Analysis of Barriers for Reverse Logistics: An Indian Perspective

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***Abstract*—Reverse logistics (RL) stands for all the operations related to the reuse of used products, excess inventory of products and materials including collection, disassembly and processing of used products, parts, and/or materials. Over the past few years, RL has received much attention because many companies are using it as a strategic tool to serve their customers and can generate good revenue. An efficient reverse distribution structure may lead to a significant return on investment as well as a significantly increased competitiveness in the market. Therefore, analysis of barriers hindering the successful implementation of RL is a crucial issue. These barriers not only affect RL but influence each other also. In existing models, the holistic view in understanding the interrelation between the barriers is not accounted for but is diagnosed independently. This paper utilizes the Interpretive Structural Modeling (ISM) methodology to understand the mutual influences among the barriers so that barriers that are at the root of some more barriers (called driving barriers) and those which are most influenced by the others (called driven barriers) are identified.**

***Index Terms*—Barriers, Interpretive Structural Modeling (ISM) , Reverse logistics(RL), transitivity.**

I. Introduction

In today's manufacturing world, globalization policies and rejuvenation have created a more intensive competition amongst manufacturers. On the other hand, manufacturers have turned to the option of adopting innovative technologies, process re-engineering and strategies such as efficient supply chain management to achieve a sustainable competitive advantage. Supply chains are undergoing radical transformations due to the mega-competition taking place on a global scale. Technological changes are becoming a primary driver in the domain of businesses. It is being observed by companies that there is an increase in the flow of returns of the product due to product recalls, warranty returns, service returns, end-of-use returns, end-of-life returns, and so on.

RL aims at the backward flow of materials from customer to supplier with the goals of maximizing value from the returned item or minimizing the total reverse logistics cost. Reverse logistics (RL) can be defined as the process of moving end products from their typical final destination for the purpose of capturing value or proper disposal. A RL system (RLS) incorporates a supply chain that has been redesigned to manage the flow of products or parts destined for remanufacturing, repairing, or disposal and to effectively use the resources. Reverse logistics starts where the traditional principles of supply chain management (SCM) come to a conclusion; this is when a consumer product reaches its end of life or use, and is redundant to its users. In future, companies will have to look beyond the re-use or recycling of packaging materials and into the potential value recovery of redundant products and, more importantly, their components and materials. This will enable them to establish logistics infrastructures and supply management interfaces to allow products to be re-used on similar markets rather than being discarded, and eventually scrapped and disposed of in landfill.

Over the past few years, RL has been gaining increasing attention and awareness in the supply chain community, both from practitioners and researchers point of view due to a number of reasons. Competition and marketing motives, direct economic motives and concerns with the environment are some of the important reasons. RL is a complicated process that requires detailed planning in terms of continual audit of returns, determining the best disposition of products that is both economically and technically feasible, warehouse and transportation management, recycling programs, and other related issues.

India is well endowed with both technology and human resources. Despite this, the concept of Reverse logistics is yet not widely accepted because of lot many barriers for its successful implementation. Some of these barriers are lack of systems, management inattention, financial resources, personal resources, company policies. It is a risky endeavor for the top management as it involves financial and operational aspects which determine the performance of the company in long run. The barriers mentioned not only affect the operations of reverse logistics but also influences one another. Thus, it is very essential to understand the mutual relationship among the barriers. A critical analysis of the barriers hindering RL and their interaction with the various aspects in integrative planning can be a valuable source of information to decision makers. The identification of barriers which can aggravate few more barriers and those independent barriers, which are most influenced by driving barriers) would be helpful for the top management implementing the reverse logistics programs. This can be a guide for taking appropriate action to tackle barriers in

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reverse logistics. An ISM approach has been proposed here to for structuring the barriers.

II. Literature Review

During the early nineties, the Council of Logistics Management started publishing studies where reverse logistics was recognized as being relevant both for business and society [1]. Other studies followed stressing the opportunities on reuse and recycling [2]. In the late nineties, marketing aspects of reuse and extending product life of manufactured items have been focused and detailed framework to set up and carry out reverse logistics programs have been proposed. Rogers and Tibben-Lembke have presented a broad collection of reverse logistics business practices [3]. Eltayeb et al. have explored that taking back products and packaging, business organizations can generate benefits to the environment, in the form of reduced waste and better resource utilization, in addition to economic benefits and cost reductions to the organizations [4].

Carter and Ellram have investigated drivers and constraints determining a company's reverse logistics activities [5]. Based on a literature study, they identify regulation and customer preferences as major stimulating factors. At the same time, inferior quality of input resources and a lack of stakeholder commitment are found to be major obstacles for successful reverse logistics programs. Moreover, they have suggested critical factors in the reverse logistic process and developed a model that proposes how these factors interact. Subramanian et al. have discussed analysis and evaluation of RL strategies according to the following decision making focus: Reverse Logistics Network Structure, Relationships, Inventory management, and planning and control [6].

Many articles dedicated to analysis of practice of reverse logistics have appeared. Pokharel and Mutha have investigated the current development in research and practice in RL through content analysis of the published literature and have shown that research publication on RL is increasing specially after 2005 and therefore it shows the growing recognition of RL as a driver of supply chain and logistics [7]. Janse et al. have summarized Barriers and facilitators in managing reverse logistics in the consumer electronics sector and provided a diagnostic tool for assessing a Consumer Electronics company's RL practices and identifying potential for RL improvement, from a business perspective [8].

In a complex system to structure the variables and get the interrelation between them is always a matter of concern [9]. However, Interpretive structural modeling (ISM) methodology which is a computer-assisted learning process that enables individuals or groups to develop a map of the complex relationships between the many elements involved in a complex situation is used to understand interrelation among elements. Faisal explored the barriers to corporate social responsibility (CSR) in supply chains and presented a hierarchy-based model and established the contextual relationships among these barriers using ISM [10]. Raj et al. identified enablers which help in the implementation of FMS and analyzed the mutual interactions between them using ISM approach. They explored that ISM methodology strengthens the practical views of manufacturing managers and depicts a clear picture about the significance of different enablers [11]. Jharkharia and Shankar have used ISM methodology to evolve the mutual relationship between barriers to the IT- enablement of a supply chain [12]. Jha and Devaya have presented a hierarchal model showing the interrelationships between international construction risk factors from the Indian construction professionals' viewpoint using ISM [13].

III. Barriers for reverse logistics

A. *Lack of awareness about reverse logistics*

The lack of awareness of benefits of reverse logistics is a major barrier for its implementation. Today, the customers have the benefits of greater product variety. It has resulted in an increase in unsold products, rate of returns, packing materials, and also the waste. This has given rise to increase in the volume of product returns in the form of reverse logistics. The reverse logistics can lead to economic benefits by the recovery of the returned products for reuse, remanufacturing, recycling, or a combination of these options for adding value to the product.

B. *Management Inattention*

The conventional wisdom has been that over the last few years, most companies have practiced reverse logistics primarily because of government regulation or pressure from environmental agencies, and not for economic gain. Thus the management is taking less interest thinking no-profit issue. Companies are organized around the forward flow of goods.

C. *Financial Constraints*

Cost considerations are a prime challenge in commercial recycling. Companies require allocation of funds and other resources for the implementation of reverse logistics. Information and technological systems require more funds because without these, the returns product tracking and tracing and product recovery by various processes like reuse, remanufacturing, recycling, etc. is not possible in the present environment. The training of personnel related to the reverse logistics is also very important for efficiently managing and eventually making the reverse logistics profitable. However, all these require financial support.

D. *Personal Resources*

A significant barrier to good reverse logistics is lack of personnel resources .Lack of training and education is a major challenge to commercial cycling. Education and training are prime requirements for achieving success in any organization.

E. *Problems with product quality*

The product quality is not uniform in reverse logistics compared to the forward logistics where the product quality is uniform. Customers usually expect the same level of quality of product from the manufacturer regardless of the nature of the returned product. The returned product quality could be in any range; like that it could be faulty, damaged, or simply unwanted by the customer. Thus, there could be variations in the pricing of the products.

F. Lack of appropriate performance management system

Measuring and managing the true performance of reverse logistics is very hard. Internal and operational metrics are in place, but metrics for end-to-end process performance are seldom used or available. If the firms take action linking their performance measurement system to their reverse logistics practices, they will be in a better position to succeed in their endeavor.

G. *Inadequate information and technological systems*

An efficient information and technological system is very necessary for supporting the reverse logistics during various stages of the product life cycle. Efficient information systems are needed for individually tracking and tracing the returns of the product, linking with the previous sales. Information technology, software and hardware, is essential for end-to-end control and transparency along the reverse chain.

H. *Company policies*

It also is related to corporate strategy for handling returns and non-salable items. Because companies do not want to see their "junk" cannibalizing their first quality or "A" channel, they often develop policies that make it very difficult to handle returns efficiently, and to recover much secondary value from those returns.

I. *Legal Issues*

Under Indian Regulations excise paid goods once sold by the manufacturer cannot be brought back to the plant without prior documentation and declaration to excise authorities. This is a very cumbersome & time consuming process and non-compliance may mean that the manufacturer will have to face legal actions. Most companies find this policy as a hurdle in applying the reverse logistics.

J. Administrative and financial burden of tax

Proper planning and management of direct and indirect taxes is a vital financial consideration within the reverse chain. Complex (and cross border) flows of goods as well as the diverse bought-in services engrained in the reverse chain create a high degree of tax complexity and lead to unexpected tax exposures and costs.

K. Limited forecasting and planning.

Accurate return forecasts are hardly available. This is a direct barrier for both strategic and operational planning. Many companies experience difficulties in forecasting and planning the reverse chain due to the degree of diversity of goods and flows.

L. Co-operative Behavior of Chain members

Co-operative behavior of chain members is desired for sharing of information. Important barrier to the reverse logistics is the reluctance of the support of the dealers, distributors, and retailers towards the reverse logistics activities.

IV. ISM METHODOLOGY AND MODEL DEVELOPED

Interpretive Structural Modeling was first proposed by J. Warfield in 1973 to analyze the complex socioeconomic systems. The ISM process transforms unclear, poorly articulated mental models of systems into visible, well-defined models useful for many purposes. It is a method for developing hierarchy of system enablers to represent the system structure.

ISM is an interactive learning process in which a set of different and directly related elements are structured into a comprehensive systematic model. The basic idea of ISM is to decompose a complicated system into several subsystems (elements) by using practical experience of experts and their knowledge.

The important characteristics of ISM are as follows:

- This methodology is interpretive as the judgment of the group decides whether and how the different elements are related.
- It is structural on the basis of mutual relationship as overall structure is extracted from the complex set of elements.
- It is a modeling technique, as the specific relationships and overall structure are portrayed in a digraph model.
- It helps to impose order and direction on the complexity of relationships among various elements of a system.

The various steps involved in ISM methodology:

1) Identification of barriers: The elements of the system are identified which are relevant to the problem or issue and then achieved with a group problem-solving technique like brain storming sessions. On the basis of review of literatures for reverse logistics, a total 12 barriers were identified.
2) Contextual Relationship: From the barriers identified in step 1, a contextual relationship is identified among barriers with respect to which pairs of variables would be examined. After resolving the barriers set under consideration and the contextual relation, a structural self-interaction matrix (SSIM) is prepared. Four symbols are used to denote the direction of relationship between the criterion (i and j):
   V -- for the relation from element i to element j and not in both directions;
   A -- for the relation from element j to element i and not in both directions;
   X – for both the directional relations from element i to element j and j to i;
   O–if the relation between the elements did not appear valid.

The following will explain the use of Symbols V, A X and O in SSIM (Table I).

- Barrier 1 helps alleviate barrier 2 i.e. as the awareness about reverse logistics will promote the top management to start taking attention towards its implementation. Thus the relationship between 1 and 2 is denoted by V
- Barrier 4 can be alleviated by barrier 7 i.e. with the availability of adequate information and technological systems the personal resources will automatically get enriched with the facilities to enable themselves in implementation of reverse

logistics. Thus the relationship between 4 and 7 is denoted by A.

- Barrier 2 and 4 helps to achieve each other .With the trained and skilled employees the management can understand the importance of reverse logistics in present scenario and if management will take attention then will surely plan to educate their manpower to get support regarding the same. Therefore the relationship between 2 and 4 is X.
- No relationship exists between financial constraint and lack of appropriate performance management system therefore is denoted by 0.

TABLE I STRUCTURAL SELF-INTERACTION MATRIX (SSIM)

Barriers	12	11	10	9	8	7	6	5	4	3	2
1	V	V	O	O	V	V	V	O	V	V	V
2	V	V	A	A	O	V	V	O	X	X	
3	V	V	A	O	V	V	O	O	V		
4	V	V	V	O	A	V	O	V			
5	V	A	O	O	V	O	O				
6	V	V	O	O	V	A					
7	V	A	O	O	V						
8	V	O	O	A							
9	O	O	O								
10	O	A									
11	A										
12											

3) Initial reachability matrix: The SSIM is transformed into a binary matrix, called the initial reachability matrix by substituting V, A, X, O by 1 and 0 as per the case. The rules for the substitution of 1's and 0's are:

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

TABLE II. INITIAL REACHABILTY MATRIX

Barriers	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	1	0	1	1	1	0	0	1	1
2	0	1	1	1	0	1	1	0	0	0	1	1
3	0	1	1	1	0	0	1	1	0	0	1	1
4	0	1	0	1	1	0	1	0	0	1	1	1
5	0	0	0	0	1	0	0	1	0	0	0	1
6	0	0	0	0	0	1	0	1	0	0	1	1
7	0	0	0	0	0	1	1	1	0	0	0	1
8	0	0	0	1	0	0	0	1	0	0	0	1
9	0	1	0	0	0	0	0	1	1	0	0	0
10	0	1	1	0	0	0	0	0	0	1	0	0
11	0	0	0	0	1	0	1	0	0	1	1	0
12	0	0	0	0	0	0	0	0	0	0	1	1

4) Final reachabilty matrix: The reachability matrix obtained in step 3 is converted into the final reachabilty matrix by checking it for transitivity. The transitivity of the contextual relation is a basic assumption in ISM which states that if element A is related to B and B is related to C, then A is related to C.

TABLE III. FINAL REACHABILTY MATRIX

Barriers	1	2	3	4	5	6	7	8	9	10	11	12	Drive power
1	1	1	1	1	1*	1	1	1	0	1*	1	1	11
2	0	1	1	1	1*	1	1	1*	0	1*	1	1	10
3	0	1	1	1	1*	1*	1	1	0	1	1	1	10
4	0	1	1	1*	1	1*	1	1*	0	1	1	1	10
5	0	0	0	1*	1	0	0	1	0	0	1*	1	5
6	0	0	0	1*	1*	1	1*	1	0	1*	1	1	8
7	0	0	0	1*	0	1	1	1	0	0	1*	1	6
8	0	1*	0	1	1*	0	1*	1	0	1*	1*	1	8
9	0	1	1*	1*	0	1	1*	1*	1	0	1*	1*	9
10	0	1	1	1*	0	1*	1*	1*	0	1	1*	1*	9
11	0	0	0	0	1	0	1	1*	0	1	1	1*	6
12	0	0	0	0	1*	0	1*	0	0	1*	1	1	5
Dependence	1	7	6	10	9	8	11	11	1	9	12	12	

5) Level partition: The reachabilty and antecedent set for each barrier is found out from final reachabilty matrix. The reachabilty set includes criteria itself and others which it may help to achieve and antecedent set consists of itself and other criterion which helps in achieving it. Subsequently, the intersection set is derived and the variable having reachabilty and intersection set same is given top level in ISM hierarchy.

Table IV shows the first iteration where in barrier 5 and 12 are found at level I

TABLE IV. PARTITION OF REACHABILTY MATRIX: ITERATION 1

Barriers	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,3,4,5,6,7,8,10,11,12	1	1	
2	2,3,4,5,6,7,8,10,11,12	1,2,3,4,8,9,10	2,3,4,8,10	
3	2,3,4,5,6,7,8,10,11,12	1,2,3,4,9,10	2,3,4,10	
4	2,3,4,5,6,7,8,10,11,12	1,2,3,4,5,6,7,8,9,10	2,3,4,5,6,7,8,10	
5	4,5,8,11,12	1,2,3,4,5,6,8,11,12	4,5,8,11,12	I
6	4,5,6,7,8,10,11,12	1,2,3,4,6,7,9,10,	4,6,10,	
7	4,6,7,8,11,12	1,2,3,4,6,7,8,9,10,11,12,	4,6,7,8,11,12	
8	4,5,7,8,10,11,12	1,2,3,4,5,6,7,8,9,10,11	4,5,7,8,10,11	
9	2,3,4,6,7,8,9,11,12	9	9	
10	2,3,4,6,7,8,10,11,12	1,2,3,4,6,8,10,11,12	2,3,4,6,8,10,11,12	
11	5,7,8,10,11,12	1,2,3,4,5,6,7,8,9,10,11,12	5,7,8,10,11,12	
12	5,7,10,11,12,	1,2,3,4,5,6,7,8,9,10,11,12	5,7,10,11,12	I

Once the top level element is found out, it is separated from other elements. In the similar manner iteration process is repeated to find the criterion in the next level and is continued till the level of each element is found . (Table V,VI,VII, and VIII)

TABLE V. PARTITION OF REACHABILTY MATRIX: ITERATION 2

Barriers	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,3,4,6,7,8,10,11	1	1	
2	2,3,4,6,7,8,10,11	1,2,3,4,8,9,10	2,3,4,8,10	
3	2,3,4,6,7,8,10,11	1,2,3,4,9,10	2,3,4,10	
4	2,3,4,,6,7,8,10,11	1,2,3,4,6,7,8,9,10	2,3,4,6,7,8,10	
6	4,6,7,8,10,11	1,2,3,4,6,7,9,10,	4,6,10,	
7	4,6,7,8,11	1,2,3,4,6,7,8,9,10,11	4,6,7,8,11	II
8	4,7,8,10,11	1,2,3,4,6,7,8,9,10,11	4,7,8,10,11	II
9	2,3,4,6,7,8,9	9	9	
10	2,3,4,6,7,8,10,11	1,2,3,4,6,8,10,11	2,3,4,6,8,10,11	
11	7,8,10,11	1,2,3,4,6,7,8,9,10,11	7,8,10,11	II

TABLE VI. PARTITION OF REACHABILTY MATRIX: ITERATION 3

Barriers	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,3,4,6,10	1	1	
2	2,3,4,6,10	1,2,3,4,9,10	2,3,4,10	
3	2,3,4,6,10	1,2,3,4,9,10	2,3,4,10	
4	2,3,4,6,10	1,2,3,4,6,9,10	2,3,4,6,10	III
6	4,6,10	1,2,3,4,6,9,10,	4,6,10,	III
9	2,3,4,6,9	9	9	
10	2,3,4,6,10	1,2,3,4,6,10	2,3,4,6,10	III

TABLE VII. PARTITION OF REACHABILTY MATRIX: ITERATION 4

Barriers	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,3	1	1	
2	2,3,	1,2,3,9	2,3,	IV
3	2,3,	1,2,3,9	2,3	IV
9	2,3,9	9	9	

TABLE VIII. PARTITION OF REACHABILTY MATRIX: ITERATION 5

Barriers	Reachability Set	Antecedent Set	Intersection Set	Level
1	1	1	1	V
9	2	9	9	V

Table IX shows the final partition level of barriers for reverse logistics after all iterations.

TABLE IX. LEVELS OF BARRIERS FOR REVERSE LOGISTICS

Barriers	Reachability Set	Antecedent Set	Intersection Set	Level
1	1,2,3,4,5,6,7,8,10,11,12	1	1	V
2	2,3,4,5,6,7,8,10,11,12	1,2,3,4,8,9,10	2,3,4,8,10	IV
3	2,3,4,5,6,7,8,10,11,12	1,2,3,4,9,10	2,3,4,10	IV
4	2,3,4,5,6,7,8,10,11,12	1,2,3,4,5,6,7,8,9,10	2,3,4,5,6,7,8,10	III
5	4,5,8,11,12	1,2,3,4,5,6,8,11,12	4,5,8,11,12	I
6	4,5,6,7,8,10,11,12	1,2,3,4,6,7,9,10,	4,6,10,	III
7	4,6,7,8,11,12	1,2,3,4,6,7,8,9,10,11,12,	4,6,7,8,11,12	II
8	4,5,7,8,10,11,12	1,2,3,4,5,6,7,8,9,10,11	4,5,7,8,10,11	II
9	2,3,4,6,7,8,9,11,12	9	9	V
10	2,3,4,6,7,8,10,11,12	1,2,3,4,6,8,10,11,12	2,3,4,6,8,10,11,12	III
11	5,7,8,10,11,12	1,2,3,4,5,6,7,8,9,10,11,12	5,7,8,10,11,12	II
12	5,7,10,11,12,	1,2,3,4,5,6,7,8,9,10,11,12	5,7,10,11,12	I

6) Development of ISM model: Diagraph for interpretive structural modeling is drawn. Having identified the levels of the elements, the relation between the elements is drawn with the help of an arrow. The diagraphs thus drawn are complex in nature. The level I barriers is given top level in the hierarchy and it won't help any other barrier to achieve. The barriers having same level are kept on the same level of hierarchy the diagraphs give information about hierarchy between the elements of barriers for successful implementation of reverse logistics.

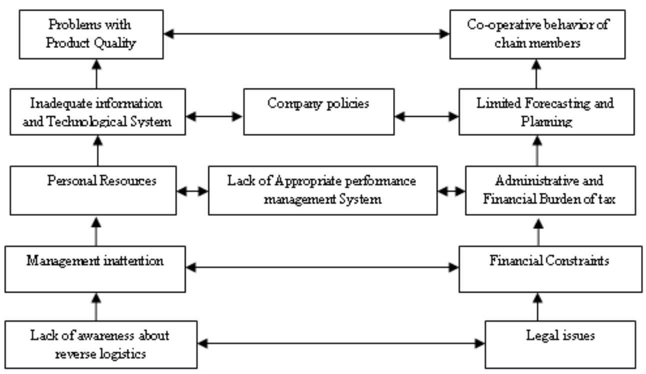

Fig. I. ISM based model for barriers of reverse logistics

V. MICMAC ANALYSIS

The MICMAC analysis has been done by drawing simple two dimensional graphs fig. 2. The objective of the MICMAC analysis is to analyze the driver power and dependence of variables

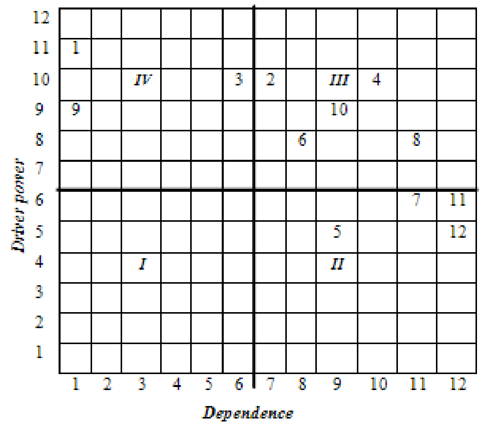

Fig. II. Driver Power and Dependence Diagram

The barriers of reverse logistics are classified into four clusters:

- The first cluster consists of autonomous variables that have weak driver power and weak dependence. These variables are disconnected from the system, with which they have only a few but strong links.
- The second cluster consists of the dependent variable that have weak driver power but strong dependence.
- The third cluster has the linkage variables that have strong driving power and also strong dependence. These variables are unstable in that any action on these variables will have an effect on others and also feedback effect on themselves.
- The fourth cluster includes the independent variables having strong driving power but weak dependence. It is observed that variables with very strong driving power, called the key variables, fall into the category of independent variables. The driving power and the dependence of each of the variables are calculated.

VI. DISCUSSION AND CONCLUSION

The methodology proposed here identifies the hierarchy of actions to be taken for handling different barriers hindering the implementation of reverse logistics. The managers can get an insight of these barriers and understand their relative importance and interdependencies. Some of the barriers are identified and are put into an ISM model to analyze the interaction between them. The driver dependence diagram gives some valuable insight about the relative importance and interdependencies among barriers. From figure 2 it can be seen that there is no autonomous barrier. Problems with product Quality, Inadequate Information and technological systems, limited forecasting and planning and co-cooperative behavior of Chain members have a weak driving power, but strong dependence on other barriers. This indicates that it requires all of other barriers to come together for overcome difficulties in successful implementation of Reverse logistics. Management Inattention, lack of appropriate performance management system, personal resources, company policies and administrative and financial burden of tax comes under category of linkage variables. They have strong driver power and strongly dependence power. These enablers should be studied even more carefully than the others. The analysis reveals that three barriers Lack of awareness about reverse logistics, Financial Constraints and Legal issues are ranked as Independent enablers as they are having the maximum driver power. This implies that these variables are key barriers in the successful implementation of Reverse Logistics in Supply Chain.

Thus the ISM based model proposed for identification of barriers of reverse logistics can provide the decision makers a realistic representation of the problem in the course of implementing reverse logistics. This can help in deciding the priority to proactively take steps in combating these barriers.

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The auhors' biographies are not available.