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MODELING IT ROLE IN SHIPPING INDUSTRY: AN APPLICATION OF ISM

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Abstract

Purpose: *Supply chain management (SCM) in Maritime sector helps shipping companies in integrating their logistics and maritime cargo operation by collaborating with other maritime entities to meet the unpredictable demand of the end user at the importing countries. Use of IT is the fundamental characteristic of a Maritime Supply Chain (MSC) needed for survival in turbulent and volatile Maritime competition, which is a requirement for the transparency in business. Getting the right cargo, at the right time for the consignee is not only the utmost priority for competitive success, but also the key to survival. Maritime fraternity's satisfaction and understanding of maritime sector are critical in the use of IT in management of supply chain both cargo and passengers. This study is an attempt to develop a structural model of variables for modeling role of IT in Shipping Industry using ISM.* ***Approach:*** *From the maritime literature review and opinion of the experts from maritime fraternity, various variables for role of IT in shipping industry have been identified. After brain storming to the top management expert of Ships (Captains and Chief Engineers), certain variables were identified. Based on the driving power and dependence of variables, classifications of these were achieved. Questionnaires were E-mailed to forty ships to rank these variables and as per responses received. These variables in the management of use of IT in maritime supply chain have been analyzed using Interpretive Structural Modeling (ISM).* ***Findings:*** *Eleven variables have been identified from the maritime literature and subsequent discussion with onboard maritime experts. Based upon the expert's opinions, the model so developed is a hypothetical. Clear understanding of interaction among these variables will help maritime sector to prioritize and manage these variables more efficiently and effectively to draw advantage in use of IT in Maritime sector.* ***Originality:*** *Through this, researcher contributes to identify the variables to implement IT in maritime sector and prioritize them. The structural model developed will help to understand interdependence of the variables in maritime sector.*

Key words: Maritime sector, Business sensitivity, Interactive, Reachability, Interaction, MICMAC

1. INTRODUCTION

An integrated Maritime supply chain engineered to cope with uncertainly can satisfy customer demand at the consignee end, while non- integrated logistics and cargo distribution leads to poor relationships with maritime fraternity and end user at discharge port at importing country. This may be the recipes of business failure at Maritime sector. In the era of time-based competition, supply chain must have the ability to meet the demand of customers at importing country in shorter delivery times and also during the peaks and troughs of the demand. To have this ability, MSC must be responsive to the needs of importing country, which requires speed and high level of maneuverability in management of vessels in Ports and sea- passage. This is greatly enhanced by the use of IT in the maritime sector. This environmental force reduces uncertainly of higher risk in the supply chain management. Turbulent and volatile markets are becoming the norm as life cycles shorten and global economic and competitive forces create additional uncertainty. The risk attached to lengthy and slow-moving logistics "pipelines" has become unsustainable, forcing organizations to look again at how their supply chains are structured and managed. (Christopher Martin, 2000). The choice of supply chain strategy should be based upon a careful analysis of the demand/supply characteristics of the various product/markets served by a shipping company through maritime sector. It presents the basis for taxonomy of appropriate supply chain strategies. (Martin Christopher et al., 2006). Sustainability and the search for solutions that are both efficient and ecologically sound (eco-efficient) have become topics of great interest. However, companies seeking to develop supply chain solutions that are eco-efficient are often hampered by their ability to control the wider supply chain and they may need to draw upon external support from logistics service providers. Efficient use of IT in Maritime Business enhances the capabilities that embrace organization structure, information system and, in particular, mindset. Proper use of IT in MSC means using maritime knowledge and virtual corporation to exploit profitable opportunities in a volatile marketplace at consignee as well as shippers end. ISM is a methodology for identifying and summarizing relationships among specific elements, which define an issue or problem and provides a means by which order can be imposed on the complexity of such element (Mandal, A., and Deshmukh, S. G., 1994). The emphasis is on adaptability to changes in the business addressing market and customer needs proactively. Changes in the business environment due to varying needs of the customers lead to uncertainty in the decision parameters. (Agarwal, A. et al., 2006). The model brings out the inter-relationships of the variable and their levels. These variables have also been categorized depending on their driving power and dependence. The insight from model would help supply chain managers in strategic planning for improving supply chain with proper use of IT.

2. LITERATURE REVIEW

Customer service is a strategic weapon in the attraction and retention of customers, and has become one of the most significant factors in the success of manufacturers and service providers (Zeithaml, 1988; Gale, 1994; Woodruff, 1997; Parasuraman, 1998). Studies on Maritime sector and connecting supply chain during ocean passage as old as when human start fathoming the oceans for their supremacy.

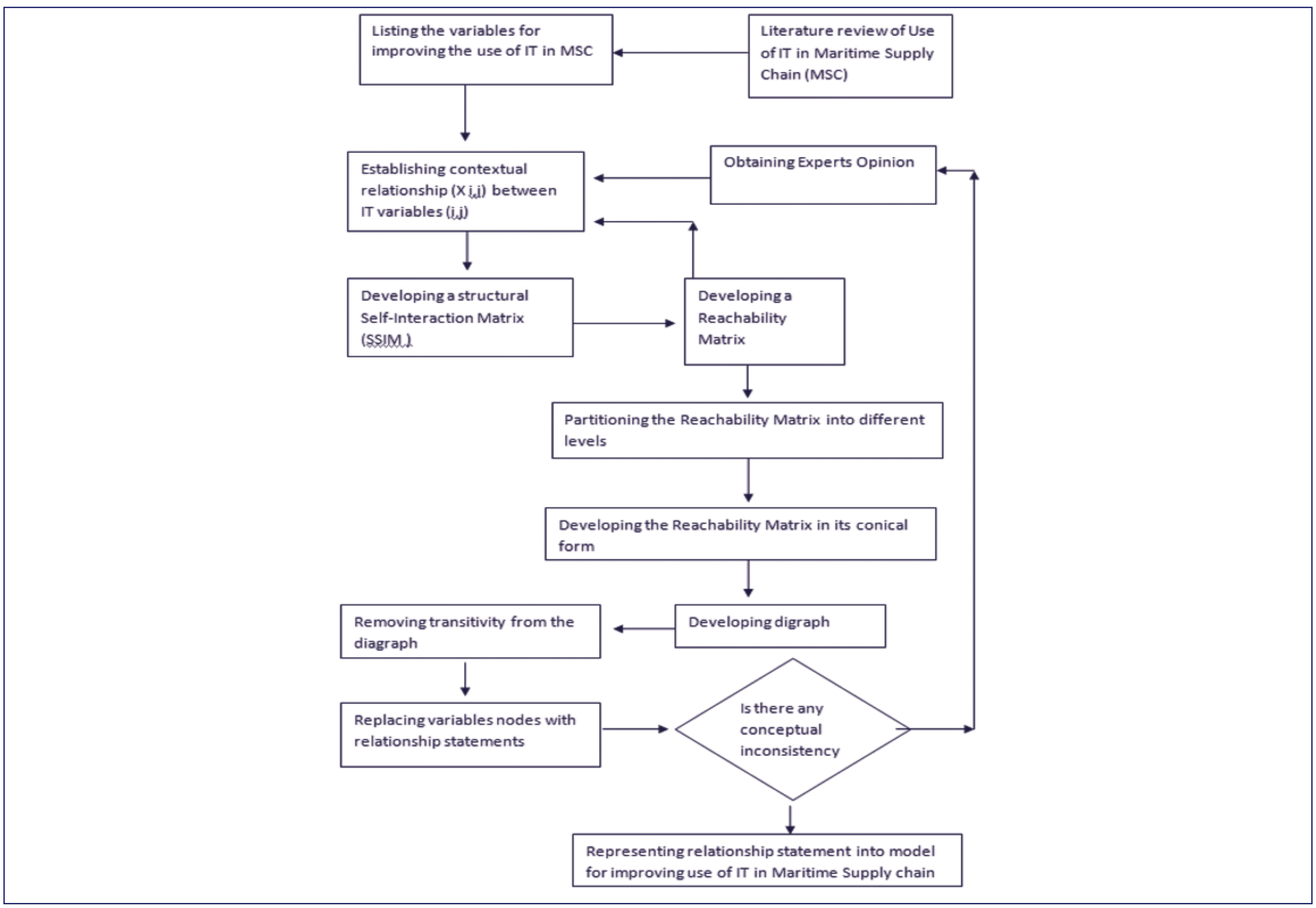
3. METHODOLOGY

ISM is an interactive learning process. A set of different and directly related element are structured into a comprehensive systemic model. The model so formed portrays the structure of complex issue or problem, a system or a field of study, in a carefully designed pattern implying graphics as well as words. . (Sage A.P. 1977). Interpretive Structural Modeling is a methodology for identifying and summarizing relationships among specific elements, which define an issue or problem. It provides a means by which order can be imposed on the complexity of such elements. (Singh M. D., et al., 2003). ISM is well established methodology for identifying and summarizes the mutual relationships among the specific items which define a problem or an issue. (Sharma et al., 2012). ISM methodology helps to impose order and direction on the complexity of relationships among element of a system. The objective of MICMAC analysis is to analyze the driving power and dependence power of variables (Saxena et al., 1990; Mandal and Deshmukh, 1994)

The various steps (Figure 1) involved in the ISM technique are:

1. Variables which can be objectives, Actions, individuals in use of IT are being listed first, then establish a contextual relationship between variables with respect to which pair of variables will be examined.
2. After this develop a Structural Self Interaction Matrix (SSIM) of variables, which indicates pair-wise relationship between variables of the system.
3. Once the development of SSIM is complete, then develop a Reachability matrix from the SSIM, and check the matrix for transitivity, then partition the Reachability matrix into different levels is to be done.
4. Then develop the Reachability in its conical form, i.e. with most zero (0) variables in the upper diagonal half of the Matrix and most unitary (1) variables in the lower half.
5. Based on the above, draw a directed graph (digraph), and remove transitive links.
6. Convert the resultant digraph into an ISM, by replacing variable nodes with statements.
7. For checking any conceptual inconsistency, review the ISM model and carry out the necessary modifications.

Fig. 1: Flow Diagrams for ISM



4. IDENTIFICATION OF ELEMENTS

Based on literature review and Marine expert's opinion, the following variables have been identified:

1. Business Sensitiveness (BS)
2. Sea-passage Connectivity (SC)
3. Data Accuracy (DA)
4. Latest Equipments Introduction (LEI)
5. Centralized and Collaborating Planning (CCP)
6. Use of IT Tools (UIT)
7. Service Level Improvement (SLI)
8. Cost Minimization (COM)
9. Customer Satisfaction (CUS)
10. Quality Improvement (QI)
11. Trust Development (TD)

5. QUESTIONNAIRE – BASED SURVEY

The questionnaire consists of eleven variables related to MSC agility. These variables are identified on the basis of a personal visit and discussion with experts in shipping company having more than five years of experience in MSC area. Questionnaire was E-mailed to management level (Captain, Chief Officer, Chief Engineers and 2nd Engineers) staff of the 40 ships. Out of 160 questionnaires sent, 42 responsive were received, resulting 26% response rate. Out of 42 responses it is found that of 37 numbers are usable. The purpose of the questionnaire-based survey was to identify the impact of IT on SC in Maritime sector from user at maritime sector at seaway point of view. Later, the correlation matrix for the variables obtained from the questionnaire results, is used together with.

6. ANALYSIS

6.1 Structural Self-Interaction Matrix (SSIM): Variables of modeling IT in shipping Industry using ISM, discussed in earlier section, are maritime business sensitiveness (element 1), data accuracy (element 2), Latest equipment introduction (element 3), centralized and collaborative planning (element 4), use of IT tools (element 5), service level improvement (element 6), cost minimization (element 7), customer satisfaction (9), quality improvement (10) and trust development (11). For analyzing variables of modeling IT in shipping industry using ISM, a contextual relationship of "leads to" type is chosen. This means that one variable led to another variable. Keeping in mind the contextual relationships for each variable, the assistance of a relation between any two sub-variables (i and j) and the associated direction of the relation are questioned.

Four symbols are used for the type of the relation that exists between the two sub-variables under consideration:

V- Variable i will help to achieve variable j;

A-Variable j will help to achieve variable i;

X-Variables i and j will help achieve each other, and

O-Variables j and i are unrelated.

The supply chain, under study, is in fast moving consumer goods business and consists of IT expert, ship mangers dealing with HR and stores, and Captain of ship's (on leave). Five experts from different ship and ashore, were consulted in identifying the variables and nature of contextual relationships among variables. The expert was having more than ten years of experience in the area of Maritime supply chain management. These experts were consulted in camera and they were asked to provide a consensus score for each pair wise comparison. Though ISM methodology suggests use of expert's opinion alone (based on various management technique such as nominal group technique etc.) in developing the contextual relationship, the correlation coefficients obtained from the questionnaire have also been used to facilitate the experts in identifying the nature of these relationships.

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

1) According to expert's opinion Business sensitiveness (element 1) and quality improvement (element 10) are unrelated; therefore, O is assigned to the cell in the SSIM at the intersection of row of Business sensitiveness (element 1) and column of quality improvement (element 10). The experts feel that Business sensitiveness hardly help in achieving quality improvement. Similarly, quality improvement does not help to enhance market sensitiveness of a supply chain.
2) Business sensitiveness (element 1) helps to achieve customer satisfaction (element 9); hence V is assigned to the cell at the intersection of Business sensitiveness (element 1) row and customer satisfaction and (element 9) column.
3) Connectivity performance (element 2) will be achieved by Business sensitiveness (element 1) and Business sensitiveness will be achieved by connectivity performance; hence A is assigned in the cell at the intersection of Business sensitiveness row and connectivity performance column.
4) Centralized and collaborative planning (element 5) helps in service level improvement (element 7), and service level integration initiates centralized and collaborative planning; therefore, relationship X is assigned in at intersection of centralized and collaboration and planning and service level improvement.

Based on these contextual relationships, the SSIM is developed as shown in Table 1.

Table 1: Structural Self Interaction Matrix (SSIM)

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

6.2 Reachability Matrix: The SSIM format is transformed into a Reachability matrix format by transforming the information in each entry of the SSIM into 1s and 0s in the Reachability matrix.

Four situations related to this model are as follows:

1. If the (i, j) entry in the SSIM is V, then the (i, j) entry in the Reachability matrix becomes 1 and the (j,i) entry becomes 0.
2. If the (i, j) entry in the SSIM is A, then the (i, j) entry in the matrix becomes 0 and the (j,i) entry becomes 1.
3. If the (i, j) entry in the SSIM is X, then the (i, j) entry in the matrix becomes 1 and the (j, i) entry also becomes 1.
4. If the (j,i) entry in the SSIM is O, then the (i,j) entry in the matrix becomes 0 and the (j,i) entry becomes 0.

Initial Reachability matrix for the variables is prepared and shown in table 2.

Table 2: Reachability Matrix

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

There was no gap found in the opinion collecting during development of structural self-instructional matrix. The final Reachability matrix is same as table 3.

6.3 Partitioning the Reachability Matrix: The matrix is partitioned by assessing the Reachability and antecedent sets for each variable. The Reachability set consists of the element itself and other elements, which it may help to achieve, whereas the antecedent set consists of the element and other elements, which may help achieving it. Then the intersection of these sets is derived for all the elements. The elements for which the Reachability and intersection sets are same are the top-level elements in the ISM hierarchy. The top-level element of the hierarchy would not help to achieve any other element above their own level in the hierarchy. Once top-level element are identifies, it is separated out from the rest of the elements. Then, the same process is repeated to find the next level of elements. These identified levels help in building the digraph and final model. In the present, the variables along with their Reachability set, antecedent set, intersection set and the levels are shown in Table 3, and completes as follows.

Table 3: Levels of Maritime sector variables

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

In Table 3, Element 8 (cost minimization) and Element 9 (customer satisfaction), are put at level I. These elements will be positioned at the top of ISM in the digraph. Elements 4 (Latest equipment introduction), Element 7 (service level improvement) and Element 10 (quality level improvement) are at level II. Element 2 (Connectivity performance) comes at level III. Element 1 (Business sensitivity) is at level IV. Element 3 (Data accuracy) is at level V. Element 11(Trust development) comes to level VI. Element 6(Use of IT tools) comes at VII. Final iteration brings out level VIII elements as centralized and collaborative planning (Element 5).

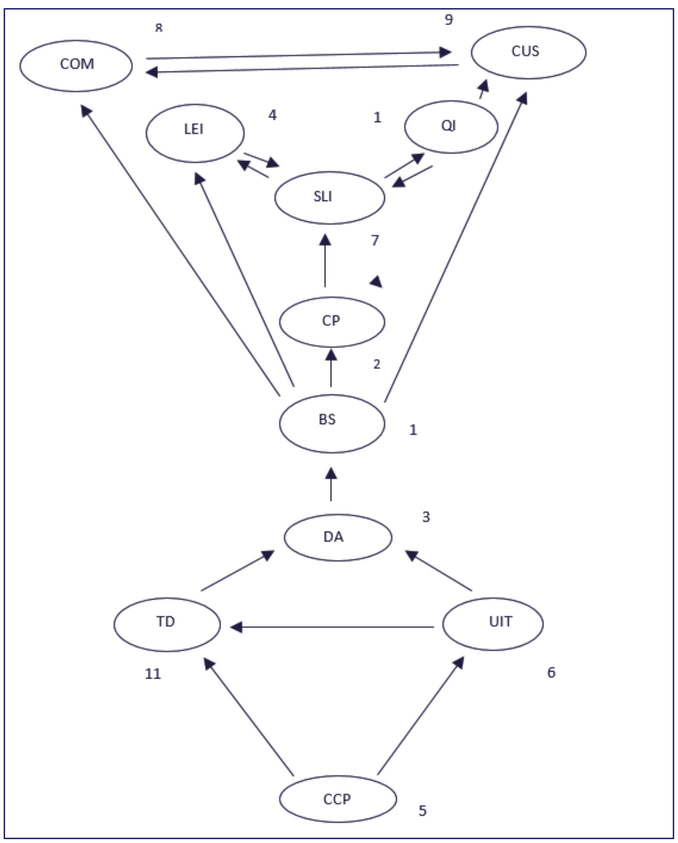
6.4 Developing Conical Matrix: A conical matrix is developed by clustering elements at the same level, across rows and columns of the final Reachability matrix, as shown in Table 4

Table 4: Conical Form of Reachability Matrix

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

6.5 Development of Digraph: Based on the conical form of reliability matrix, the initial digraph including transitive links is obtained. After removing indirect links, the final digraph is obtained, as shown in Figure 2. From Figure 2, it is observed that centralize and collaborative planning (element 5), use of IT tools (element 6) and Trust development improvement (element 11) play significant role in modeling IT in the Maritime supply chain in shipping industry under consideration and they form the base of ISM hierarchy. Cost minimization (element 8), customer satisfaction (element 9), and Latest equipment introduction (element 4) are variable which appear at the top of digraph. Effective centralized and collaborative planning (element 5) and use of IT tools (element 6) provides an environment which helps in increasing connectivity performance (element 2) and thus improves the quality improvement in service (element 10). This leads to developing trust (element 11) among maritime trading partners. This helps in achieving efficient data accuracy (element 3) and better business sensitiveness (element 1). Effective service level improvement (element 7) is achieved due to better data accuracy (element 3) and Business sensitiveness (element 1). Connectivity performance (element 2) for supply chain under consideration enhance as a result of effective service level improvement (element 7). Latest Equipment introduction (element 4) helps management to concentrate on better use of IT Tools (element 6) for cost minimization (element 8) which result in better connectivity performance (element 2). Connectivity performance (element 2) provides better service level (element 7), which result into improve level in customer satisfaction (element 9). Service level improvement (element 7) minimize impact of waste including time; therefore, expert feel that improvement in quality level (element 10) can be achieved with effective service level improvement (element 7). Improvement in customer satisfaction level (element 9) is also achieved with better quality level (element 10).

Figure 2: ISM-Based Model of Variables of IT for Improving Supply Chain after Removing Indirect Links.



7. MICMAC ANALYSIS

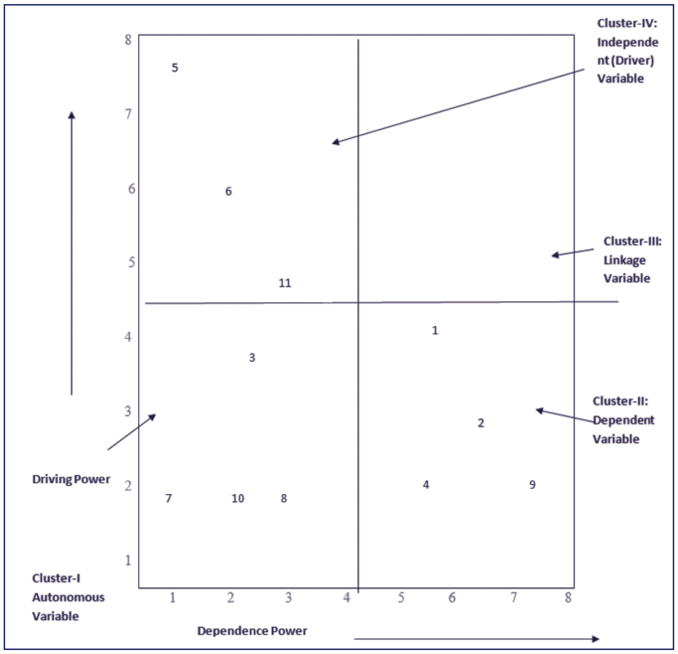
The objective of MICMAC analysis is to analyze the driving power and dependence power of variables (Saxena et. al., 1990; Mandal and Deshmukh, 1994; Sharma et.al., 2012). The variables in maritime supply chain are classified into four clusters. First cluster includes “autonomous variables” that have weak driver power and weak dependence. These variables are relatively disconnected from the system, with which they have only few links, which may be strong. Second cluster consists of the dependent variables that have weak driving power but strong dependence. Third cluster has the linkage variables that have strong driving power and also strong dependence. These variables are unstable. Any action on these variables will have an effect on others and also a feedback effect on themselves. Forth cluster includes independent variables having strong driving power but weak dependence. It is observed that a variable with the very strong driving power, called as the key variables, falls into the category of independent or linkage variables. In Table 5, an entry of “I” along the column and rows indicates the dependence and driving power, respectively.

Table 5: Conical Form of Reachability Matrix

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

The variables are categorized into ranks according to their driving power and dependence rank. For example, element 4 has third rank in dependence and sixth in driving power; while element 2 has second rank in dependence and fifth rank in driving power. All the 11 elements are grouped under four clusters as shown in figure 7.1. Centralized and collaborative planning (5), use of IT tools (6) and Trust Development (11) comes under cluster IV and, therefore, categorized as independent drivers. Nil element is there in cluster III which strong driving power and strong dependence. Data accuracy (3), Service level improvement (7) , Cost minimization (8) and Quality improvement (10) are autonomous variables and are kept under cluster I. Business Sensitiveness (1) , Connectivity performance (2) , Latest equipment introduction (4) and customer satisfaction (9) are kept under the cluster of dependent variables. (cluster II).

Figure 3: Cluster of Variables for improving IT in Supply Chain



8. DISCUSSION

One of the major objectives of this study is to analyze the driving and dependence power of the variables that significantly affect the improvement of use of IT in Maritime sector. The result of the survey indicates that use of IT brings strong customer satisfaction, quality of improvement in service, cost minimization, connectivity performance, latest instrument introduction and finally business sensitivity. The top-level variables emerging in ISM have weak driving power, but strong dependence on other variable for use of IT. It has been observed that use of IT leads to quality improvement, cost minimization, service level improvement and finally brings transparency in trading partners in shipping sector. These attributes depend on other variables like information enrichment, vessel tracking and collaboration across the supply chain. In ISM, the bottom level variables like Centralized and Collaboration Planning and use of I T tools are considered to have strong drivers to improve the role of IT in supply chain. These variables help to achieve improvement in variables business sensitiveness, data accuracy and trust development. Service level improvement, cost minimization and quality improvement are the middle level variables. Performance of these variables can only be improved when improvement of bottom level variables is achieved. Improvement in middle level variables helps to achieve top-level variables. Improvement in top level variables helps in enhance use of IT in maritime sector. Therefore, management should focus its attention to build up a strong network of maritime partners through better use of IT equipment on ships, centralized and collaborative planning and service level improvement. They should develop strategies to achieve better quality, higher service level, improved customers satisfaction, enhancing connectivity performance, and latest Equipment introduction to have integrated and responsive supply chain in Maritime sector. Similar interdependent action plan could emerge out of combinations of these variables. For example, data accuracy (element 3), business sensitivity (element 1) and service level improvement (7) are variables having medium driving power and medium dependence. These variables need consistent attention of the management in enhancing the use of IT in supply chain Management should always keep a watch on the level of these variables. Slight variation in the level of these variables may strongly affect the role of IT in maritime sector.

Variables like use of IT tools (6), centralized and collaborative planning (element 5), service level improvement (element 7) and trust development (11) have strong driving power. These variables have capability to condition the whole supply chain and can be called independent drivers of effective improvement for the supply chain in Maritime sector.

9. CONCLUSION

The level of variables is important in understanding the characteristics of variables to improve use of IT in maritime sector. Cost minimization, customer satisfaction and quality improvement are the key performance related variables in maritime sector and, thus, therefore these appear at the top of the hierarchy. The trading partners in maritime sector using maritime supply chain should share information and assist each other's in their strategic planning to achieve the desired business goal. Data accuracy would be affected by other variables such as use of IT tools, centralized and collaborative planning, service level improvement and development of trust. However, it acts as a driver for importer market sensitive supply chain and thus quickly respond to the market demand. Strategy to develop Trust among maritime partners helps to improve business sensitiveness which supports the use of better IT tools. Ability to introduce latest IT Equipments in maritime supply chain is governed by the capability to visualize and manage the uncertainty in getting update information. Uncertainty in maritime activity could be better managed if supply chain has centralized and collaborative planning. This needs to be overall supported by effective use of IT Equipments in the supply chain. Trust development among maritime partners help to generate reliable data at each stage of the supply chain. All three variables namely, use of IT tools, centralized and collaborating planning and service level improvement are the major drivers, hence they appear the top priority for the use of IT in maritime sector. Service level improvement again can be termed as the most important variable for improving the role of use of IT. It is driven by the business sensitiveness and helps in making fast turnaround of vessels. This improved turnaround of the vessel enhances consignee satisfaction. Increased consignee satisfaction will help to improve market share at his end by reducing lead time, wastes at various leg of journey and providing better quality of service. Quality improvement is captured in the present model by considering the customers satisfaction level, which is also necessary to gain market shares. Supply chain integration variables like use of IT tools, centralized and collaborative planning and process integration have relatively low dependence and thus appears at the bottom level of hierarchy in ISM. This implies that use of IT tools, centralized and collaborative planning and service level play significant role and work as the driver of the supply chain integration.

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