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A Planning of Forward and Reverse Logistics for a Closed-Loop Supply Chain Model

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Abstract

In this paper, we develop a supply chain model in a closed-loop supply chain environment with the manufacturing of new product and remanufacturing of returned product. We consider our model for a single item and it consists of a single plant, single demand market, single collection center and single disposal center. The item manufactures in a plant then it distributes to the demand market. The product which is rejected by the customers is moved to the collection center. The product which is recoverable is distributed to the plant for remanufacturing and the remaining will distribute to the disposal center. The objective of his model is to minimize the total cost in the entire supply chain environment. Finally, the model is illustrated with a numerical example.

Keywords: Closed-loop supply chain, Product manufacturing, Product remanufacturing, Product recovery.

I. Introduction

The integration of the forward and the reverse flow of the product in the entire supply chain model are referred to as the closed-loop supply chain. In forwarding flow in the closed-loop supply chain consists of the facilities of the manufacturing product whereas the reverse flow in the closed-loop supply chain consists of the facilities of the remanufacturing of the valuable reused product. Product remanufacturing consists of the transformation of the used products into the marketable demand by following repairing or up-gradation according to their cost benefits. It is important in the method of remanufacturing to reuse and recycle the waste materials in the logistics supply chain network.

A generic model of product manufacturing and remanufacturing in the inventory management system is developed in Van Der Laan and Salomon (1997). In this paper, they proved that there is no difference between the manufacturing new product and the remanufacturing of the returned product.

Manufacturing and recovering of the product has become an obligation to the environment which is discussed in Gungor and Gupta (1999). In this paper, they developed a recycling model to extend the life cycle of the product.

Savaskan et al. (2004) developed three reverse logistics models for closed-loop supply chain management system. They designed their model with the collection channel of manufacturer, retailer and a third party. They observed that the retailer’s collection channel obtained far better results than the other two.

Different design option for a closed-loop supply chain network is developed in Schultmann et al. (2006). The model is designed on the planning of vehicle routing. Finally, the model is verified using a real-life example.

Francas and Minner (2009) developed a two-stage stochastic model in the supply chain environment. The model is designed in an uncertain environment.

A closed-loop supply chain model with a dynamical approach is simulated in Miao et al. (2017). In this paper, the recycling approach is dominated by a third party. They proved that the simulation method is more effective than the traditional recycling model.

A closed-loop supply chain with the manufacturer as a Stackelberg leader is developed in Xu and Liu (2017). In this paper, the manufacturer faces three different reverse channels managed by manger, retailer and a third party. They discussed the reference price effect on the performance of the decentralized reverse channel using optimal strategies. Here, the reference price effect is compared with the non-reference price effect.

Information sharing on increasing resilience of closed-loop supply chain is developed in Dominguez et al. (2019).

In this paper, we develop a model in a closed-loop supply chain environment to reduce the total cost in the entire environment. The model consists of a single plant, single demand market, single collection center and single disposal center. In a plant the new product is manufactured then the finished product is distributed to the demand market. In the demand market if any shortcoming is found in the product or it is not fulfilled to the customer needs then it moves to the collection center. The collection center has the full authority to decide the product to be remanufactured or to be disposed off. The product which is recoverable will move to the plant for remanufacturing and the remaining product will move to the disposal center. Finally, the model is verified with a numerical example.

II. MODEL FORMULATION

In this paper, a closed-loop supply chain inventory model is designed for a single plant and single demand market for a single product with a single collection center and single disposal center. The product is manufactured in a plant after that the finished product is ready to distribute to the demand market according to the customer demand. If the demand is not satisfied according to the customer needs then it distributes to the collection center. In the collection center, the product is segregated for remanufacturing and disposal. The product which has some value is decided for recoveries at the plant through remanufacture procedure and treated as a remanufacturing product and the remaining is moved to the disposal center and they are treated as the dispose product. In this paper, the objective of this model is to minimize the total cost of the entire supply chain management system. Finally, the model is verified with a numerical example.

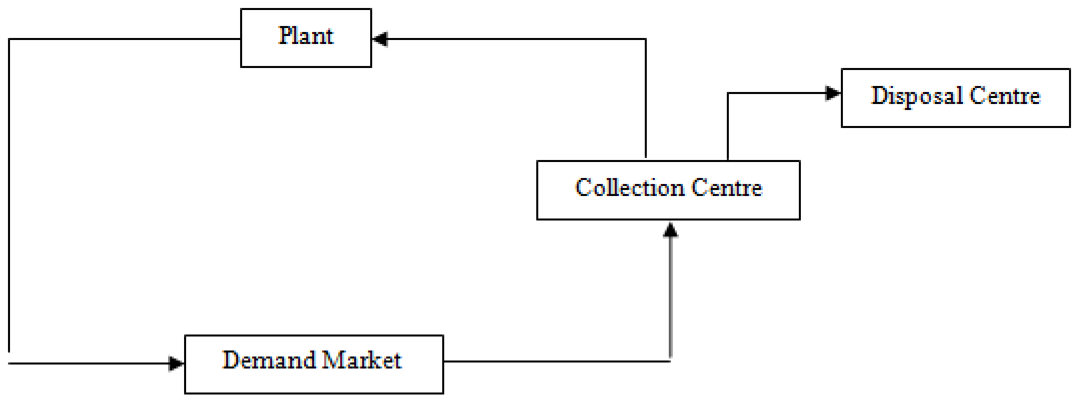

Fig: An Integrated Model of Closed Loop Supply Chain

Notations

A= Transportation Cost per km. distance per unit item between Plant to Demand Market

C= Transportation Cost per km. distance per unit item between Demand Market to Collection Centre

D= Transportation Cost per km. distance per unit item between Collection Centre to Plant

E = Transportation Cost per km. distance per unit item between Collection Centre to Disposal Centre

t= Distance between Plant to Demand Market

t_1 = Distance between Demand Market k to Collection Centre

t_2 = Distance between Collection Centre to Plant

t_3 = Distance between Collection Centre to Disposal Centre

$P =$ Production Cost per unit item

$F =$ Disposal Cost per unit item

$R =$ Product Recovery Cost per unit item or Inspection cost per unit item

$S =$ Product Remanufacturing Cost per unit item

β = Minimum Disposal Fraction of each item

Assumptions

(1) Shortage is not allowed.

(2) An infinite planning horizon.

(3) Quantity discount is not allowed

(4) Deterioration is not allowed.

(5) Remanufacturing product is not compared with the newly manufacturing product.

(6) Lead time is zero.

Decision Variables

X= Quantity of Product Produced by Plant to Demand Market

Z_1 = Quantity of Product Returned from Demand Market to Collection Centre

U = Quantity of Product Returned from Collection Centre to Plant for Remanufacturing

V = Quantity of Product Disposed from Collection Centre to Disposal Centre

$TC =$ Total Cost in Supply Chain Management System

Objective Function

Minimize

$$\mathrm{TC} = \left[(P + A\times t)\times X + (R + C\times t_1)\times Z_1 + (S + D\times t_2)\times U + (F + E\times t_3)\times V\right]$$

Constraints

(1) Non-Shortage Constraint:

i.e., $X \geq (U + V)$

(2) Minimum Disposal Fraction of Each Product in Disposal Centre:

i.e., $\beta \times Z_1 \leq V$

III. COMPUTATIONAL RESULTS

Input Parameters:

P=200; A=50; t=14;
R=100; C=50; t_1=10;

S=75; D=35; t_2=12;
F=35; E=25; t_3=8;
β=0.11;

Result 1: (Using LINGO)

X	Z_1	U	V	TC
192	**27**	**21**	**6**	**20165**

IV. CONCLUSION

The objective of this closed-loop supply chain model in supply chain management system is to minimize the total cost in the entire supply chain environment. We obtain a total cost of Rs. 20,165 using an optimization technique. We observed that the number of products produced in the plant is 192 and the number of products returned from the demand market to the collection center is 27. Therefore, the number of products sold in the demand market is 165 or near about 86%. After inspection at the collection center, it is found that the number of the product is required to be manufactured is 21 and the remaining will move for disposal center. We have applied LINGO software as a method of solution. But, we may use some other optimization technique as a method of solution. We develop our model in a deterministic nature but in a real-life example, it may not possible. We can extend our model in an uncertain environment. In our model, we consider a single objective function but we can extend our model with a multi-objective function in the future.

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