Supply Chain Management in Indian Railways: A Study of Barriers to IT- Enablement

Navneet Kumar Sharma

Research Scholar, FMS, University of Delhi

Abstract

Purpose: Information technology (IT) is the most important driver of supply chain management (SCM) as it can be used to make supply chains more efficient and at the same time more responsive. For other drivers a tradeoff is required to be made between efficiency and responsiveness.

Indian Railways (IR) procure about Rs. 42,0000 Crore worth of materials annually for operations, maintenance and production of rolling stocks (locomotives, coaches, wagons etc.). Although, Indian Railways has been pioneer in adoption of IT, its use in maintenance operations has been minimal. The maintenance/ productions units spread all over India provide the backbone for train operations. However, there are some barriers in the implementation of a seamless IT enabled supply chain management in Indian Railways. These barriers not only influence one another but also adversely affect the IT- enablement of supply chain. The aim of this paper is to identify the barriers that significantly affect the IT- enablement of supply chain and further classify them into driving barriers (root of few more barriers) and dependent barriers (most influenced by the others) so as to provide insights to the management to systematically and effectively deal with these barriers by way of prioritization and formulation of appropriate strategy for the same.

Design/ methodology/ approach: Literature review, interviews/ discussions with experts in Indian Railways, automobile industry and academia and use of interpretive structural modeling (ISM) approach.

Findings: The results of the literature review, field study, interviews/ discussions with experts and application of interpretive structural modeling (ISM) have been used to establish contextual relationships among these barriers and to identify the strategy, project and operational level barriers.

Originality/ value: There is a lack of literature in the area of IT enablement of supply chains particularly with respect to Indian Railways**.** This paper provides a research in this area and identifies the barriers which have both high driving power and dependency and therefore need to be given more attention by the management.

Keywords: Supply Chain Management, Indian Railways, Information Technology

Paper type: Research Paper

1.0 Introduction

Indian Railways (IR) is the fourth largest railway network in the world in terms of route kilometers, after those of the United States, China and Russia. It is also the third largest system in the world under single management. However, over the years, despite significant growth of freight and passenger traffic, the market share of Indian Railways has declined and road transport is emerging as the predominant mode for passenger and freight transport.

Several expert committees have been set up by Ministry of Railways, Government of India to look into the functioning of Indian Railways. The reports submitted by these expert committees, have been pointing out a lack of efficient usage of Information Technology (IT) and its capabilities in Indian Railways. The committees have also been highlighting the disparate functioning of different IT solutions, developed by different departments or divisions, as islands of information not interacting with one another due to lack of common platform or set of standards for information exchange.

These committees have been recommending an enterprise wide implementation of IT including best-in-class inventory management system and modernization of procurement process. The committees had also recommended review and re-engineering of business processes but little has been done on these fronts. The use of IT in maintenance and operations also remains minimal. Majority of IT initiatives have been on the customer side of the organization, e.g. passenger reservation, freight operations, mobile apps etc.

In the field of Materials Management, E- procurement system has been fully implemented. Initially, Materials Management Information System (MMIS) was implemented in Zonal Railways and Production Units but there was no integration of Depot Module with the Purchase Module. Now, an improved "iMMIS" is being deployed. However, still the post contract management module is yet to be implemented. Further, Loco Shed Management System (LMS) for diesel locomotive maintenance sheds and Freight Maintenance Management Module (FMM) for wagon workshops, as part of the Asset Management Project are yet to be fully developed. Similar is the case with implementation of IT systems in Electric locomotive maintenance sheds. Integration of these IT systems with Materials Management Information System (MMIS) is yet to be planned.

The various issues relating to supply chain management (SCM) in Indian Railways, particularly lack of IT enablement of materials supply chain contribute in long lead time of items and loss of responsiveness and efficiency of the supply chain with resulting implications of many items remaining out of stock and on the other hand excess inventory of some other items.

As per Indian Railway's Year Book, 2014-15, Indian Railways procures materials worth about Rs. 43,000 Crore annually. Out of this fuel costs about Rs. 15,000 Crore and material for construction activities is around Rs. 1,100 Crore. The balance about Rs. 27,000 Crore is spent on purchase of stores for manufacturing, operation, repair and maintenance and purchase of complete units. The materials procured are stocked in 262 stocking depots spread over length and breadth of the Zonal Railways and attached with the production units. These depots stock over 1.3 lakh material components of various descriptions and ensure uninterrupted supply of materials to various divisions, loco sheds, carriage & wagon workshops, Electric Multiple Units (EMU) car sheds and production units.

One of the major performance indicators of Materials Management Department, Inventory Turnover Ratio (TOR) is a measure of efficiency of inventory management in Indian Railways. It is the ratio of balances as on 31st March of each year divided by the total issues during the financial year. For the financial year 2014-15, the TOR was 15 % (without fuel) as against 14 % (without fuel) during 2013-14. The inventory (without fuel) held by IR as a whole was Rs. 2,987.65 Crore (as on 31st March, 2015 against total issues of 20,369.10 Crore during the year.

In addition to TOR, an efficient inventory management also requires that required items should be available and at the same time there should not be an overstock, inactive and surplus item in the system. Overstocking and clogging of the supply chain with inactive and surplus items results in blockage of capital thereby increasing the cost of operations and making the supply chain inefficient.

Materials Management which concerns itself with providing the input of materials necessary to keep IR running presents an opportunity for profitability improvement through cost reduction by implementation of IT enabled supply chain management (SCM). Application of IT coupled with modern SCM practices will not only make the materials supply chain more efficient but at the same time more responsive. There can be substantial savings not only in the material cost but also in the inventory held by large number of depots throughout the year.

This paper, therefore, aims to identify issues and challenges concerning implementation of IT enabled supply chain management in IR and create a model framework for its implementation in Materials Management Department of Indian Railways so as to help the management to deal with these barriers effectively and systematically.

The main objectives of this paper are the following:

1. To identify the barriers to implementing IT enabled supply chain management in Indian Railways.

2. To establish contextual relationships among the identified barriers.

3. To prioritize and classify the identified barriers.

4. To prepare and suggest a framework for implementation of IT enabled SCM in Indian Railways.

2.0 Methodology

The research design for this study is primarily exploratory and descriptive in nature, as the objective of the study is to identify the various issues and challenges in implementing IT- enabled supply chain management in Indian Railways and to develop a framework for implementation of the same.

For identifying relationships among specific items, which define a problem or an issue, Interpretive structural modelling (ISM) has been widely used and has emerged as a well-established methodology (Warfield, 1974; Sage, 1977). Therefore, in this research, the barriers have been analyzed using ISM approach.

3.0 Identification of Barriers

The following 11 barriers have been identified based on literature review and opinion of experts both from industry and academia.

Table I. Barriers in the implementation of IT- Enabled SCM in IR

SN	Barrier Description
1	Lack of IT Vision for supply chain management
2	Low priority by the management
3	Lack of policy support for strategic/ long-term contracting
4	Public procurement processes and Codal provisions
5	Multiplicity of departments and departmentalism
6	Lack of integration of IT systems
7	Lack of standard codification of items
8	Lack of IT skilled/ trained manpower in field units
9	No IT connectivity with vendors
10	Lack of Financial resources
11	Country-wide geographical spread of operational/ maintenance units

4.0 ISM Methodology and Development of ISM Model

Interpretive Structural Modelling (ISM), is a methodology developed by Warfield (*Warfield, 1974*) to identify relationship among specific items which define a problem or issue. Warfield used it to analyze complex socio economic systems.

ISM provides an ordered, directional framework for complex problems and transforms unclear, poorly articulated mental models of systems into visible and well- defined models (Attri, Rajesh et al., 2013). It is an interactive learning process in which a set of directly or indirectly related elements are structured into a comprehensive systematic model so as to portray the structure of complex issue or problem in a carefully designed pattern implying graphics as well as words (*Ravi et al., 2005*).

The various steps generally involved in ISM modelling (Attri et al., 2013; Ravi et al. 2005; Sage, 1977; Warfield, 1974) are as follows:

(1) Identify and list the elements relevant to the problem.

(2) Establish a contextual relationship between elements with respect to which pairs of elements would be examined.

(3) Develop a structural self- interaction matrix (SSIM) of all elements. This matrix indicates the pairwise relationship among elements of the system.

(4) Develop a reachability matrix from the SSIM.

(5) Partition the reachability matrix into different levels.

(6) Convert the reachability matrix into canonical form.

(7) Draw digraph based on the relationship given in reachability matrix and remove transitive links.

(8) Convert the digraph resultant digraph into an ISM based model by replacing element nodes with the statements.

(9) Review the model to check for conceptual inconsistency and make the necessary modifications.

The above steps are applied in the following sections to develop the ISM model.

4.1 Structural Self Interaction Matrix (SSIM) of Barriers

As per ISM methodology, opinion of experts/ interviews has been used in developing the contextual relationship among the barriers through extensive discussions on each barrier. In order to analyze the relationship among the barriers a contextual relationship of "leads to" type is chosen. The following symbols are used to denote the direction of relationship between barriers (i and j) for development of SSIM.

V = Barrier i will help alleviate barrier j,

A = Barrier j will be alleviated by barrier i,

X = Barriers i and j will help alleviate each other; and

O = Barriers i and j are unrelated.

The following statements explain the use of symbols V, A, X and O for barriers in SSIM as depicted in Table II.

(i) Barrier 1 helps to alleviate barrier 9 i.e. if there is an IT vision for supply chain management the management will take steps to connect vendors through IT. Hence, the relationship between 1 and 9 is denoted by 'V' in Table II.

(ii) Barrier 7 can help alleviate barrier 6 i.e. standard codification of items will help in integration of IT systems. Thus, 'A' denotes the relationship between barrier 6 and 7 in SSIM as exhibited in Table II.

(iii) Barrier 2 and 10 help alleviate each other. With high priority by the management, financial resources will be allocated for IT enablement of supply chain. Similarly, when there is no lack of financial resources, IT enablement of supply chain management will get the priority it deserves. Thus, 'X' denotes the relationship between these two variables in SSIM as shown in Table II.

(iv) No relationship exists between barrier 4 and barrier 11 as public procurement processes and codal provisions do not have any link with country- wide geographical spread of operational/ maintenance units. Thus, 'O' denotes the relationship between barrier 4 and 11 in SSIM as exhibited in Table II.

Table II. Structural Self Interaction Matrix (SSIM) of the Barriers

SN	Barrier Description	Barrier Number									
		11	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
1	Lack of IT Vision for supply chain management	O	O	V	V	V	V	O	V	V	V
2	Low priority by the management	O	X	V	V	V	V	A	V	V	X
3	Lack of policy support for strategic/ long-term contracting	O	O	O	O	O	O	O	V	X	
4	Public procurement processes and Codal provisions	O	O	O	O	O	O	O	X		
5	Multiplicity of departments and departmentalism	O	V	O	O	O	V	X			
6	Lack of integration of IT systems	A	A	A	O	A	X				
7	Lack of standard codification of items	A	O	O	O	X					
8	Lack of IT skilled/ trained manpower in field units	O	A	O	X						
9	No IT connectivity with vendors	O	A	X							
10	Lack of financial resources	O	X								

11	Country-wide geographical spread of operational/ maintenance units	X

4.2 Reachability Matrix (RM) of Barriers

The SSIM is converted into a binary matrix, called initial reachability matrix by substituting V, A, X and O by 1 and 0 as per the following rules:

- 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.
- If the (*i*, *j*) entry in the SSIM is A, then in the reachability matrix the (*i*, *j*) entry becomes 0 and the (*j*, *i*) entry becomes 1.
- If the (*i*, *j*) entry in the SSIM is X, then the (*i*, *j*) entry in the reachability matrix is made as 1 and the (*j*, *i*) entry is also made 1.
- If the (*i*, *j*) entry in the SSIM is O, then in the reachability matrix, the (*i*, *j*) entry is made as 0 and the (*j*, *i*) entry is also made 0.

By following the above procedure, an initial reachability matrix of the barriers is prepared which is given in the Table III.

From the initial reachability matrix, final reachability matrix is made in Table 7.4 by incorporating trasitivities (indicated as 1*) as described in the ISM methodology. The transitivity of the contextual relation indicates that if variable A is related to B and B is related to C, then A is related to C.

In the final reachability matrix, the driving power and dependence of each barrier are also shown. Driving power of a barrier is the total number of barriers (including self), which it may help achieve. On the other hand, dependence is the total number of barriers (including self), which may help achieving it. For example, barrier 1 (lack of IT vision for supply chain management) and barrier 5 (multiplicity of departments and departmentalism) are having maximum driving power of 9 and barrier 4 (public procurement processes and codal provisions), barrier 6 (lack of integration of IT systems) and barrier 8 (lack of IT skilled/ trained manpower in field units) have the least driving power of 1 among all the variables. Similarly, barrier 6 (lack of integration of IT systems) has maximum dependence of 8 and barrier 1 (lack of IT vision for supply chain management), barrier 5 (multiplicity of departments and departmentalism) and barrier 11 (country- wide geographical spread of operational/ maintenance units) are having least dependence of 1.

These driving power and dependencies are later used in the MICMAC analysis for classification of barriers into four groups of autonomous, dependent, linkage and independent (driver) barriers.

Table III. Initial Reachability Matrix for the Barriers

SN	**Barrier Description**	**Barrier Number**

		1	2	3	4	5	6	7	8	9	10	11
1	Lack of IT Vision for supply chain management	1	1	1	1	0	1	1	1	1	0	0
2	Low priority by the management	0	1	1	1	0	1	1	1	1	1	0
3	Lack of policy support for strategic/long-term contracting	0	0	1	1	0	0	0	0	0	0	0
4	Public procurement processes and Codal provisions	0	0	0	1	0	0	0	0	0	0	0
5	Multiplicity of departments and departmentalism	0	1	0	0	1	1	0	0	0	1	0
6	Lack of integration of IT systems	0	0	0	0	0	1	0	0	0	0	0
7	Lack of standard codification of items	0	0	0	0	0	1	1	0	0	0	0
8	Lack of IT skilled/ trained manpower in field units	0	0	0	0	0	0	0	1	0	0	0
9	No IT connectivity with vendors	0	0	0	0	0	1	0	0	1	0	0
10	Lack of financial resources	0	1	0	0	0	1	0	1	1	1	0
11	Country-wide geographical spread of operational/ maintenance units	0	0	0	0	0	1	1	0	0	0	1

Table IV. Final Reachability Matrix for the Barriers

SN	Barrier Description	Barrier Number											DP#
		1	2	3	4	5	6	7	8	9	10	11	
1	Lack of IT Vision for supply chain management	1	1	1	1	0	1	1	1	1	1*	0	9
2	Low priority by the	0	1	1	1	0	1	1	1	1	1	0	8

	management												
3	Lack of policy support for strategic/long-term contracting	0	0	1	1	0	0	0	0	0	0	0	2
4	Public procurement processes and Codal provisions	0	0	0	1	0	0	0	0	0	0	0	1
5	Multiplicity of departments and departmentalism	0	1	1*	1*	1	1	1*	1*	1*	1	0	9
6	Lack of integration of IT systems	0	0	0	0	0	1	0	0	0	0	0	1
7	Lack of standard codification of items	0	0	0	0	0	1	1	0	0	0	0	2
8	Lack of IT skilled/ trained manpower in field units	0	0	0	0	0	0	0	1	0	0	0	1
9	No IT connectivity with vendors	0	0	0	0	0	1	0	0	1	0	0	2
10	Lack of financial resources	0	1	1*	1*	0	1	1*	1	1	1	0	8
11	Country-wide geographical spread of operational/ maintenance units	0	0	0	0	0	1	1	0	0	0	1	3
	Dependence	1	4	5	6	1	8	6	5	5	4	1	46

DP = Driving Power

4.3 Level Partition of Reachability Matrix

From the final reachability matrix, the reachability and antecedent set for each barrier are found. The reachability set for a barrier consists of the barrier itself and other barriers, which it may help achieve. The antecedent set of a barrier on the other hand consists of the barrier itself and the other barriers, which may help achieving it. Subsequently, the intersection set of these sets is derived for all barriers. The barrier for which the reachability and intersection sets are same is the top level variable in the ISM hierarchy as it would not help achieve any other barrier above their own level. The top level barrier so identified is removed from the list of barriers. The same process is then repeated to find the next level barriers till the levels of each barrier are found. These identified levels help in building the digraph and final model. Table V given below gives first, second, third and fourth iteration in partitioning the reachability matrix of the barriers under study.

From Table V, first iteration, it is seen that barrier 4, 6 and 8, i.e. public procurement processes and codal provisions, lack of integration of IT systems and lack of IT skilled/ trained manpower in field units come at level 1, i.e. at the top of the ISM hierarchy. This iteration is repeated to obtain successive levels for each of the barriers. As a result of second iteration barriers 3, 7 and 9 come at level 2. The third iteration gives the level of barriers 2, 10 and 11 at the next level 3 and fourth iteration gives the level of barriers 1 and 5 at the last most important level 4.

Table V. Partition of Reachability Matrix for the Barriers

First Iteration

Barrier No.	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,3,4,6,7,8,9,10	1	1	
2	2,3,4,6,7,8,9,10	1,2,5,10	2,10	
3	3,4	1,2,3,5,10	3	
4	4	1,2,3,4,5,10	4	Level 1
5	2,3,4,5,6,7,8,9,10	5	5	
6	6	1,2,5,6,7,9,10,11	6	Level 1
7	6,7	1,2,5,7,10,11	7	
8	8	1,2,5,8,10	8	Level 1
9	6,9	1,2,5,9,10	9	
10	2,3,4,6,7,8,9,10	1,2,5,10	2,10	
11	6,7,11	11	11	

Second Iteration

Barrier No.	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,3,7, 9,10	1	1	
2	2,3,7,9,10	1,2,5,10	2,10	
3	3	1,2,3,5,10	3	Level 2
5	2,3,5,7,9,10	5	5	

7	7	1,2,5,7,10,11	7	Level 2
9	9	1,2,5,9,10	9	Level 2
10	2,3,7,9,10	1,2,5,10	2,10	
11	7,11	11	11	

Third Iteration

Barrier No.	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,10	1	1	
2	2,10	1,2,5,10	2,10	Level 3
5	2,5,10	5	5	
10	2,10	1,2,5,10	2,10	Level 3
11	11	11	11	Level 3

Fourth Iteration

Barrier No.	Reachability Set	Antecedent Set	Intersection Set	Level
1	1	1	1	Level 4
5	5	5	5	Level 4

4.4 ISM Model Formulation

The levels found through partitioning of the final reachability matrix and various barriers at these levels have been summarized in the Table VI.

Table VI. Various Levels of Barriers

Level No.	Barrier No.	Barrier Description
1st	4	Public procurement processes and Codal provisions
	6	Lack of integration of IT systems
	8	Lack of IT skilled/ trained manpower in field units

2nd	3	Lack of policy support for strategic/long-term contracting
	7	Lack of standard codification of items
	9	No IT connectivity with vendors
3rd	2	Low priority by the management
	10	Lack of financial resources
	11	Country-wide geographical spread of operational/ maintenance units
4th	1	Lack of IT Vision for supply chain management
	5	Multiplicity of departments and departmentalism

From the final reachability matrix, and partitioned levels a structural model is generated by means of nodes and lines of edges. The level 1 barrier is given top level in the hierarchy and it won't help any other barrier to achieve. If there is a relationship between barriers i and j, an arrow pointing from i to j is used to depict the same. The resultant graph is called directed graph or in short digraph. The digraphs before removing the transitivity and after removing the same are shown in Figure 1 and 2.

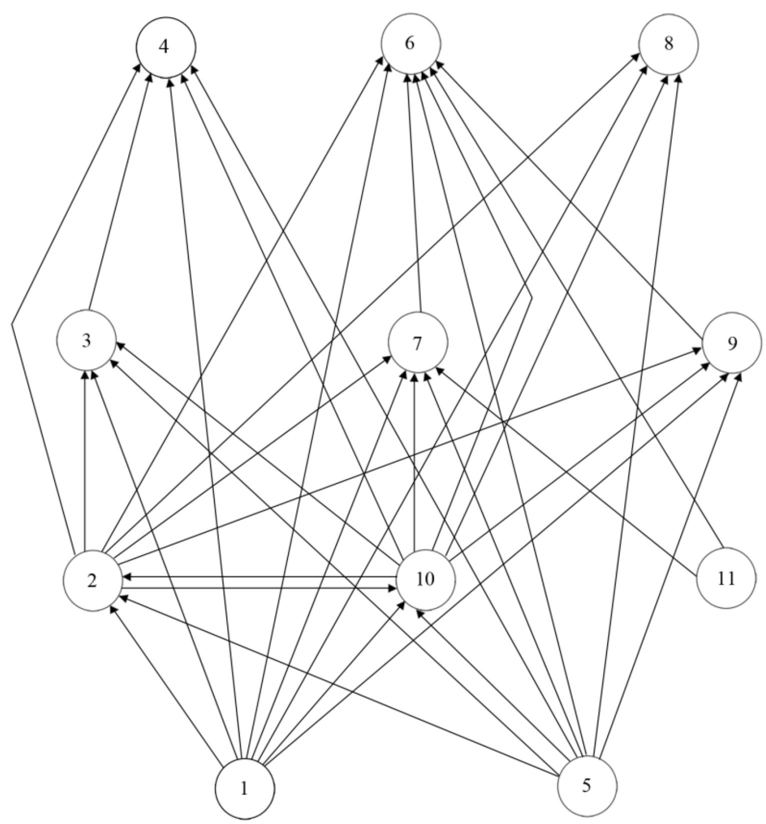

Figure 1. Digraph before removing transitivities

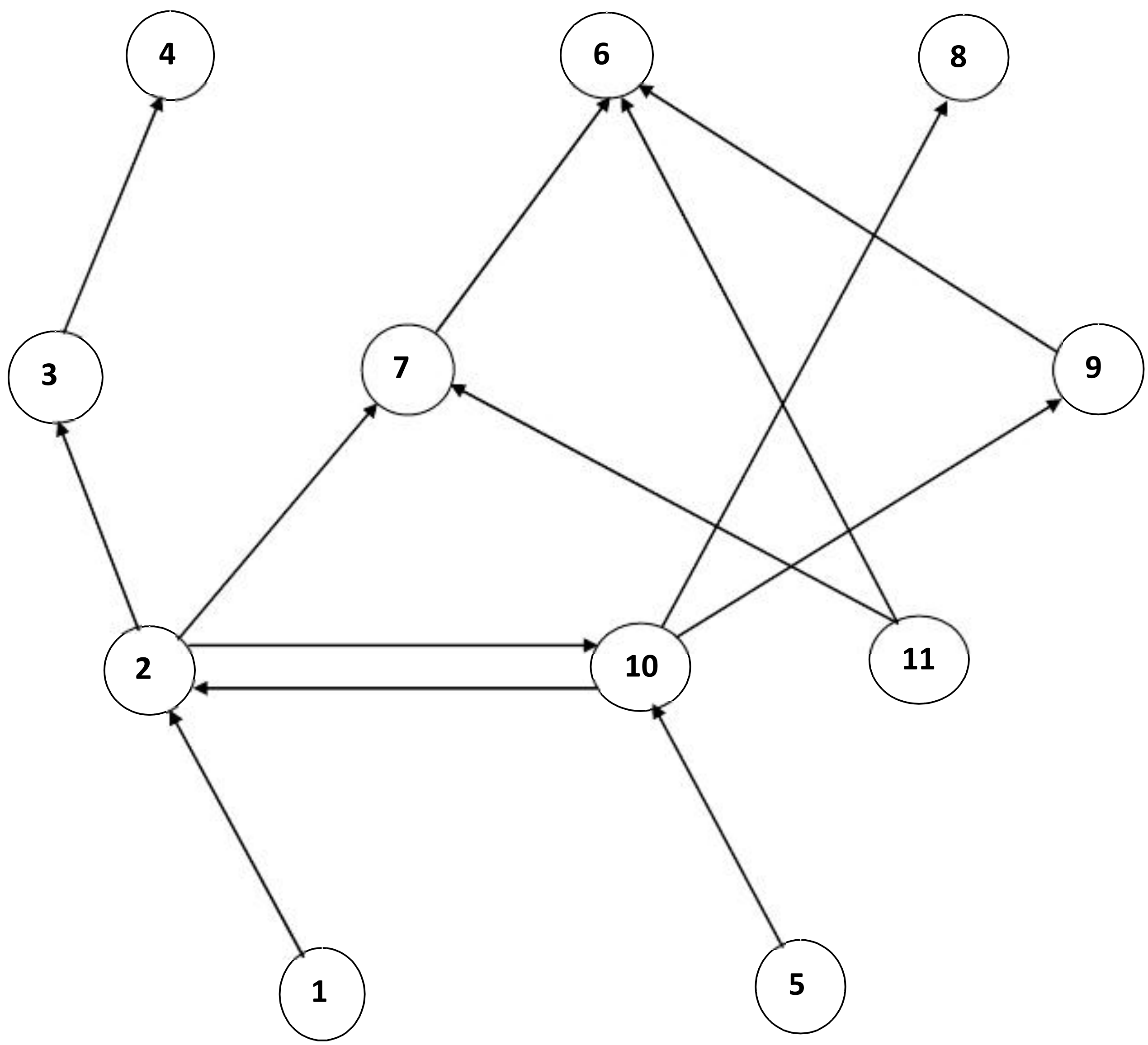

Figure 2. Digraph after removing transitivities

The resultant digraph is converted into an ISM, by replacing barrier nodes with statements. The ISM model for barriers in implementing IT- enabled supply chain management in Indian Railways is shown in Figure 3.

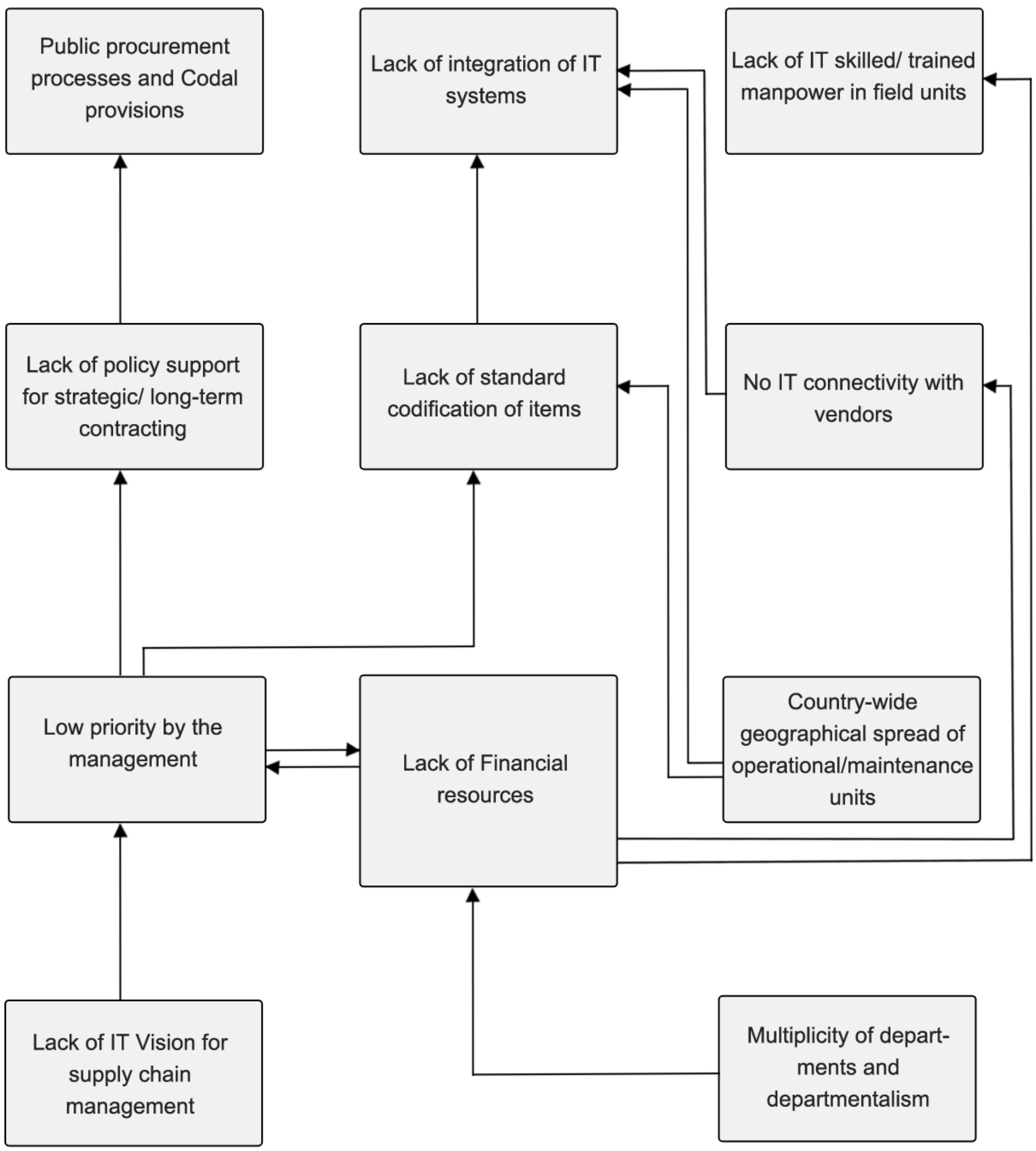

Figure 3. ISM Model of barriers to implementation of IT enabled SCM in IR

4.5 MICMAC Analysis

MICMAC is the abbreviation of "Matrice d'Impacts Croises- Multiplication Applique en Classment" meaning cross-impact matrix multiplication applied to classification. The purpose of MICMAC analysis is to identify the key variables that drive the system in various categories by analyzing the drive power and dependence power of factors.

MICMAC principle is based on multiplication properties of matrices. In this analysis, based on their driving power and dependency, variables are classified into four categories i.e. autonomous, linkage, dependent and independent (*Mandal et. al, 1994*).

Variables that have weak driver power and weak dependence power and are relatively disconnected from the system are classified as “autonomous barriers” and fall in the first cluster in the MICMAC analysis diagram. The second cluster includes “dependent barriers”. Those variables which have weak drive power but strong dependence are classified as dependent variables. The third cluster includes “linkage Barriers”. These are the ones with strong drive power as well as strong dependence power. These are relatively unstable as any action on them has an effect on others and also a feedback effect on themselves. Variables that have strong drive power but weak dependence are “independent barriers” and fall in the fourth quadrant of MICMAC diagram.

Based on the driving power and dependence as derived in the final reachability matrix (Table IV), the barriers are plotted in a graph having dependence on X- axis and driving power on the Y- axis and the resultant MICMAC analysis diagram is given in the Figure 4 given below. As an illustration barrier 1 (lack of IT vision for supply chain management) has dependence of 1 and driving power of 9. Hence it has been placed in the fourth cluster of driver variables with high driving power and low dependence.

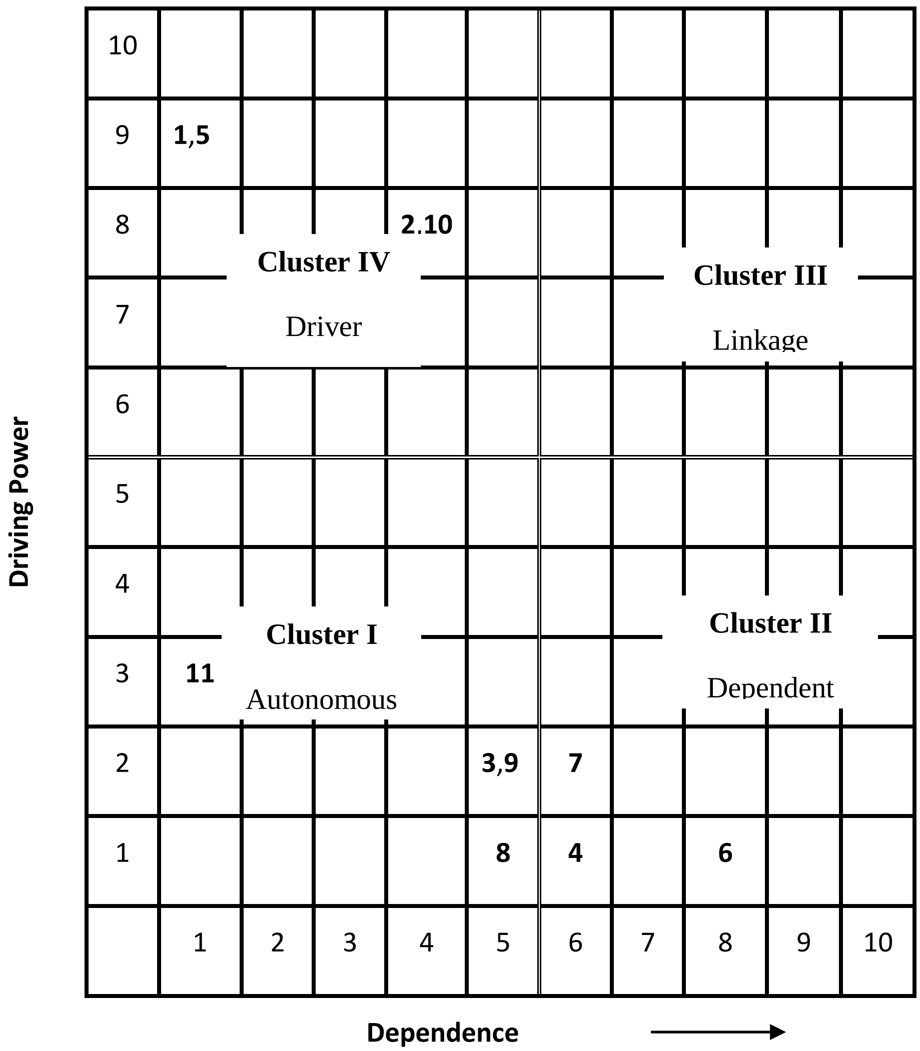

Figure 4 MICMAC Analysis Diagram

5. Discussion and Conclusion

The MICMAC analysis along with the ISM model gives very useful insights about the relative importance and interdependencies of the barriers and helps in developing a framework /roadmap for IT enabled supply chain management in Indian Railways.

ISM model of barriers to implementation of IT enabled supply chain management in Indian Railways as depicted in Figure 3, indicates that barrier number 1 (lack of IT vision for supply chain management) and 5 (multiplicity of departments and departmentalism) are the key barriers at the base of the hierarchy. These barriers are also the key drivers as per MICMAC analysis with very low dependence. These barriers are the root cause of all the barriers and therefore, need greater attention from top management.

The barriers at the next higher level are barrier number 2 (low priority by the management), barrier number 10 (lack of financial resources) and barrier number 11 (countrywide geographical spread of operational/ maintenance units). All these three barriers are related to strategy and impact other barriers. Barrier number 2 (low priority by the management) and barrier number 10 (lack of Financial resources) are two barriers which are impacting each other. Both of these are strategic level barriers interdependent on each other. In order to implement IT- enabled SCM in IR in the most effective and time bound manner, barriers viz. barrier number 1 (lack of IT Vision for supply chain management), barrier number 2 (low priority by the management) and barrier number 10 (lack of financial resources) need to be addressed first.

Barrier number 3 (lack of policy support for strategic/ long-term contracting), 7 (lack of standard codification of items) and 9 (no IT connectivity with vendors) appear at the second top most level in the ISM hierarchy and are project based barriers. Addressing the strategic barriers of low priority by the management, lack of financial resources and country-wide geographical spread of operational/maintenance units will help in overcoming these barriers.

Barriers like barrier number 4 (public procurement processes and Codal provisions), barrier number 6 (lack of integration of IT systems), and barrier number 8 (lack of IT skilled/ trained manpower in field units) are on the top of the hierarchy with very few linkages with any other variables. These are performance and operating level barriers and can be addressed relatively easily as compared to other barriers, once project based barriers are addressed.

The study, therefore, suggests that there is an urgent need to clearly define IT vision for implementation of supply chain management in Indian Railways. There is also a very strong need for arranging necessary financial resources to accomplish this vision. Formulation of IT vision for SCM will lead to priority and support by the top management. Priority by the management will in turn remove the barrier of lack of financial resources. Also, restructuring of the organization is required to remove multiplicity of departments and accompanied departmentalism. Issues like countrywide geographical spread of operational/ maintenance can also be taken up simultaneously as it has significant impact on other barriers.

Once the management has high priority for IT enablement of supply chain management, decisions shall be forthcoming to remove the project based barriers by putting in place policy for strategic/ long term contracting and project of standardization of codification of items and IT connectivity with vendors can be easily taken up.

6.0 Likely Contributions of the Study

There is a paucity of literature in the field of IT enablement of supply chain management in general and Indian Railways in particular. This study will go a long way to contribute to the existing literature on present scenario and implementation of IT enabled supply chain management in Indian Railways.

The study has managerial as well as academic contributions. This study identifies the main barriers to implementation of IT enabled supply chain management in Indian Railways, establishes contextual relationship among the barriers, classifies them into independent, dependent, autonomous & linkage variables and also prioritizes them. ISM model developed for the barriers to implementation of IT enabled supply chain management in Indian Railways can be gainfully utilized for other academic and business studies.

The study also suggests a model framework for implementation of IT enabled supply chain management in Indian Railways. It will provide policy makers in Indian Railways insights into the factors inhibiting IT enablement of IR's supply chain and help in their prioritization and formulation of appropriate strategy for tackling the same.

7.0 Limitations

There are few limitations to this study that need to be acknowledged. This study is specific to Indian Railways and can not be generalized and made applicable to other organizations.

It is a study of macro level issues in implementation of IT enabled supply chain management in Indian Railways and it does not take into account several other related issues such as resistance to change to IT- enabled supply chain management, poor IT infrastructure etc. Complexity of ISM may increase when there are too many variables to a problem. Thus, only limited number of variables may be considered in the development of ISM model

This is a first of its kind study on IT enablement of supply chain management in Indian Railways and consequently is limited in scope.

Further, expert's help is taken in analyzing the driving and dependence power of the variable of a problem or issue. These models are not statistically validated. Structural Equation Modelling (SEM), also known as Linear Structural Relationship approach, has the capability of testing the validity of such hypothetical model (*Attri et. al, 2013*).

8.0 Scope for Further Research

Through the present study an ISM model for the implementation of IT- enabled supply chain management in Indian Railways has been developed. This ISM model for the implementation of IT-enabled supply chain management may provide basis for further research to develop similar model in some other types of industry like retail business, electronics and electrical industry. In developing a model for another businesses/ industry or country some of the barriers may be deleted while some other suitable ones may be included.

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