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Investigating Responsiveness of Reverse Logistics for Manufacturing Industries

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Abstract: Reverse logistics supports in moving goods from consumer to a facility where recapturing of value of the End of Life (EOL) goods is possible. This can be achieved by product recovery management. The recovered material can be reused as raw material in manufacturing giving an edge of cost competitiveness. Besides this, reverse logistics (RL) also mitigates problem of pollution, cheaper raw material, value for waste, and making return policy easy in online shopping. This paper aims to investigate the responsiveness of RL (RRL) using analytical hierarchal process in maintaining cost, product recovery management, environment, and customer satisfaction citing examples of major manufacturing sector. This paper highlights the importance of RRL to make it more responsible toward environment and making RL as a profitable venture. The study also provides roadmap to top management in furnishing their social responsibility to take care of EOL goods produced from their firms as the human being no more be as wasteful and insensitive toward his surroundings. The best implication of RL may ease the problem of electronics and plastics waste disposal, pollution of land, air and aquatics, and vanishing of precious rare metals from the earth.

Keywords: reverse logistics, responsiveness, End of Life, waste management, environment, competitiveness

1. Introduction and Literature Support

Reverse logistics (RL) has been defined by Council of Logistics Management as the process of efficient planning and controlling of reverse flow of goods from the point of consumption to the point of origin of the product. RL is a research about the management of the recovery of products once they are no longer desired by the consumers, in order to obtain an economic value from the recovered products. Kusi-Sarpong et al. [1] pointed out that human being can be no longer wasteful in present scenario; therefore, RL is helping in getting much out of the waste. This helps in recapturing value from returned goods and in preservation of environment [2]. It has now become imperative to realize the importance of utilization of End of Life (EOL) products. Many products made of plastics and metals, e.g., mobile phones, computer items, and other electronic gadgets, are either thrown away or kept lying at consumers end for very long time [3]. These waste products not only create environmental hazards but also result in wastage of important and rare materials, which are diminutive in nature. Kusi-Sarpong et al. [1] reported that as our planet's resources are depleting at faster rate than ever due to huge draining of raw material from it, the scarcity of supply of such raw material has been encountered in many industries. Best example of this is the shortage of semi-conductors in recent times due to which automobile, computer, mobile phones, and electronics industries are facing huge production challenges. Secondly, facilities of return/exchange in e-shopping have increased many folds and shipping back in minimum time to the originator is required to maximize the turnaround time. Alnoor et al. [4] reported that return of electronics goods sold online requires robust and responsive reverse supply chain to satisfy and assure the customer of the company commitments. This will also give a competitive advantage by retaining customers for longer time. Rubio et al. [2] described RL as planned backward flows of EOL goods. Similarly, Mangla et al. [5], Ramazani et al. [6], and Cricelli et al. [7] reported RL is a planned activity, which emphasizes economic, environmental, and social needs for sustainable business.

Industries have started a take-back program in their supply chains through which some incentives are offered to retailers to collect and return the used products to the, Cricelli et al. [7]. Kazemi et al. [8] have cited the example of Dell which started a take-back program in 2014 of used products. The company recovered 10% of the plastic as raw material and used them in manufacturing processes of new product and meeting the challenge of cost competitiveness. Another example of using plastic waste from oceans to develop their new line of shoes "Parley" on a global level by Adidas and reducing enormous carbon foot print. Such initiative not only served the cost cut of raw material but saved the aquatic pollution also, Zheng et al. [9]. Giri et al. [10] suggested that EOL of electronics goods such as DVDs, batteries, mobiles, camera, projectors, photocopiers, printers, LEDs, and fluorescent lighting can be collected for retrieval of useful rare materials using third-party logistics and e-tail channel. Rubio et al. [2] have mentioned remanufacturing, environmental concern, depleting reserve of raw materials, economic recovery from waste, and corporate social responsibility as main factors of RL.

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But timeliness of RL is very important for smooth running of remanufacturing, refurbishment, and canalization firms. For this, the support team at the back end should be responsive and prompt so that the collected EOL goods are taken care to reach at the proper destination. Prajapati et al. [11] have cited responsiveness of RL (RRL) for Implementation of effective RL. Ramezani et al. (2013) reported the RRL as quickness of logistics to collect, transport, and do required processes on the retuned goods to get competitive advantage in business. RRL depends upon factors such as cost involved in return process, environmental effects, product recovery management, customers' response, return policy of the company, government policies, and social awareness. Sukati et al. [12] have explained competitive advantage due to RL by optimized product recovery.

To understand how effectively RL is being taken by industries as a venture, a case study of three major sectors of manufacturing firms of India has been explored. After consultation with experts from academia and industries, the three major sectors, where RL can be a major game changer, have been considered. These three sectors are automotive, electronics, and paper and plastics, of which large volume of products are sold in market. The quantities of EOL of these sectors are voluminous and hazardous and urgently need attentions of policy makers. Recently, Government of India has announced scrap policy (2021) based on life of the vehicles. This is again a boost to RL.

Therefore, this paper explores the RRL of three major sectors of manufacturing, i.e., automotive, electronics, and paper and plastic industries using analytical hierarchal process (AHP), a multi-criteria decision-making (MCDM) approach [13]. Also, the developing countries like India, China, Taiwan, Korea, etc. are becoming hub of manufacturing of these three sectors. Usefulness of RL has been felt in these sectors, as EOL of the products are increasing enormously. Therefore, strategic management is required to handle wastes into resourceful manner. Also, while choosing the manufacturing sectors, two things are taken into consideration (i) it should cover vast area of manufacturing sector and (ii) possible gain from the operation of RL. The three industries are meeting our requirement, whereas other industries can also be considered for better understanding of RRL. Therefore, this study can be generalized with some addition or deletion in enablers of RL.

After keen study of several articles in the field of RL, it has been seen that most of the papers have mentioned to measure the performance of RL and none to explore RRL. This paper is aimed to explore RL in terms of RRL, which is unique in nature. The study can be applied in any other industries to compare the readiness and benefits gained through the RL. Therefore, the main objectives of this paper are three folds.

1) To identify the factors affecting RRL
2) To explore RRL and its benefits in some Indian industries.
3) To discuss the managerial implications of this research work and suggest directions for future research

2. Enablers of RRL

Singh [14] described RRL is promptness of reverse supply chain or reverse flow of material. This will depend upon promptness to collect, transport, process, and making ready for reuse of the flowed material/goods, Govindan et al. [15, 16] suggested that cost effectiveness, product recovery management, global environmental pressure, customer's (returnee) cooperation, and return policy are important enablers of RRL. Discussing about the main enablers of RL, Mangla et al. [5] have mentioned environmental, customer awareness, economical gains, and attractive return policy. Kazemi et al. [8] have reviewed RL and outline the important factors such as development of facility of remanufacturing, rewarding end customer for readily disposing of EOL goods, and long-term impact of RL. Jack et al. [17] highlighted the need of economical transportation and warehousing in RL. Gurita et al. [18] have stressed upon the development of remanufacturing facilities of e-waste to use benefits of RL.

However, Wang et al. [19] pointed out an uncertainty factor in RRL. It is quite possible that the quality, duration, accident, strike, traffic jam, relationship, etc. are important in deciding the RRL. But Lee and Dong [20] suggest that it is impossible to capture every single uncertainty in the RL as nature of reverse flow of material may differ even though the uncertainty influences decision making. The uncertainty due to changing technology and market mood is taken care with prior planning. This study has been carried out in ideal conditions, where uncertainty factors have been taken care by proper planning: implementing advanced tracking systems and real-time monitoring. Also, the study of RL is mainly focusing the area of reuse, remanufacture, and recycle out of the collected waste and not the online shopping, where uncertainty of return of items is very high. Therefore, we have not considered uncertainty factor as enabler of RRL.

Finally on the basis of exhaustive literature reviews and consultations with the experts from industries and academia, following five enablers are outlined, mentioned in section in Table 1. The table enlists the enablers and sub-enablers of RRL along with the researcher citations.

1) Cost effectiveness (CE)
2) Product recovery management (PRM)
3) Environmental consideration (EC)
4) Customers impact (CI)
5) Return policy (RP)

3. Methodology

This paper uses AHP to find out the best performing manufacturing sector in respect of RRL. Initially, important enablers and sub-enablers are selected from the available literature. The final selections of the enablers are done in consultation of the experts. A hierarchy model of the RRL enablers, sub-enablers, and industries is prepared. Expert-based decision matrices (DMs) have been prepared for enablers and sub-enablers of RRL.

3.1. Analysis of RRL using AHP

RRL based on comparative performance of enablers in three industries is illustrated here. Those enablers are "cost effectiveness, product recovery management, environmental consideration, customer's impact and return policy." For relative performance, AHP has been used. The three industries are selected arbitrarily, seeing the most vulnerable area, where applying RL will be profitable venture. For example (1) automotive (AM), (2) electronics (EL), and (3) paper and plastic industries (PP) are chosen keeping in view of high return from even scraps of these products [29]. Most of the parts can be recovered from the waste of automotive equipment similarly; electronics and plastics waste disposal in efficient way is need of the world to reduce continued deteriorations of land, water, and air [30]. Also, recovering of paper from the waste is making high sense, as it saves lot of deforestation and is key to its survival and growth. Secondly, these three sectors are very vast and can be

Table 1
List of enablers and sub-enablers

Enablers	Sub-enablers	Description	References
Cost effectiveness (COE)	Collection (COE1)	Competitive cost of collection of the EOL goods	Zheng and Zhang [9]
	Transportation (COE2)	Transportation cost of collected items	Jack et al. [17]
	Storage (COE3)	Storage/warehouse cost in locality	Dyckhof et al. [21]
	Processing (COE4)	Cost of smelting, re-manufacturing, retrieval of useful material/components, etc.	Alnoor et al. [4]
Product recovery management (PRM)	Repair (PRM1)	Minor/major repair to make product useable	Campos et al. [22]
	Cannibalization (PRM2)	Minor/major changes in shape, sizes, and other features to make it more attractive	Chan et al. [23]
	Recycling (PRM3)	Recycling of plastic, metal product to get back the material	Pokharel and Mutha [24]
	Remanufacturing (PRM4)	Remaking of product out of retrieved materials	Gurita et al. [18]
Environmental consideration (EC)	Hazardousness (EC1)	All harmful effects due to emission, waste disposals, etc.	Govindan et al. [15]
	Impact on surrounding (EC2)	The long-term and short-term impact on surrounding and environment of RL	Kazemi et al. [8]
	Government norms (EC3)	Government ordinance for disposing off EOL goods	Campos et al. [22]
Customers impact (CI)	Social status (CI1)	Social behavior of customer	Glock and Kim [25], Govindan et al. [26]
	Financial status (CI2)	Developed and developing economy impacts RL as business	Giri et al. [10]
	Customer retention (CI3)	For long-term association, RL by company gives customer retention	Prajapati et al. [11]
Return policy (RP)	Vendor agreement (RP1)	Agreement between vendors in supplying of EOL product to processing firm	Batarfi et al. [27]
	Simple and attractive (RP2)	All return policy should be simple and with incentives	Alnoor et al. [4]
	Periodically revision (RP3)	Revised time to time	Banihashemi et al. [28]

generalized for any kind of industries using RL. It is also made clear here that any other industries can be compared using our present study; however, minor chances to vary the enablers and sub-enablers are not avoided.

Of course, using AHP is an old multi-criteria decision analysis but is very easy and logical to apply. The AHP is not only using the text opinion but also uses numeric values of each opinion. In this study, we have used Likert scale (1–9) for giving relative advantage of the enablers and sub-enablers while comparing. Ishizaka and Nemery [31] opined the main goal of MCDM is not to suggest the best decision but to aid the decision makers in selecting shortlisted alternatives in line with their preferences. The methodology is quite suitable and simple to meet the objective of this study.

3.2. RL in automotive industries

Luthra et al. [29] reported that RL plays a significant role in automobile industry in the salvage of parts and retrieval of useful materials from EOL vehicles. These parts/materials can be used in remanufacturing of the automobile parts/components. Society of Indian Automobile Manufacturers Association in its report claims to recover 1.5 million tons of steel scrap, 180,000 tons of aluminum scrap, and 75,000 tons of recoverable plastic and rubber from scrapped automobile. Ravi [32] reported that recovered materials can be used to cater the demand of automotive parts. Some of the automotive components such as engines, alternators, starters, and transmissions mechanisms may be reused after some refurbishment. Of course reuse of such components needs to be tested for its worthiness. RL helps to collect and continuous supply of EOL vehicles to the refurbishment/manufacturing center. To maintain the continuous supply, a quick collection and transportation of these EOL goods is urgently required. Reuse, refurbishment, and recovery of material are great steps toward low carbon production system.

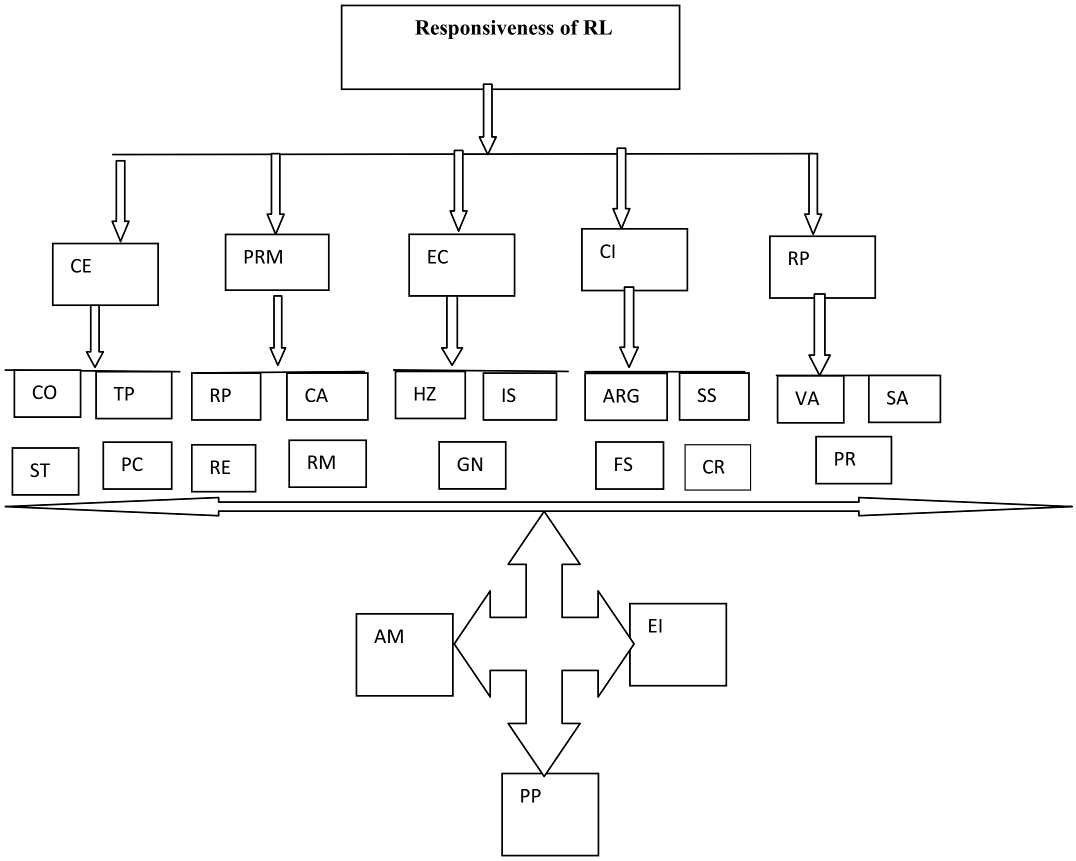
3.3. RL in electronics industries

The need to use EOL of electronics goods in any form is urgently required reported by Poppelaars et al. [33]. The RRL in EL industries is needed as quick lifecycle for these high velocity products and evolving technology. It is being sensed by the companies that RL will become a more defined competitive advantage for entities that can reclaim lost revenues quickly in EL industries. E-waste is posing threat to the environment and quick attention is urgently needed, which gives an edge to companies to develop RRL chains.

3.4. RL in paper and plastics industries

Plastic and papers are quickly recyclable and give competitive advantage in the usage of packaging, toys, automotive parts, computers, etc. Plastics are being used in civil constructions like making roads mainly by recycling plastic carry bags, disposable cups, medical plastic waste, water bottle, etc. This is helping in

Figure 1
Hierarchical diagram of RRL



reduction of use of cement and other constructional materials. RL is playing a very important role in collecting and fetching the used papers and plastic waste to the remanufacturing center. The raw materials for the paper are already in a critical state. Pati et al. [34] reported increase of paper industries by 8% per annum. But, it has been reported by Ravi and Shankar [35] that, there is significance shortage of the basic raw materials like wood pulp in manufacturing of the paper. Similar shortage can be seen in raw plastic raw materials. This leads to a big gap between the supply and demand; this could be minimized by recycling the post-consumer waste paper. The reuse of EOL goods of plastics and paper is not only economical but is a bold step toward low carbon emission.

4. Application of AHP

Here, AHP will be applied in two steps to explore RRL of the above said three sectors of manufacturing industries.

Step 1: Setting up Expert team. In AHP, relative weightage to each enabler is given. For this, three teams of experts from academia and industry were invited. Experts from each industry, i.e., automotive, electronics, and paper and plastics, who were handling SC operation at senior position and three academicians at professor level specialized in SC, have been contacted (refer Table A4 of Appendix). The relative weightage given by the experts was used to make DM.

Step 2: Preparing DM. DM in respect of enablers and sub-enablers were formed based on opinion given by experts. Finalizing of DM has been carried out in three stages.

Stage 1: In the first stage, all factors affecting RL, i.e., enablers and sub-enablers (Table 1) from literature with a final opinion of experts, have been finalized. After this, a hierarchy in finding RRL has been framed. Figure 1 shows the hierarchy in which the goal to derive index of RRL is at the top. At the bottom of this hierarchy, the three industries where RRL is to be evaluated on the basis of interlinking of the enablers and sub enablers are shown.

Stage 2: In this stage, we will find enablers scoring highest weightage. For this, DM containing fall enablers (here five) is prepared (Table 2). The expert's relative weightage (1–9) has been used in DM; Table A1 of appendix may be referred. For example, cost effectiveness is 8 times more important than PRM. Therefore, PRM is lesser important than CE by 0.125 times. The local weightage (LW) has been calculated by using several iterative steps of AHP. For example, LW of EC is 0.4234. This is the highest weightage, among the five enablers. It indicates that the CE remained the key factor in deciding RRL. For checking consistency of the result, Tables A2 and A3 of Appendix can be referred.

Stage 3: Determining Global Weightage (GW). This stage will be discussed in two steps. In first step, DM of sub-enablers of each enabler are prepared and LW is calculated (Table 3). Thus, five DMs are obtained (refer Appendix Table A5, Table A6, Table A7 and Table A8 for another 4 tables). In second step, DM of sub-enablers in context of the three industries are obtained. Thus, 15 DMs, five for each sector, i.e., for auto, EL, and paper and plastics, are obtained. The results of these 15 matrices are

Table 2
DM of enablers of RL

Enablers	(CE)	(PRM)	(EC)	(CI)	(RP)
CE	1	8	0.5	3	2
PRM	0.125	1	0.2	0.25	0.5
EC	2	5	1	5	3
CI	0.333333	4	0.2	1	1
RP	0.5	2	0.333333	1	1
Local weightage	0.287558	0.050033	0.423453	0.119062	0.119894
EV/CR	5.204219	0.0454			

Table 3
DM of cost effectiveness

Sub-enabler	Collection	Transportation	Storage	Processing
COE1	1	3	0.5	0.2
COE2	0.333333	1	0.25	0.111111
COE3	2	4	1	0.333333
COE4	5	9	3	1
LW	0.129458	0.054287	0.222181	0.594074
EV/CR	4.033977	0.012453		

conveyed in Table 4 in column 6 a, b, c. As numbers of iterative steps are involved in making 15 DMs, those matrices are not shown in text. Table 3 is shown for the example. Finally, GWs are found for each industry by multiplying column 5 to 6a, b, c to get column 7a, b, and c. All the GWs found against each sub-enabler for an industry are summed to find out RRL index of that industry, which is shown in respective cell at the bottom. It is observed that highest index of RRL is of paper and plastics industries, followed by automotive and electronics sector. The detailed discussion of result has been given in Section 5 of this article.

5. Result and Discussion

In this section, discussion on result obtained is being presented. RL is gaining huge importance in this time of e-commerce. This paper is highlighting the key enablers of RRL in the three major manufacturing sectors. AHP has been used to explore the effectiveness of RL in terms of RRL. A hierarchical model of RRL is developed taking into consideration the enablers, sub-enablers, and the three manufacturing sectors. The results of AHP are displayed in Table 4. From Table 3, it is observed that the LW of enablers, cost effectiveness, product recovery management, Environment Consideration, customers' impact and return policy are 0.288, 0.05, 0.423, 0.119 and 0.120 respectively. Pathak and Srivastava [3] also outline EC as the most influencing enabler of RRL. GW of these sub-enablers is 0.4132, 0.3506, and 0.4323 in respect of automotive, electronics, and paper and plastics industries, respectively. It is observed that paper and plastics industries are most responsive in business of

Table 4
Determination of index of RRL

1. Enablers	2. LW	3. Sub-enablers (SE)	4. LW of SE	5. Global weight	6. LW of industries			7. GW of industries		
					AM	EL	PP	AM	EL	PP
Cost effectiveness	0.2876	COE1	0.1295	0.0372	0.1367	0.088	0.165	0.0051	0.0033	0.0062
		COE3	0.0543	0.0156	0.0659	0.2754	0.0650	0.0010	0.0043	0.0010
		COE3	0.2222	0.0639	0.2989	0.0472	0.1040	0.0191	0.0030	0.0066
		COE4	0.5941	0.1708	0.4986	0.5889	0.6657	0.0852	0.1006	0.1137
Product recovery management	0.0500	PRM1	0.2994	0.0150	0.2039	0.2111	0.0425	0.0031	0.0032	0.0006
		PRM2	0.5266	0.0263	0.6141	0.6065	0.1108	0.0162	0.0160	0.0029
		PRM3	0.0585	0.0029	0.0552	0.0483	0.3007	0.0002	0.0001	0.0009
		PRM4	0.1156	0.0058	0.1268	0.1341	0.5461	0.0007	0.0008	0.0032
Environmental consideration	0.4235	EC1	0.0819	0.0347	0.1283	0.0732	0.2363	0.0045	0.0025	0.0082
		EC2	0.6817	0.2887	0.5954	0.2560	0.6817	0.1719	0.0739	0.1968
		EC3	0.2363	0.1001	0.2764	0.6708	0.0819	0.0277	0.0671	0.0082
Customers impact	0.1191	CI1	0.1375	0.0582	0.1376	0.2749	0.3334	0.0080	0.0160	0.0194
		CI2	0.0743	0.0088	0.0741	0.0416	0.0794	0.0007	0.0004	0.0007
		CI3	0.4949	0.0589	0.5132	0.1561	0.5151	0.0302	0.0092	0.0304
		CI4	0.2933	0.0349	0.2751	0.5274	0.0721	0.0096	0.0184	0.0025
Return policy	0.1199	RP1	0.6483	0.0777	0.2256	0.2560	0.1692	0.0175	0.0199	0.0132
		RP2	0.1220	0.0146	0.6738	0.6708	0.3874	0.0099	0.0098	0.0057
		RP3	0.2297	0.0275	0.1006	0.0732	0.4434	0.0028	0.0020	0.0122
	RRL							**0.4132**	**0.3506**	**0.4323**
	Ranking of industries							2nd	3rd	1st

RL due to three-fold reasons. Firstly, disposing of paper and plastics is easy from customer end to its processing units. Secondly, recycled paper and plastics are easily used to make new product. Thirdly, PRM is simple and does not impact environment if due care is taken. The second most responsive industry is automotive manufacturing sector. RL in automotive sector is growing steadily since last decades due to growing demand of used car, vehicles, and machinery. Even several parts of disposed off automotive can be retrieved by simple processes like cutting, heating, and breaking. This way whole metal parts are utilised in remanufacturing.

Recovery of useful material from electronics goods is comparatively low due to complex technology involved in its retrieval, whereas the recovered material by PRM is cost competitive. Retrieval of plastic, rare metals, and some serviceable components from used computers, TV, camera, mobile, printers, photocopiers, etc. can be used as raw material in manufacturing. Valuable metals such as copper, silver, gold, and platinum could be recovered from e-wastes, if better technology is available. Sukati et al. [12] also reported about slow progress of RL in electronics industries. Summarizing the result, it is found that paper and plastics industries are showing highest RRL, whereas electronics industries are least responsive. This is due to difficulties complex technology involved in retrieval and low gains of useful material.

6. Sensitivity Analysis

The result obtained in AHP depends on the relative interlinking of LW and GW at each level. The result shows that it is a function of relative weightage and is dependent on the opinions of the experts. Who may be biased, however, care has been taken to avoid biasness in AHP result. Sensitive analysis is the tool to check the robustness of these weightages by varying one parameter of any enabler. For this, ranking of the given industries is to be checked by using sensitive analysis. It is found that after varying data of one enabler result (final foal, i.e. RRL of Industry) remained unchanged. This establishes the correctness of the result. To carry out sensitive analysis, LW of PRM has been changed by 20, 30, 50, 70, 90 percentage, making others' LW constant. It is seen that overall sum of GW changed, but the position (rank) of the three sectors of manufacturing industries in respect of RRL remains unchanged (Table 5). Figure 2 displays consistency in the final result.

Figure 2
Graph of variation in RRL of the three industries with respect to change in LW of PRM

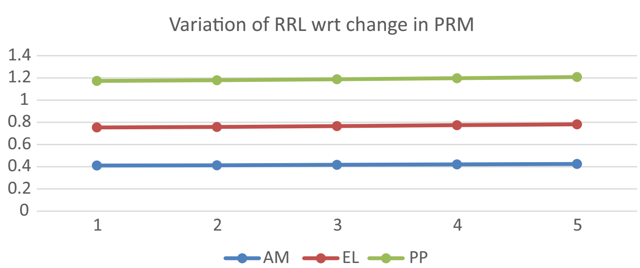


Table 5
Sensitivity analysis

Increment % in LW of PRM	AM	EL	PP
20	0.411	0.343	0.419
30	0.413	0.345	0.421
50	0.417	0.349	0.422
70	0.421	0.353	0.423
90	0.425	0.357	0.426

7. Conclusion

RL is a reverse supply chain of used goods for the purpose of retrieval of useful material or for exchange. Necessity of RL was felt when it was found that waste/EOL can be reused by doing some modifications, refurbishment, repair, or retrieval to get cost competitiveness. RL is also supporting the items under guarantee/warranty. This paper has explored the RRL of the three sectors of manufacturing industries taking five enablers such as cost effectiveness, PRM, environmental consideration, customer impact, and return policies. The hierarchical model of AHP taking RRL, enablers, sub-enablers, and the three industries has been developed. The three industries, automotive, electronics, and paper and plastics, are placed at the bottom and RRL at the top. With the application of AHP, it has been found that paper and plastics industries are most responsive to RL. It may be due to easy in processing with good return on investment. The processing of these EOL has become comparatively less hazardous. Electronics industries are least responsive due to complex technology and environmental impacts. The retrieval of useful material from EOL goods is complex, secondly due to faster changing of technology in electronics industries retrieved components are becoming obsolete or of no furthur usage in remanufacturing.

Limitations and Managerial Implications

The study is an opinion of a closed group. Of course, care has been taken to find the opinion of experts unbiased but chances of biasness cannot be completely denied. In addition to this, the study is done keeping the status of RL in Indian context. It may vary as per the regions too. Thirdly, the selection of enablers is not absolute; some other enablers can also be suitably chosen.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data available on request from the corresponding author upon reasonable request.

Author Contribution Statement

Om Prakash Mishra: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing – original draft, Supervision, Project administration. **Surender Singh:** Validation, Data curation.

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Appendix

Table A1
Interpretation of opinion on numerical value

Description	Equal important	Very weak	Weak	Moderate	Fare	Satisfactory	Good	Very good	Excellent
Numerical value	1	2	3	4	5	6	7	8	9

Table A2
Random index

Order of matrix	1	2	3	4	5	6
Consistency index	0	0	0.58	0.90	1.2	1.24

Table A3
Matrix size and CR table

Matrix size	3 × 3	4 × 4	n > 5
CR	0.05	0.08	0.1

Table A4
Profile of the experts

Expert	Expert designation	Specialization	Experience (years)
Academician	Professor	Supply chain and environmental science	20 and above
Manager	Sr. Level	Supply chain manager (one from each sector, automotive, electronics, and paper and plastics)	15 and above

Table A5
DM of PRM

Sub-enabler	Repair	Cannibalization	Recycling	Remanufacturing
RP	1	0.5	5	3
CA	2	1	9	4
RE	0.2	0.111111	1	0.5
RM	0.333333	0.25	2	1
LW	0.299373	0.526595	0.058453	0.115579
EV/CR	4.013957	0.005116		

Table A6
DM environmental consideration (EC)

Enablers	Hazardousness	Impact on surroundings	Government norms
HZ	1	0.125	0.333333
IS	8	1	3
GN	3	0.333333	1
LW	0.081935	0.681728	0.236337
EV/CR	3.001531	0.001598	

Table A7
DM of customer impact (CI)

Sub-enabler	Aware of return of goods	Social status	Financial status	Customer retention
ARG	1	2	0.25	0.5
SS	0.5	1	0.2	0.2
FS	4	5	1	2
CR	2	5	0.5	1
LW	0.137489	0.074291	0.494883	0.293337
EV/CR	4.047317	0.017343		

Table A8
DP of return policy

Sub-enabler	Vendor agreement	Simple and attractive	Periodically revision
VA	1	5	3
SA	0.2	1	0.5
PR	0.333333	2	1
LW	0.648329	0.12202	0.229651
EV/CR	3.003696	0.003857	