A Review on Practices of Reverse Supply Chain Management

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Abstract: Reverse supply chain has got considerable attention as it directly leads to achievement of green supply chain and sustainable supply chain. By going through a large number of literature it seems that research on reverse supply chain is not sufficient. There are some gaps which needs to be fulfilled. The objective of this paper is to review various literature on Acquisition of product, collection of product, reverse logistics process, selling of product reverse supply chain structure and identify the gaps existing in the literature.

1. Introduction
Reverse logistics (RL) has received considerable attention due to potentials of value recovery from the used products. Besides, legislations and directives, consumer awareness and social responsibilities towards environment, emerging of sustainable and green supply chain are also the drivers for Reverse logistics. The focus on reverse supply chain is on waste management, material recovery by recycling, parts recovery or product recovery by remanufacturing. Basically closed-loop supply chains (CLSC) focus on taking back products from customers and recovering added value by reusing the entire product, and/or some of its modules, components and parts. Over the last years closed-loop supply chains have gained considerable attention in industry, as well as in academia. Its total evolution and scope of improvement is already told by V. Daniel et al [1]. They also described the different phase and potential future OR research opportunities.

There are many opportunities of research in this field, as this field is unexplored as compare to supply chain management, Fleischmann et al [2] and Fleischmann [3] suggested seven opportunities for further research in their literature review.

The review presented in this paper extends the review to consider important features of reverse logistics such as product acquisition, sorting, inspection, refurbishing, remanufacturing and sell. The review of 100 papers is done by Jayant Arvind et al [4], which are published till 2009.

The rest of the paper is organized as follows. In the next section research methodology is discussed. From Section 3 on ward, the results of review are presented with research directions for the future research. The paper ends with conclusions and some thoughts on further research.

2. Review methodology

The paper uses content analysis method [18] to review the previous research paper. Content analysis is an observational research method that is used to evaluate content. Content analysis as a research technique for making replicable and valid inferences from data of context. This method creates opportunities for research. The reverse supply chain is consisting of several steps. Therefore research is focused on each steps separately.

3. Research on reverse supply chain

A reverse supply chain consist of acquisition of used product then these products are tested, inspected, sorted which segregated the product according to level of quality. The sorted product transported to their respected secondary operation i.e. remanufacturing or recycling or selling direct into market as a whole product or in parts [5]. This structured part of reverse supply chain becomes a process to optimize. The optimization could be in terms of method of product acquisition, cost effective inspection and sorting method, in disassembly and recycling process of product. The reverse supply chain should be designed such that it provides maximum profit in terms of financial and social aspects. The reverse supply chain could be efficient or responsive which fully depends on the product and market requirement. Recently, a good number of research paper, case studies have been reported which state reverse supply chain network design in the product recovery and remanufacturing context. Table 1 is given in appendix 1 and table 1 summarizes the papers related to design of reverse supply chain networks and relevant issues and a details of abbreviation used in the table 1 are given in table 2.

3.1 Acquisition of product
The first step which is acquisition of product is very important and crucial part for whole chain because of uncertainty associated with quality and quantity of product, which is returned by customer. Suppose a firm which is coupled with the large number of collection points have the high degree of uncertainty about the quantities collected from each location and the timing of collection chains. These uncertainties make the collection process difficult and costly. There should be such actions needed which reduces uncertainty associated with timing and quantity of returns, balance return rates with demand rates, and make material recovery more predictable [10],[11]. Some researcher suggest offering attractive incentives to motivate the end-user to return the product to a designated place. Even, in a few papers uncertainty in parameters, while acquiring the product, is considered, but uncertainty is modeled through stochastic programming. This stochastic programming method has some drawbacks, just say a newly firm which did not have any past data can’t work on stochastic model for product acquisition. So we need models which fits in all situations. Gernot Lechner et al [19] presented a numerical model for a firm which acquires used product’s part for remanufacture new product. They presented model which integrates the link between acquisition and manufacturing−remanufacturing disposition with stochastic demands but there exists a lack of potential disposition possibilities, as solely as new products are demanded. Another critical point is the consideration of quality, which would have high impact on acquisition and disposition decisions.

3.2 Collection of product
Second steps which is taking back of product which is collected from customer to the deposit center or in simple words reverse logistics. Here our primary concern is to setting up an appropriate logistics Network which has a fundamental impact on the economic viability of a reverse supply chain. In order to successfully exploit the opportunities of recovering value from used products, managers need to design a logistics structure that provides the arising goods flows in an optimal way. Here decisions need to be taken on where to locate the various processes like sorting, inspection of the reverse supply chain and how to design the corresponding transportation links. Some researchers also focuses on the reverse logistics design and its cost effectiveness. N.mishra et al [6] have developed a multi agent architecture for reverse logistics in a green supply chain. Frank schultman [7] et al also develop a model for reverse logistics task within closed loop supply chain in the context of automotive industry.

3.3 Reverse logistics process
To make reverse supply chain more effective and efficient some researchers focuses on the uses of product. Monique L. French et al [12] studied re-use issues and practices related to process industry firms. Some researcher focused on remanufacturing of product, as remanufacturing represents a higher form of reuse by focusing on value-added recovery. V. Daniel et al [13] write a technical note on production planning and control for a remanufacture industry. He state that Production planning and control activities are more complex for remanufacturing firms due to uncertainties from stochastic product returns, imbalances in return and demand rates, and the unknown condition of returned products. While some focuses on the recycle of the product which have completed their life. Anna Nagurney et al [14] developed an integrated framework for the modeling of reverse supply chain management of electronic waste, which includes recycling of waste.

3.4 Selling of product
Selling a used product is tough task due to uncertain demand of used product and competition with original equipment manufacturers. Here pricing of product is critical issue due to stochastic returns and demands. Thus pricing play important role in total earning/profit or revenue of firm. Researchers have studied the relationship between markets for new and remanufactured products and developed models to determine the optimum selling price for remanufactured products and parts (17).

3.5 Reverse supply chain structure
A large numbers of research have been done on reverse supply chain. Review on various quantitative models for reverse logistics network is given by Fleischmann et al [15]. A mathematical model of reverse multilayer multi-product supply chain for minimizing the total costs including returning, disassembly, processing, recycling, remanufacturing, and distribution centers is prepared by hoda mahmoudi [8] This paper propose a multi-layer, multi-product reverse supply chain problem which consist of returning center, disassembly center, processing center, manufacturing center, recycling center, material center, and distribution center costs while minimizing of total costs in reverse supply chain for returned products. With increasing concerns over environmental degradation and increased opportunities for cost savings or revenues from returned products prompted some researchers to formulate more effective reverse logistics strategies. Using IT in the reverse supply can help in achieving more efficient network of reverse supply chain. Vaidhyanathan Jayaraman et al [9] collaborate IT
with reverse logistics supply to mitigate many problems and deficiency. They use RIFD to focus on flow of product returns through the warehouse. R. N. Mahapatra et al [16] developed a model which operates both on direct manufacturing as well as remanufacturing. A methodology is used for the calculation of optimum level for the newly manufactured items and the optimum level of the remanufactured products simultaneously. The model is formulated depending on the relationship between different parameters. In the mathematical model care has been taken to optimize the inventory level of direct manufacturing as well as that of the remanufacturing.

Table 1. Literature Based on Various Issues

<table>
<thead>
<tr>
<th>Content</th>
<th>Literature</th>
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<tbody>
<tr>
<td>Introduction</td>
<td>Lak N. Van Wassenhove (2008/07)</td>
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<td></td>
<td>Fleischmann M(2000), Fleischmann M(2003),</td>
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<td>Review methodology</td>
<td>Lal Das (2008)</td>
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<td>Research on reverse supply chain</td>
<td>Joseph D. Blackburn et al</td>
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<td>Selling of product</td>
<td>Shaligram Pokharel (2009)</td>
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Table 2. Abbreviation used

<table>
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<tr>
<th>SR NO.</th>
<th>Parameter</th>
<th>Abbreviation</th>
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<tr>
<td>1</td>
<td>Model</td>
<td>SIM=Simulation , LP = linear programming model, MILP = mixed integer linear programming model, MINLP = mixed integer non-linear programming model, NE = network equilibrium model, ST = stochastic model, SM = simulation model, OT = other models)</td>
</tr>
<tr>
<td>2</td>
<td>Solution method</td>
<td>GA=Genetic Algorithm , EX = exact solution method, HE = heuristics method, MHE=Multi-heuristics method</td>
</tr>
<tr>
<td>3</td>
<td>Period</td>
<td>S = single-period, M = multi-period</td>
</tr>
<tr>
<td>4</td>
<td>Commodity</td>
<td>S = single, M = multiple</td>
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4. Conclusion and future research direction

This paper presents a comprehensive literature review of the journal papers on reverse/closed loop supply chain. By going through several research papers it is clearly seems that reverse supply chain is going to have more importance in future as it is directly related to green supply chain and sustainable supply chain. There is a lot of work is done in this topic but there are many points and aspects which are untouched.

Starting from the beginning, the uncertainty in acquisition is a challenge. If this could be minimized by any means then the performance of reverse supply chain can be increased. Research in this field can be strengthened if we made some robust and more generic models for product acquisition although there are many stochastic model but they lags behind in many areas.

The second area of research is making the reverse supply chain efficient and effective. In some cases the firm is in dilemma that what type chain it should opt. Basically these two type of supply chain manly depends on product a firm dealing with but we do not have any mathematical approach which could optimize between these two type of reverse supply chain.

Third area for research is pricing for acquiring and remanufactured product. As these prices direct influences the revenue of firm. The acquiring product price should be depends on many factors like quality, life of product, its technology, demand. So there should be a proper approach to regulate or monitor the price of acquisition used product. The price of remanufactured product is of main concerned. There should be proper approach for fixing the price of remanufactured product so that it could compete with the original product, which already available in market.

Fourth area for research is selection of return facility like centralized return or decentralized return centers, location of warehouses and management of return centers. The total cost spent in reverse logistics is huge. In order to minimize the total reverse logistics cost and high utilization rate of collection points, selecting appropriate locations for collection points is critical issues in RSC/reverse logistics. There are many researchers which works on it but all of the proposed papers have not included more realistic assumptions, i.e., multi-objective, multi-period, multi-commodity flow, capacitated, closed-loop network structure into a single model.

There is very low research on the time value of the product. We should have evolve such tools which
can contribute to this field. Recognizing the significant value remaining in product returns and their time sensitivity should be the keys to designing reverse supply chains.

Another direction of research should be development of performance measurement mechanism to investigate remanufacturing influences on production, planning & control in the RSC. We are only beginning to develop an understanding of the constraints in remanufacturing that challenge our traditional PP&C systems. Previous work on traditional PP&C systems, recent PP&C case studies in RSCs and normative research on remanufacturing systems provide a good foundation for future work. To extend our current understanding of the difficulties of using PP&C systems with both remanufacturing and new products, empirical research can be used to audit the applicability of PP&C systems in different remanufacturing environments.

5. Acknowledgement
I would like to thanks all the people who directly and indirectly help me to write this review paper

6. References


16. R. N. Mahapatra, B. B. Biswal, and P. K. Parida, A Modified deterministic Model for Reverse supply Chain in Manufacturing,


APPENDIX 1

<table>
<thead>
<tr>
<th>References</th>
<th>Model</th>
<th>Solution Methodology</th>
<th>period</th>
<th>Commodity flow</th>
<th>RL structure</th>
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