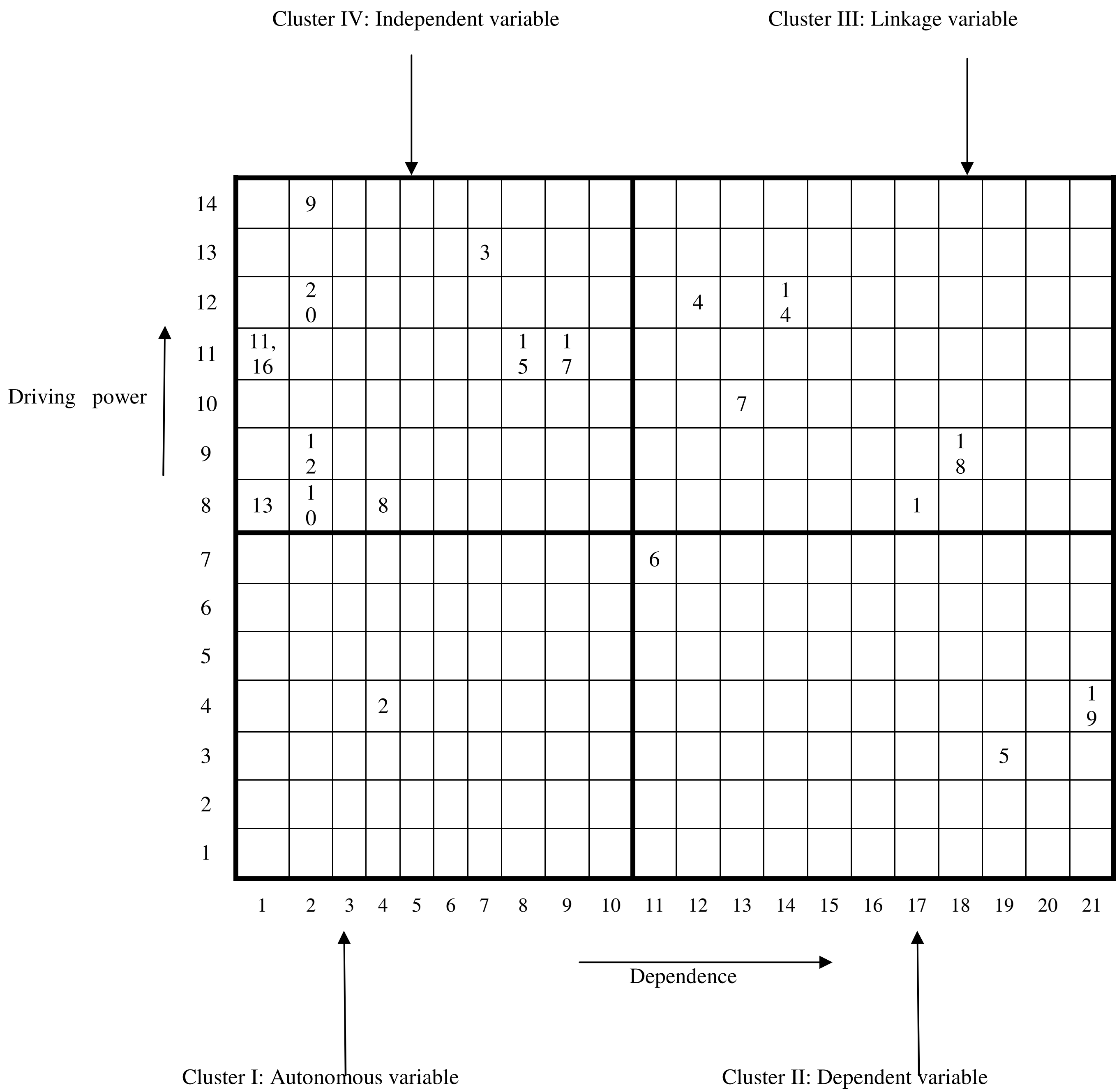

Figure-5: Cluster of elements in the implementation of risk variables.

Study and development of ISM for this model implementation in the industry result into following findings:

Cluster I is referred as Autonomous variables. These variables are located in the south-west frame and have only a few links with the system. This come into view quite out of line with the system. “Driving power- dependence matrix” reveals (element 2) is an autonomous element in risk minimizing process. This variable is a weak driver and has weak dependence. It plays relatively less important role risk minimizing process in Organization.

Cluster II is made reference to Depending variables. These variables, in the south – east location of the chart, are at the same time little impactful and very dependent. Therefore, they are especially sensitive to the evaluation of influent variables. For the system they are exit variables. Dependent elements are 5,6,19. These elements are weak drivers but strongly dependent on one each other.

So, organization should focus their attention to build up strong risk minimizing resources through better strategic planning. Similar interdependent action plans could emerge out of the combinations of these variables.

Cluster III is referred as Linkage variables. These variables are at the same time very impactful and very dependent. They are also called Relay variables. These variables are situated in the north-east frame of the chart and are unstable. Any action on these indicators will have influence on others and feedback effect on themselves which may turn up or support the initial pulse. Hereby, element 1,4,7,14,18 is under Linkage element that has a strong driver power and also a strong dependence.

Cluster IV is referred as Independent variables. These variables are entirely very impactful and compact dependency. These variables are located in the north-west frame of the perception chart. Most of the trust building system thus depends on these variables. Ranks of the elements based on their driving power indicate that element 9 is the key element in implementing the model in the organization. It has very strong driving power but has extremely weak dependence on other variables under study. There are other elements such as 3, 20,11,16,15,17,12,13,10,8 in this cluster which have strong driving power with frail dependence.

Initially 8 factors were taken under the company as variables. Other factors couldn’t be found to make the supply chain process smoother. This research work has been done with twenty factors, also the percentage of the drivers, linkages, autonomous along with the independent variables have been found. This unique research work helps the company to erase the barriers related to supply chain risk management process to make the process smoother. The company has become satisfied with the research that has been done in this research work.

Table-9: Percentage of the variables in different clusters.

Types of the variables	Percentage
Driver	55
Linkage	25
Autonomous	5
Dependent	15

Conclusion

In this paper, all the key variables has identified for inter organizational risk minimizing in supply chain management. Total 20 variables for Ananta group were identified and ISM approach has been applied. There exists a variety of standard for risk minimizing in supply chain management. It proves that no solo criterion would be self-sufficient for risk mitigation in supply chain, so it becomes significant to pick out and categorize both the dependent and independent variables and also their co-relationships with each other. In this paper Integrated Model has been used for minimizing risk factors using ISM and the MICMAC approach, which may be obliging to supply chain managers to employ this model for identifying and classifying the significant criteria for their needs and to disclose the direct and indirect effects of each criterion on the risk minimizing process in supply chain management .The variables single out in this model are quite collective and with some adjustments can be used for risk minimizing for efficacy and efficiency of supply chain. These findings provide necessary guidelines to the supply chain managers that they should evaluate various information of supply chain risks to make the organizational supply chain even on the basis of above results. Accordingly Supply Chain managers may also purposely plan its long-term growth strategy to meet risk minimizing action plan. By using this model in further areas, the risk minimizing factors will be minimized along with the growth of the organization as well as the decreasing of the overall cost in supply chain sectors.

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