On Exploration of Possible Hierarchical Inter-Relationship amongst the Challenges Faced by Reverse Logistics Supply Chain in India

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ABSTRACT

This paper is aimed at introducing the concept of reverse logistics (RL) and its implications for supply chain management (SCM). Further , this paper aims to study the possible challenges faced by reverse logistics supply chain India.

Keywords
Supply chain management; ISM methodology; hierarchical interrelationships ;reverse logistics supply chains

1. INTRODUCTION
Reverse logistics supply chain is a research area focused on the management of the recovery of products once they are no longer desired (end-of-use products, EoU) or can no longer be used (end-of-life products) by the consumers, in order to obtain an economic value from the recovered products. In Reverse Logistics, in order to understand in which category or remanufacturing process the objects fall, a clear identification is essential.
These uncertainties are linked to the inability to establish the identity of a returning product [Tho-2009]. Whereas, it is easy to apply the implementation of identification methods in forward supply chain, since there are no customers involved, the same solutions are not valid in Reverse Logistics. The main challenge becomes implementing technologies for tracing products [Gon-2010] and thus filling the gap of information [Lee-2012].

Present research studies the hierarchical inter-relationships amongst the challenges faced by reverse logistics supply chain. The paper is arranged as follows: Section 2 discusses the challenges faced by reverse logistics supply chain in India. Section 3 presents the ISM methodology and section 4 the case example.

1.1 Literature Review
Reverse logistics based research studies have been developed in specific industrial sectors, such as the Pharmaceutical industry (De Campos et al., 2017), Construction industry (Brandão *et al*., 2021; Hosseini *et al.,* 2015; Pushpamali *et al.,* 2019; Schamne and Nagalli, 2016), plastic industry (Tesfaye and Kitaw, 2020), humanitarian operations (Peretti *et al.,* 2015) and leather footwear industry (Moktadir *et al.*, 2019). Regarding reviews for generic types of waste, Pokharel and Mutha (2009) used a content analysis method for their literature review. They sought to show an integrated perspective of the reverse logistics system from inputs to outputs and then to inputs again. Agrawal *et al*. (2015) focused on presenting a comprehensive review on reverse logistics wherein they have classified their 242 collected articles in five categories: (1) Adoption and implementation; (2) Forecasting product returns; (3) Outsourcing; (4) Reverse logistics network from secondary market perspective; (5) Disposition decisions. From another perspective, Govindan *et a*l. (2015) have done a comprehensive review targeting reverse logistics and closed-loop supply chains in scientific journals. A very detailed systematic review of the available RL literature was produced by Prajapati *et al.* (2019).

Factors that negatively affect the adoption of Reverse Logistics are called reverse logistics barriers (Prajapati, Kant & Shankar, 2019b). Identifying obstacles in RL implementation is the first step in developing strategies to improve RL performance (Schamne & Nagalli, 2016). Reverse logistics is one strategy to overcome limited resources that cannot be renewed and are not environmentally friendly (Chen *et al*., 2019). Therefore, identifying obstacles is an aspect that must be considered in formulating strategies (Radomska, 2014). Govindan and Bouzon (2018) conducted a literature review of articles on reverse logistics barriers from 2004 to 2015. Analyzing RL barriers is an alternative in accelerating the circular economy (Govindan & Hasanagic, 2018). Kaviani, Tavana, Kumar, Michnik, Niknam and Campos (2020) shows that reverse logistics systems are integral parts of sustainable operations and cleaner production. However, there are different barriers to implementing RL systems, particularly in developing countries, which inhibit companies from fulfilling their environmental responsibilities (Kaviani *et al.,* 2020). Involving all stakeholders and aligning stakeholder interests are essential in making strategic plans (Govindan & Bouzon, 2018). Considering these barriers from these multiple perspectives is critical for creating a comprehensive industrial strategy to implement RL successfully. Barriers analysis results of Govindan and Bouzon (2018) need adjustments to formulate a plan for implementing RL in the construction sector due to the different roles of stakeholders in the construction and manufacture sectors so that stakeholders' views on significant barriers will be different.

1. CHALLENGES FACED BY REVERSELOGISTICS SUPPLY CHAIN IN INDIA [7,8,9 ,10,13]

Ch 1: Difficulty in value assertion [DVA]: Typically, the usable status of the goods needs to be taken into consideration to reach the value of the product. For instance, it is difficult to calculate or even predict the correct value of the cost of product even if when it is minorly defective.

Ch 2: Search for an efficient repair process [SERP]: An efficient repair process is essential for the proper functioning of any reverse logistics system. Video tutorials for compressing the learning curve and helping the bench techs will go a long way in speeding up the entire repair process. But often a lack of the right software makes the process slow and cumbersome.

Ch 3: Keeping track of the warranty status [KTWS]: This is perhaps one of the most complex things to handle. There are many situations when tracking the secondary warranties is difficult for organizations. Thus, the organization ends up losing warranty reimbursement amount from the suppliers.

Ch4: Lots of uncertainties [LoU] : Due to the uncertainties concerning quality, quantity, the time of returning products, and the costs linked to the implementation of a Reverse Logistics network, it is challenging for companies to motivate the investment in this solution.

Ch 5 : Lack of social awareness of environmental problems [LoSA] : The increasing social awareness of environmental problems is demanding the industry to enforce sustainable strategies, including moving towards a circular economy. It describes the process that manages the flow of unusable materials from the customer to the remanufacturing point. Notwithstanding its economic and environmental opportunities, industries are still struggling with its implementation.

Ch 6: Economic Issues [EI]: Especially the economic issues represent an important challenge for the automotive industry. When establishing the Reverse Logistics network, there are high costs for the purchase of the needed adaption, such as machines and licenses [Del-2003].

Ch7: More expensive recycled material [MERM]: Furthermore, recycled material can become expensive due to the costs of disassembly [Cha-2012]. To encourage manufacturers to use recycled items, new technical procedures are needed to lower the dismantling prices of returned products.

Ch-8: Inflexibility amongst the supply chain members [ISCM]: Establishing a reverse logistics system can also be challenging when it comes to the creation of the network. There needs to be a strong collaboration between the supply chain members, which leads to dependency and inflexibility among them [Thu-2009]. An important issue is the visibility of results by implementing Reverse Supply Chain.

Ch-9: Political and social aspects [PASA]: A major challenge in food reverse logistics concerns political and social aspects. In addition, since demand in a returning network is still limited, it is hard to see commercial benefits, and the environmental ones are hard to measure [Sim-2020]. The missing concern of consumers towards environmentally friendly products is a further obstacle for retailers to launch Reverse Logistics [Vij-2014].

Ch-10: Rise in Costs [RoC]: Instead of benefitting from tax incentives for the environmental efforts, industries are afraid of a rise of costs [Vij-2014]. Because of the uncertainties and the costs related to the return management, RL is seen as a threat to the stability of a company [Has-2012].

Ch-11: Lack of collaboration [LoC]: A further challenge for food suppliers is the organization of the supply chain network and the lack of collaboration [Tro-2017], because of the unequal distribution of costs and the lack of funding from other members [Sim-2020].

Ch-12: High investment costs [HIC]: Since suppliers have short terms relationships with dealers, for example supermarkets, and focus on discounting strategies, in order to beat the competition, they are sceptical when it comes to high investment costs [Sim-2020].

Ch-13: Planned obsolescence [PO]: Customers should understand the negative impact on the environment of planned obsolescence. Nevertheless, since it is unavoidable that products get old and obsolete, remanufacturing them must be mandatory and, thus, a stronger encouragement for companies to implement reverse logistics practices are needed [Rav-2005].

Ch 14: Difficulty in obtaining permits and operational locations [DOP&OL]: Since re-manufacturing is an interest concerning the whole society, because it could limit climate change, companies establishing a recycling system should be supported and helped when it comes to the infrastructure and granting licenses [Bou-2018].

Ch 15: Missing support from government [MSG]: The operational challenges are mainly referred to missing support from governments . Missing support from legislations and a lack of knowledge about the topic add to this difficulty. Nevertheless, through the appropriate use of identification systems and new technologies, it is possible to effectively use returned items and save costs on production processes.

Ch 16: Insufficient sustainability focused regulations [ISFR]: There is a lack of guidelines and rules as well as of procedures explaining how to process End-of-Life (EoL) products [Gon,2010]. Since the topic of Reverse Supply Chain is still little known, there is a missing organizational infrastructure to encourage industries, as well as a lack of policies and financial aids.

Ch17: Expensive dissembling of items [EDI]: Industries also face an economic difficulty when it comes to the stage of processing the returned products. Despite representing an added value in the production phase, disassembling items can be expensive [Fle,1997]. On the one hand, there is the need to dismantle the products manually due to their complex composition, which is costly due to the manpower and, on the other hand, a recycling process needs its technological infrastructure [Bou-2018].

Ch 18: Forcing customers to pay for reused products [FCRP]: Industries need to rely on customers' willingness to pay for refurbished, recycled, or reused products. According to Michaud [Mic,2010], only a small part of clients is willing to trade the environmental aspects of a remanufactured product with its quality. In order to achieve better financial results through Reverse Logistics, this issue needs to be changed.

Ch 19 : Cannibalization of new products [CNP] : A further marketing difficulty refers to the cannibalization of new products. Selling a restored item could affect the sales of the new version. For example, with smartphones, selling a remanufactured device for a small price may convince the customer to choose it, rather than the more expensive new one.

Ch 20 : High costs of reverse logistics [HCRL] : A challenge which the industry has to face are the high costs of Reverse Logistics specialists and qualifying employee [Bou,2018], since there is a lack of expertise [Del,2003], and new machines or working tools are needed to implement a well-organised Reverse Logistics.

3. INTERPRETIVE STRUCTURAL MODELING METHODOLOGY

Interpretive Structural Modeling (ISM) is an interactive learning process in which a set of unique, interrelated variables are structured into a comprehensive model presented as a hierarchy graph. It involves the steps such as identifying the elements and establishing the contextual relationship between elements with respect to which pairs of elements will be examine. Thereafter, developing a self-interaction matrix (SSIM) which includes establishing VAXO relationship amongst the two variables i.e. 'i' and 'j'. Thereafter, reachability matrix is formed which first includes an initial reachability matrix and thereafter and final reachability matrix . Thereafter , level partition matrices and canonical matrices are created from the final reachability matrix using reachability set , antecedent set and the intersection set . The element for which the reachability and intersection sets are the same is the top-level element. The whole process of partitioning is based on establishing the precedence relationships and arranging the elements in a topological order. Classification of variables Based on relative driving power and dependence power, factors are classified in various categories like autonomous, dependent, driver and linkage and finally development of Diagraph/ ISM from the canonical matrix form.

4. CASE EXAMPLE

20 major challenges faced by reverse logistic supply chain discussed above in section 2.1 *viz*. Difficulty in value assertion [DVA] ; Search for an efficient repair process [SERP]; Keeping track of the warranty status [KTWS]; Lots of uncertainties [LoU]; Lack of social awareness of Environmental problems [LoAoEP]; Economic Issues [EI]; More expensive recycled material [MERM]; Inflexibility amongst the supply chain members [ISCM]; Political and social aspects [PASA]; Rise in Costs [RoC]; Lack of collaboration [LoC]; High investment costs [HIC]; Planned obsolescence [PO]; Approach to customers to remanufacture products[ARMP]; Difficulty in obtaining permits and operational locations [DOP]; Missing support from government [MSG]; Insufficient sustainability focused regulations [ISFR]; Expensive dissembling of items [EDI] ; Forcing customers to pay for reused products [FCRP]; Cannibalization of new products [CNP]; High costs of reverse logistics [HCRL] are studied with the help of ISM methodology.

Explanation: Difficulty in value assertion (affirmation) leads to more search for an efficient repair process. This also leads to keeping track of warranty status . On the other hand , lots of uncertainties leads to challenges in appropriate value assertion. This difficulty may be due to lack of social awareness of environmental problems and may lead to economic issues . This also results in buying more expensive raw material . Similarly, other factors could also be considered in the same way . This matrix is a result of a judgement b ya single person / view . However, this may be subject to change. Similarly, lack of collaboration , difficulty in obtaining permits and operational locations , insufficient sustainability focused regulations etc, lead to high investment costs; rise in costs.

4.1 Construction of Structural self-interaction Matrix (SSIM)

This matrix gives the pair-wise relationship between two variables *i.e. i and j* based on VAXO. SSIM has been presented below in Fig 1.

4.2 Construction of Initial Reachability Matrix and final reachability matrix

The SSIM has been converted in to a binary matrix called the initial reachability matrix shown in fig. 2 by substituting V, A, X, O by 1 or 0 as per the case. After incorporating the transitivity, the final reachability matrix is shown below in the Fig 3.

	Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		DVA	SERP	KTWS	LoU	LoSA	EI	MERM	ISCM	PASA	RoC	LoC	HIC	PO	DOP	MSG	ISFR	EDI	FCRP	CNP	HCRL
1	DVA		V	V	A	A	A	V	X	X	V	A	X	A	A	A	A	A	X	X	X
2	SERP			V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
3	KTWS				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4	LoU					V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
5	LoSA						V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
6	EI							X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	MERM								X	X	X	X	X	X	X	X	X	X	X	X	X
8	ISCM									V	V	V	V	V	V	V	V	V	V	V	V
9	PASA										V	V	V	V	V	V	V	V	V	V	V
10	RoC											A	A	A	A	A	A	A	A	A	A
11	LoC												V	V	V	V	X	X	X	X	X
12	HIC													A	A	A	A	A	X	X	X
13	PO														A	A	A	A	A	A	A
14	DOP															X	X	X	X	X	X
15	MSG																X	X	X	X	X
16	ISFR																	X	X	X	X
17	EDI																		X	X	X
18	FCRP																			X	X
19	CNP																				X
20	HCRL																				

Fig 1: SSIM for pair wise relationship amongst challenges faced by reverse supply chain logistics industry in India

The SSIM has been converted in to a binary matrix called the initial reachability matrix shown by substituting V, A, X, O by 1 or 0 as per the case. After incorporating the transitivity, the final reachability matrix can also be obtained.

	Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		DVA	SERP	KTWS	LoU	LoSA	EI	MERM	ISCM	PASA	RoC	LoC	HIC	PO	DOP	MSG	ISFR	EDI	FCRP	CNP	HCRL
1	DVA	1	1	1	0	0	0	1	1	1	1	0	1	0	0	0	0	0	1	1	1
2	SERP	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	KTWS	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	LoU	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	LoSA	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	EI	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	MERM	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	ISCM	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	PASA	1	0	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
10	RoC	0	0	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
11	LoC	1	0	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1
12	HIC	1	0	1	0	0	1	1	0	0	1	0	1	0	0	0	0	0	1	1	1
13	PO	1	0	1	0	0	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1
14	DOP	1	0	1	0	0	1	1	0	0	1	0	1	0	1	1	1	1	1	1	1
15	MSG	1	0	1	0	0	1	1	0	0	1	0	1	0	1	1	1	1	1	1	1
16	ISFR	1	0	1	0	0	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1
17	EDI	1	0	1	0	0	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1
18	FCRP	1	0	1	0	0	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1
19	CNP	1	0	1	0	0	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1
20	HCRL	1	0	1	0	0	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1

Fig 2: IRM for pair wise relationship amongst challenges faced by reverse supply chain logistics industry in India

	Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	D.P
		DVA	SERP	KTWS	LoU	LoSA	EI	MERM	ISCM	PASA	RoC	LoC	HIC	PO	DOP	MSG	ISFR	EDI	FCRP	CNP	HCRL	
1	DVA	1	1	1	0	0	0	1	1	1	1	0	1	0	0	0	0	0	1	1	1	11
2	SERP	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20
3	KT	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	WS																					9
4	LoU	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
5	LoSA	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
6	EI	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
7	MERM	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
8	ISCM	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
9	PASA	1	0	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	16
10	RoC	1	0	1	0	0	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	14
11	LoC	1	0	1	0	0	1	1	0	0	**1**	1	1	0	0	0	1	1	1	1	1	11
12	HIC	1	0	1	0	0	1	1	0	0	**1**	0	1	0	0	0	1	1	1	1	1	6
13	PO	1	0	1	0	0	1	1	0	0	**1**	0	1	1	1	1	1	1	1	1	1	12
14	DOP	1	0	1	0	0	1	1	0	0	1	0	1	0	1	1	1	1	1	1	1	11
15	MSG	1	0	1	0	0	1	1	0	0	1	0	1	0	1	1	1	1	1	1	1	11
16	ISFR	1	0	1	0	0	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1	11
17	EDI	1	0	1	0	0	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1	11
18	FCRP	1	0	1	0	0	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1	11
19	CNP	1	0	1	0	0	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1	11
20	HCRL	1	0	1	0	0	1	1	0	0	1	1	1	0	1	1	1	1	1	1	1	11
	De.P	20	2	20	3	4	19	20	8	9	20	15	20	10	17	17	19	19	20	20	20	

Fig3 : Final reachability matrix

4.3 Level Partition

From the final reachability matrix, reachability and final antecedent set for each factor are found. The elements for which the reachability and intersection sets are same are the top-level element in the ISM hierarchy. After the identification of top level element, it is separated out from the other elements and the process continues for next level of elements. Reachability set, antecedent set, intersection set along with different level for elements have been shown below in table 1.

Table 1: Iteration I

S.No.	Reachability set	Antecedent set	Intersection set	Level
1.	**1,3,7,10,11, 12,18,19,20**	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15, 16,17,18,19,20	1,3,7,10,11,12,18,19,20	**I**
2.	**1,3,6,7,10,11, 12,16,17, 18,19,20**	2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20	3,7,10,11, 12,18,19, 20,6,16,17	
3.	**1,3,6,7,10,11, 12,14,15,16,17, 18,19,20**	2,3,4,5,6,7,8,9,10,13, 14,15,16,17,18,19,20	3,7,10,18, 19,20,6,16,17,14,15	
5.	**1,3,6,7,10,11, 13,12,14,15,16,17, 18,19,20**	2,3,4,5,6,7,8,9,10,13	3,7,10,,6, 13	
6.	**1,3,6,7,9,10,11, 12,13,14,15,16,17, 18,19,20**	2,3,4,5,6,7,8,9	3,7,10,18, 19,20,6,16,17	
8	**1,3,6,7,8,9,10,11, 12,13,14,15,16,17, 18,19,20**	2,3,4,5,6,7,8	3,7,10,18, 19,20,6,16,17	

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

Table 4.1.2 : Final set of iterations

S. No.	**Reachability set**	**Antecedent set**	**Intersection set**	**Level**
1.	**1,3,7,10,11, 12,18,19,20**	1,2,3,4,5,6,7,8,9,10, 11,12,13,14,15, 16,17,18,19,20	1,3,7,10,11,12,18,19,20	**I**
2.	**6,16,17**	2,4,5,6,8,9,13,14,15,16,17	6,16,17	**II**
3.	**14,15**	2,4,5,8,9,10,13,14,15,18,19,20	14,15	**III**
5.	**13**	2,4,5,8,9,10,13	13	**IV**
6.	**9**	2,4,5,8,9	9	**V**
8	**8**	2,4,5,8	8	**VI**
9	**5**	2,4,5	5	**VII**
10	**4**	2,4	4	**VIII**
11	**2**	2	2	**IX**

4.3 ISM diagraph

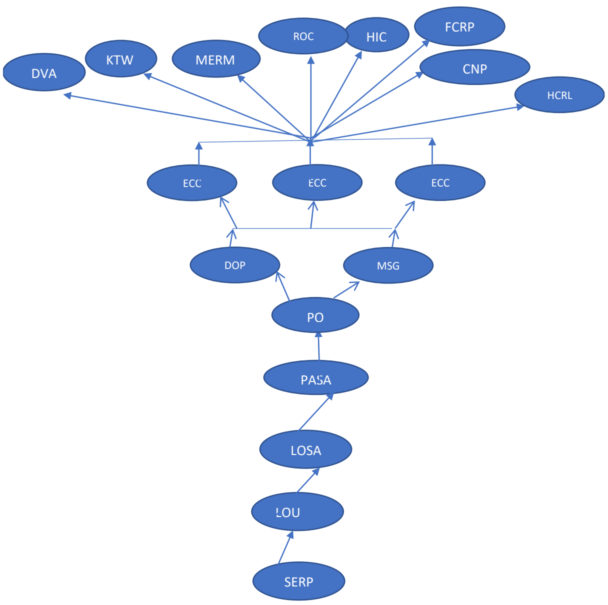

Figure 1 : ISM Diagraph

5. POSSIBLE EXTENSION

We can make use of Fuzzy TOPSIS TECHNIQUE , AHP technique , hybrid AHP-SWOT-PESTLE technique after identifying the challenge`s and probably putting them into various categories such as political factors ; economic challenge ; environmental challenge etc. similarly we can recognise these challenges into categories of threats to reverse logistics or weaknesses of reverse logistics which should be rectified .

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