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A Comprehensive Review of Closed Loop Supply Chain

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Abstract

In recent years, closed loop supply chain have gained considerable attention in industry and in academia based on environmental and socio economic factors. The Closed loop supply chain management is defined as the design, control and operation of a system to maximize value creation over the entire life-cycle of a product with dynamic recovery of value from different types and volumes of returns over time. The product recovery and reuse do serve as the foundation for the development of industrial system that is both economically and environmentally sustainable. The aim of this paper is to review recently published papers in reverse logistic and closed-loop supply chain.

AMS subject classification:
Keywords: Reverse Logistics, Closed Loop Supply Chain Management, Sustainable Supply Chain Management.

1. Introduction

Closed loop supply chains couple the forward and reverse operations in supply chain in order to maximize economic and/or ecological value. According to Guide and Van Wassenhove (2003), the process of materials flowing from suppliers for manufacture and then to retailers for sale and finally purchased by customers is referred to as a forward supply chain. Then, in case of returns, the process of retailers accepting the returned products from customers and then transferring them back to suppliers for possible remanufacturing is referred to as a reverse supply chain. The forward supply chain essentially involves the movement of goods/products from the upstream suppliers to the downstream customers. The reverse supply chain involves the movement of used/unsold products from the customer to the upstream supply chain, for possible recycling and reuses. Most of the supply chain research concentrates on the forward movement and transformation of the materials from the suppliers to the end customer. Only for the past decade, reverse logistics has grown to a significant business sector. Most logistics service providers offer reverse logistics as one of their core competences. Reverse logistics is a set of activities that includes collection, inspection, sorting, disassembly, reworking/recycling, and disposal of used products/product returns. The Closed loop Supply Chain Model is given below:

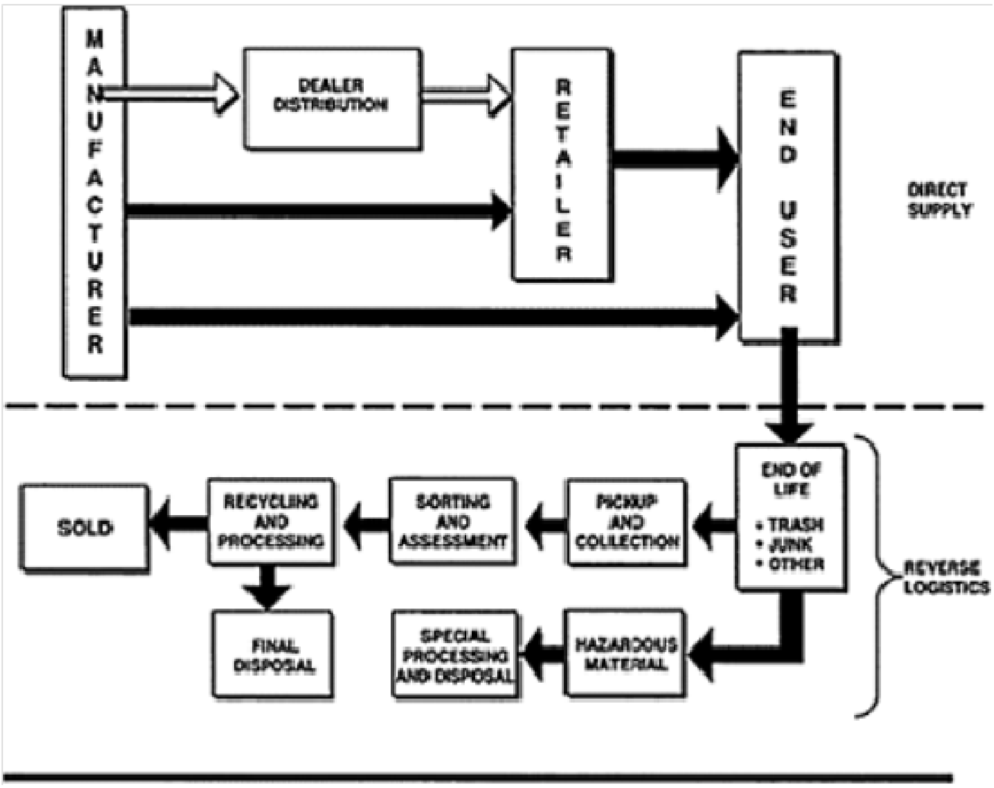

Figure 1: Closed Loop Supply Chain Model

2. Literature Review

The authors [1] analyze the closed loop supply chain management problem by formulating the problem as a mixed integer nonlinear mathematical model, focusing on the facility location, inventory and pricing issues. Three different meta heuristics: Simulated Annealing, Genetic Algorithm and Tabu Search with variable neighborhood search was proposed for the solution of this model. An upper bound for the objective function is found and the effectiveness of these heuristics was analyzed through an extensive numerical study. The optimal solution is obtained through all three meta heuristics method when there are $N = 10$ customer locations and the percentage deviation of the profits obtained by the heuristics from the upper bound are less than 5% for $N = 200$ customer zones. The effects of the parameters are also analyzed. The computational study shows that TSVNS gives better results than SAVNS and GAVNS in terms of the profits obtained. Their future work is to propose an exact algorithm to this problem, to find the optimal solution or more effective heuristics to be developed. As an extension of the above work, capacity limits, multi product systems, quality differentiation for returns and uncertainty in demand and return rate can be considered.

XIA Wen-hui, et al. extensively defines closed-loop supply chain and remanufacturing supply chain through a closed loop supply chain network.. This thesis describes the remanufacturing logistics process which based on closed-loop supply chain management. Through analysis of the current remanufacturing supply chain management problem, the authors propose some measures of the implementation of remanufacturing supply chain management. It has an important significance on remanufacturing reverse logistics management based on closed-loop supply chain management processes. With the limited resources and waste treatment capacity, remanufacturing, as an advanced form of recycling has become the focus of attention. The effective and rational management of remanufacturing reverse logistics give enterprises the potential gains that can enable enterprises to establish a good image in the community. The article analyzed the current remanufacturing reverse logistics and made some recommendations for their development, but not enough, then the reverse logistics of remanufacturing remains to be further study.

According to the authors [3] uncertainty of recovery reverse logistics is reduced by giving the collection of returns to third party contractors to manage outbound logistics. Outsourcing helps the organization to concentrate on their core business. The paper presents a case study of a plastic industry to choose the most efficient reverse logistics contractors from n number of contractors. A hybrid methodology based on Analytical Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) under fuzzy environment is presented. The methodology is used to select the best logistics contractor and the reverse logistics contractor can use the outcomes for service promotion.

A detailed model [4] is developed to optimize the cost of RTIs management in a real CLSC, which consists of a pallet provider, a manufacturer and 7 retailers, and to evaluate the flows of RTIs in the system study to investigate the issue of optimizing the asset management process. The model is then reproduced on a Microsoft Excel simulator and exploited for multi-objective optimization purpose, supported by the commercial software ModeFRONTIER, to identify the optimal setting of the system under different operating conditions of the manufacturer. The optimization investigates three scenarios, which refer to as many operating conditions of the manufacturer. Scenario 1 basically reproduces the current operating conditions of the manufacturer, while scenarios 2 and 3 are both hypothetical, and describe situations where the manufacturer would like to minimize the purchase of new assets and the pick-up of assets from its customers, respectively. According to the authors the model developed could be applied for the analysis of a different CLSC, in terms of input data or supply chain structure, with the purpose of analyzing the performance of systems different to that investigated.

The authors [5] introduce a general mathematical programming framework that employs an innovative composition coupled with forward and reverse logistics. The work addresses a multi-product, multi-echelon and multi-period Mixed-Integer Linear Programming (MILP) problem in a closed-loop supply chain network design, solved to obtain global optimality using standard branch-and-bound techniques. The main feature of this paper is the innovative generalized node with fourfold role in place of a hybrid facility. The model will manage different types of products such as, products unwanted, damaged, or defective; but can be repaired or remanufactured and resold; products unsold from retailers, or products that can be recycled such as pallets, containers. The model aims to find the optimal structure of the network in order to satisfy market demand with the minimum overall capital and operational cost. The proposed MILP CLSCND model was evaluated in a real case study from a Europe based consumer goods company in order to illustrate its applicability while two comparisons with a FSCN main-stream design model revealed its superiority.

The paper [6] considers a two-echelon closed-loop supply chain with set-up and inventory holding costs at all the stages and shortage costs at the stages stocking serviceable inventory. Deterministic and Stochastic model is developed with correlated demands and returns. The demands and returns in different periods are independent and in same period may be correlated, assuming normal distribution for both demand and returns which assumes the system under periodic review for stochastic model. The paper addresses the following: Do closed-loop supply chains cost more than traditional forward supply chains? 2. Does a higher rate of return translate into lower demand variability? 3. What is the relationship between the expected costs of the system and correlations between demands and returns? 4. Given that the availability of information reduces expected costs and correlations between demands and returns? in this paper, holding costs are assessed based on the time-average inventory levels and shortages are allowed for the stochastic version of the problem. The results of the deterministic model are used to derive the policy parameters for the stochastic models. Numerical examples are considered to estimate the extent of errors and sensitivity analysis is done.

The CLSC network proposed in the paper [7] consists of four echelons in the forward chain and five echelons in the backward chain. It integrates decisions made at the strategic level (such as designing the CLSC network) with decisions made at the tactical level (related to transportation activities). A mathematical modelling approach is used to represents the problem of optimizing revenue while simultaneously decreasing transportation related costs. The validate of the applicability of the model is done with the help of data from a real life case study, based on a geyser manufacturer. The model also results in a fact that with the implication of the extended supply chain, a firm can create a green image of their product which eventually results in an increase in their demand while significantly reducing their usage of transportation in both directions.

The aim of this paper [8] is to cope with a large and complex CLSC design and planning problem through a deterministic approach using meta-heuristic algorithms is an appropriate approach. The term complex for this problem refers to its Non-deterministic Polynomial (NP-hard) characteristics deals with a deterministic, large scale CLSC design and planning problem, and the aim is to provide successful tools for solving large-scale problems. This paper considers improving closed-loop supply chain network optimization processes through dealing with mathematical programming tools by developing a deterministic multi-product, multi-echelon, multi-period model. A new hybrid algorithm is proposed and a complete validation process is undertaken using CPLEX and MATLAB software. The global optimum points of CPLEX for the proposed hybrid algorithm are compared to genetic algorithm, and particle swarm optimization, the result reveals the superiority of the hybrid algorithm than GA and PSO.

The most important novel characteristic of the problem is considered by the authors [9], in comparison with existing contributions, is the origin of the uncertainty in the procurement/manufacturing lead-time. Specifically, variable lead-time is attributed to the different quality states of the returned units that compose the remanufacturing lot. The analysis evaluates the impact of different types of available quality information on system's economic outcome taking into account certain simplified process planning and inventory management approaches, which are commonly adopted in industrial applications. A remanufacturing facility is considered which recovers subassemblies (cores) from used products, and consequently remanufactures and assembles them into new products in order to satisfy demand in a multi-period setting. The numerical study indicates that the information on the distribution of the proportion of each quality class in returned quantity is more useful when quality variability is small.

A stochastic optimization model [10] based on chance-constrained programming is developed to deal with these sources of uncertainties in take-back and inventory planning systems. Here the authors assume that the initial inventory is zero and that the model is formulated for one cycle. The first major source of uncertainty considered here is the amount of returned products the manufacturer receives for each quality grade. Moreover, the quality grades of incoming products are variable. The other major uncertainty is the market demand for each quality grade. Once the process of remanufacturing is formulated, maximizing the profit is generated from it. Variations in the quantity and market demand of received products as well as varying levels of quality are the factors that influence the cost-effectiveness of remanufacturing operations. The current paper address this problem and introduce a stochastic optimization model to help remanufacturing companies to decide about the most profitable upgrade level for incoming used products. An example of a personal computer with five different quality grades has been provided to show the application of the model. The model has been solved by using chance-constrained programming technique, and the optimized upgrade strategy has been suggested. The results of the model were further investigated through some sensitivity analyses.

According to the authors [11] only few studies have addressed the reverse logistics network for office supplies. In the paper industry, existing research has focused on total pulp and paper production, facility location and the environmental impact of producing paper. Although the reverse logistics of office supplies have their own features, the knowledge drawn from reverse logistics in one sector/industry can be applied to the similar product type in another sector/industry. To address this gap in the literature, and to build upon existing research into office supplies reverse logistics, the authors present an operation based on the characteristics of office paper reverse logistics. A nonlinear mixed integer programming model is proposed that determines the number and location of recycling stations and plants, and the allocation of waste office paper to recycling stations by assuming the transportation cost is in direct proportion to the quantity of waste office paper and the distance between two points. The aim is to reduce the construction and transportation costs, and improve the way to use waste office paper. To discuss the reverse logistics operation mode for office paper the features of office paper reverse logistics and the Generic operation mode for reverse logistics are discussed. Sensitivity analysis is done to investigate how the number and locations of recycling stations and plants were influenced by changes in the amount of waste office paper, the maximum throughput capacity of recycling stations, the proportion of renewable raw materials transported from recycling plants to paper manufacturers, and the unit transportation cost.

The authors [14] insist that CLSCM gives competitive edge and improves the economic status of an organization. Effective implementation of CLSCM leads to reduction in waste, reduction in environmental pollution, optimization of resource utilization and reduction in costs by discussing the issues like Green Operations, Green Design, Green Management, Waste Management and Product life cycle assessment.

Devika et al. [15] presented a sustainable closed loop supply chain network design to cover the gap in the quantitative modelling by considering the social impacts, environmental impacts and economic impacts in the network design problem. They developed three new hybrid metaheuristic methods based on adapted imperialist competitive algorithms and variable neighbourhood research, to solve this NP hard problem.

Paneerselvam et al. [16], also reviewed and classified the research work by the researchers on reverse logistics into nine categories based on the methods used to design the logistics network. Tagaras G., et al., [17] derived conditions for the determination of the optimal acquisition and remanufacturing lot-sizing decisions under alternative locations of the unreliable classification/sorting operation by formulating an objective function for a reverse supply chain with multiple collection sites and the possibility of returns sorting.

3. Conclusion

This paper tries to present a literature review of recent published papers in RL/CLSC. The papers are selected and reviewed to find the future directions and opportunities of research in RL/CLSC. The product life cycle has been studied in great depth. However, more research is needed in understanding RL and its connection to the product life cycle. More study of the impact of marketing on returns is needed. In general, theory and models need to be developed and consolidated to establish the relationship between new product sales and returns rates. More Research is needed in understanding the secondary markets and also how companies should process, store and dispose of returned goods.

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