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Forward and Reverse Closed-Loop Supply Chain with Remanufacturing Approach

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Abstract
A closed-loop supply chain is referred as the return processes of a product for remanufacturing where the manufacturer added some additional value of the product. It consists of both the forward and the reverse supply chain. The forward supply chain includes the production and the distribution of the product where the reverse supply chain includes the return processes of the used and unused product collected from the regional collection centers. The remanufacturing logistics supply chain describe in a supply chain management system which is based on the closed-loop supply chain management system. We observe the implication of the remanufacturing waste materials to be reused or to be resale in an open market. In this paper, shortages are not considered. Finally, we discuss how environmental factors are applicable to the entire chain of the supply chain management system.

Keywords: Forward supply chain, Reverse supply chain, Remanufacturing waste materials, Closed-loop supply chain.

1. INTRODUCTION

It is necessary to measure the performance of the entire supply chain management to deliver the sufficient amount of goods from the production house to the supplier then to the customer according to the customer demands. Every business organization should be measured their performance continuously for the improvement of their business in the entire world. The feedback of the customer plays an important role to improve the quality of the product in the entire supply chain management.

When there is no longer use of the distributed product then it should be returned back to their source for either be repaired or be reused in the future purposes. Closed-loop supply chain follows the forward and the reverse flow to recover the value from the waste products to be used. There is a basic difference between the forward and the reverse supply chain activities. In forward supply chain the product is required to move from the raw materials to the customer in the forward direction whereas in reverse supply chain the used products are returned back from the customer to the manufacturer due to some manufacturing defect. However, reverse supply chain improves the customer satisfaction by increasing the product lifecycles than the forward supply chain.

The traditional supply chain begins with suppliers and ends with the customers, so the product flows in one way there is no need to remanufacture whereas in closed supply chain the product flows in circular way and there is a need to remanufacture the returned product according to meet the customer satisfaction. For the better improvement of our knowledge in closed-loop supply chain we have been studied several literatures which are discussed below:
A non-linear model of the reverse supply chain is developed in Louwers et al. (1999). In this paper, they focused on the appropriate capacity location for the regional area.

A multi-period closed-loop supply chain model developed in Beamon and Fernandes (2004) where the model is solved using a linear integer programming technique. Here, a new product is produced according to the demand of the customer and the used product is remanufactured due to the improvement of the customer satisfaction.

A reverse structure of the supply chain management is described in Savaskan et al. (2004). In this paper, the used product is collected from the collection centers. The objective of this model is to maximize the overall profit of the supply chain management.

Reusing a product as a whole in a closed-loop supply chain management is described in Krikke et al. (2004). They focused the model on a commercial return that increased the trends of a commercial market.

A link is made for the reverse logistic supply chain model in Ravi et al. (2005). It consists with different types of factors like internal, external, tangible, intangible, financial and non-financial for the various goals of the business. In this paper, an analytic network process is applied for the evaluation of supply chain management.

A reverse logistics waste management problem is designed in Bautista and Pereira (2006). Here, the citizens throw their different types of waste material in a special collection area before they are stored in a special refusal bin. The waste is collected separately from it and then they are moved to its final destination either there is a need for remanufacture or they are fully dumped in the disposal centers. Finally, a heuristic approach is applied for the method of solution of this model.

The reverse logistics network is used to manage highly variable return flows in Biehl et al. (2007). Here, it is compared to the effect of system design factors with the environmental factors using and experimental design technique.

A closed-loop supply chain model with multiple products is developed in Kannan et al. (2010). In this paper, they discussed on the returned product for being recycled in the production house. A heuristic-based genetic algorithm is applied for a method of solution of this model.

A supply chain model is developed in a closed-loop supply chainenvironment in Pishvaee et al. (2011). The model is solved using a mixed integer programming and a robust optimization technique.
Stochastic programming is applied in a closed-loop supply chain network in Amin and Zhang (2013) where the objective of this model is to minimize the total cost using mixed integer linear programming method. The model is considered with multiple plants, collection centers, demand markets and the products. Here the demand and the return product are taken in an uncertain environment.

A closed-loop supply chain model is developed in Garg et al. (2015) where an interactive non-linear multi-objective programming algorithm is applied in forward and reverse supply chain model. There are different types of echelons are considered to determine the optimal flow of the products.

A tire manufacturing multi-products closed loop supply chain network is formulated to optimize the overall profit in Amin et al. (2017). In this paper, a new decision methodology is applied to calculate the net present value of the problem and it is used to compare with the several design options of the closed supply chain management.

An integrated optimization model on a car battery firm in a supply chain management is developed in Gaur et al. (2017). In this paper, the profitability of the supply chain configuration is discussed for not only for the forward supply chain system but also for the closed-loop supply chain system.

A circular economic policy within a supply chain management is formulated in Angelis et al. (2018). Here, policies are made on several types of supply chain relationship under some certain limitations.

A two-echelon closed-loop supply chain model is developed in Modak et al. (2018) where customer demand and quality of the product are considered in an uncertain environment. The effects of recycling in the closed-loop supply chain network are analyzed with several approaches and it is observed that the product recycling is varied over the level of quality and the price of the product directly.

A four level closed-loop supply chain model with remanufacturing of the used products which are collected either from the customers or from the recovery center is developed in Hasanov et al. (2019). In this paper, the several inventory policies have applied to minimize the total cost of the entire supply chain network with an improvement of the environmental effects.

Effects of product return in a green closed-loop supply chain management has formulated in Shaharudin et al. (2019). In this paper, the green supply chain management is discussed in terms of an eco-friendly manufacturing procedure of a product. The model has highlighted on the relationship between product recovery and integration capabilities for the entire supply chain management.

Multi-objective mixed integer linear programming problem for circular supplier selection and order allocation problem is developed in a closed-loop supply chain model in Govindan et al. (2020). The objective of this model is to minimize the overall cost. Here, shortages has considered in an uncertain environment.

In our paper, we discuss the advantages of using a closed-loop supply chain network with the impact of the forward and the reverse problem for the waste products along with the remanufacturing procedure. The refuse product from the customer end is moved to the regional collection centers. Then the products which can able to be manufactured go to the production house for remanufacturing and those which will never be reused will move to the disposal centers. The decision maker of a supply chain network has the power to take the right decision of their products. The products which are to be remanufactured and the products which are to be totally disposed are totally depends on the decision maker.

2. PROCEDURE OF REMANUFACTURING SUPPLY CHAIN MANAGEMENT

The concept of remanufacturing in closed-loop supply chain is the recycling process that may reuse or resale in the marketing aspects. In this process,the whole product or some of the parts of the productare recycled to make it reusable.The performance of the remanufactured products is actually different from the original products. Remanufacturing is currently being used in electronics and engineering equipment in the entire world as a major purpose.

Remanufacturing is fully coordinated with the parts of two types supply system- new parts supply system and the re-parts supply system. The new parts supply system means the products is fully remanufactured for the external purposes whereas the re-parts supply system refers the recovery of the products using some replacement of the parts of the products. However, remanufactured products have some significant advantages in the market compared with the new product.

3. STRATEGY OF REMANUFACTURING SUPPLY CHAIN MANAGEMENT

The important part of the reverse logistics is to make the waste product to be a new one. It follows the chain of the reduction, reuse and recycle of the waste products. The main activities of this process are to be collected the waste or rejected products from the collection center.An appropriate detection and segregation is made according to their percentage ratio of the acceptance for reuse the products.Finally,the product is redistributed either to the manufacturing house for remanufacturing or to the disposal center depending on the acceptance ratio.

It is difficult for the manager to control the reverse logistics over the forward logistics supply chain. Analysis of the remanufacturing is fully dependent on an uncertain environment and the uncertainty of the remanufacturing process is the sum of the uncertain amount of waste materials are to be recycled, the uncertainty of product recovery and recycled, the uncertainty of the demand and the remanufacturing cost. Uncertainty changes the design and planning of the supply chain management for the remanufacturing products accordingly.

Most of the recycling centers do not have the professional attitude of the waste products. The non professional recycling centers treated the waste materials for resale to the manufacturer directly whereas the professional recycling centers have the professional attitude to manufacture the product. They focus on the maximum number of items is recovered and to make a balance between the quantity and quality of the products. The co-operative relationship between the recycling centers is used to improve the reverse supply chain management to compete in the market. However, there is a significant advantage in a remanufacturing of waste products in a supply chain management system.

4. CONCLUSION

Waste treatment for the remanufacturing procedure is an advanced form of the recycling procedure which becomes effective in an uncertain environment. There are many qualitative factors in our environment. We can utilize such factors in the closed-loop supply chain model for our future aspects. Also we can make a balance of the closed-loop supply chain between the economic and environmental aspects. The environmental factors may be used in forward logistics as well as in the reverse logistics supply chain management system. We may apply a real-life example in a closed-loop supply chain management system where the model may be compared with an environmental effect.

REFERENCES

[1] Amin S.H. and Zhang G., "A Multi-Objective Facility Location Model for Closed-Loop Supply Chain Network under Uncertain Demand and Return", Applied Mathematical Modelling, Vol. 37, Issue 6, pp. 4165-4176,2013.
[2] Amin S. H., Zhang G. and Akhtar P., "Effects of Uncertainty on a Tire Closed Loop Supply Chain Network", Expert Systems with Applications, Vol. 73, Issue 1, pp. 82-91, 2017.
[3] Angelis R.D., Howard M. and Miemczyk J., "Supply Chain Management and the Circular Economy: Towards the Circular Supply Chain", Production Planning and Control, Vol. 29, Issue 6, pp. 425-437, 2018.
[4] Bautista J. and Pereira J., "Modeling the Problem of Locating Collection Areas for Urban Waste Management: An Application to the Metropolitan Area of Barcelona", Omega, Vol. 34, Issue 6, pp.617-629, 2006.
[5] Beamon M.B. and Fernandes C., "Supply-Chain Network Configuration for Product Recovery", Production Planning and Control, Vol. 15, Issue 3, pp.270-281, 2004.
[6] Biehl M., Prater E. and Realff M.J., "Assessing Performance and Uncertainty in Developing Carpet Reverse Logistics Systems", Computers and Industrial Engineering, Vol. 34, pp.443-463, 2007.
[7] Garg K., Kannan D., Diabat A. and Jha P.C., "A Multi-Criteria Optimization Approach to Manage Environmental Issues in Closed Loop Supply Chain Network Design", Journal of Cleaner Production, Vol. 100, Issue 1, pp.297- 314, 2015.
[8] Gaur J., Amini M. and Rao A.K., "Closed-Loop Supply Chain Configuration for New and Reconditioned Products: An Integrated Optimization Model", Omega, Vol. 66, Part B, pp. 212-223, 2017.
[9] Govindan K., Mina H., Esmaeili A., Mohammad S. and Zanjani G., "An Integrated HybridApproach for Circular Supplier Selection and Closed Loop Supply Chain Network Design under Uncertainty", Applied Mathematical Modelling, Vol. 242, Issue 1, pp. 118-317, 2020.
[10] Hasanov P., Jaber M.Y. and Tahirov N., "Four-Level Closed Loop Supply Chain with Remanufacturing", Applied Mathematical Modelling, Vol. 6, pp. 141-155, 2019.
[11] Kannan G., Sasikumar P. and Devika, "A Genetic Algorithm Approach for Solving a Closed Loop Supply Chain Model: A Case of Battery Recycling", Applied Mathematical Modelling, Vol. 34, Issue 3, pp. 655-670, 2010.
[12] Krikke H., BlancL. L. and Velde S. V.D., "Product Modularity and the Design of Closed Loop Supply Chains", California Management Review, Vol. 46, Issue 2, pp.23-39, 2004.
[13] Louwers D., Kip B.J., Peters E., Souren F. and Flapper S.D.P., "A Facility Location Allocation Model for Reusing Carpet Materials", Computers and Industrial Engineering, Vol. 36, Issue 4, pp.855-869, 1999.
[14] Modak N.M., Modak N., Panda S. and Sana S.S., "Analyzing Structure of Two-Echelon Closed-Loop Supply Chain for Pricing, Quality and Recycling Management", Journal of Cleaner Production, Vol. 171, Issue 10, pp. 512-528, 2018.
[15] Pishvaee M.S., Rabbani M. and Torabi S.A., "A Robust Optimization Approach to Closed-Loop Supply Chain Network Design under Uncertainty", Applied Mathematical Modelling, Vol. 35, Issue 2, pp. 637-649, 2011.
[16] Ravi V., Ravi S. and Tiwari M.K., "Analyzing Alternatives in Reverse Logistics for End-Of-Life Computers:ANP and Balanced Scorecard Approach", Computers and Industrial Engineering, Vol. 48, Issue 2, pp.327-356, 2005.
[17] Savaskan R.C., Bhattacharya S. and Van Wassenhove L. N., "Closed-Loop Supply Chain Models with Product Remanufacturing", Management Science, Vol. 50, Issue 2, pp.239-252, 2004.
[18] Shaharudin M. R., Tan K. C., Kannan V. and Zailani S., "The Mediating Effects of Product Returns on the Relationship between Green Capabilities and Closed-Loop Supply Chain Adoption", Journal of Cleaner Production, Vol. 211, Issue 20, pp. 233-246, 2019.

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