Environmental Sustainability with eco-friendly green inventory model under Fuzzy logics considering carbon emission

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Abstract

Environmental consistency is the study of environmental interactions to prevent environmental degradation. To allow and preserve natural resources and long-term environmental quality. The key to being environmentally friendly is environmental sustainability. Global warming is one of the biggest threats to our planet. The cause of global warming emission of greenhouse gases (GHG). This article describes the green patterns of different social costs. Reduce carbon emissions strategies to achieve environmental sustainability with carbon sensitive products. Finally, determination of the favorable order amount and the total cost of the system in both the scenarios. The document ends with a numerical example validating the study.

Keywords: Fuzzy, Heptagonal Fuzzy number, green, Inventory

1 INTRODUCTION

In the present scenario of competitiveness prevailing in the market, the manufacturers and the units are not close to the retailer or selling outlets. The products, when received at the vendee end, is bound to have certain percentage of defective goods. These imperfect goods are to an extent realized as low-cost products in the system or are treated as waste products. If these goods go waste they are thrown in the surroundings and pollute the environment in many ways. To have sustainability in preserving the environment, it is important to treat these goods in a prominent manner. Also these goods, add to the cost of the inventory system in the form of deterioration, shortages and sometimes lost sales, and if unintentionally sold to a consumer can lead to the loss of goodwill of the product and the organization. Thus to ensure effective inventory management, quality of the items and the reputation of the brand/organization, the goods can be repaired, remanufactured or even recycled for their absorption in the system. Green inventory system not only is the way to protect the environment against the hazards of these waste/imperfect goods but also adds in the revenue generation of the inventory system. Adequate work including several facets and aspects of the green system is available.

Detailed reviews on the green system design is done in the world by [1]. A detailed and comprehensive review of the green supply chain management is done by [2]. He incorporated various facets of green system as the importance of green inventory, design of green system, and the operations done for green inventory system. [3] investigated a detailed state of the art review of the green supply management and discussed the usage of green inventory like the eco-friendly raw materials, recycled papers used in packaging, reducing dependency on the petroleum and its products and many others. [4] modeled a three level supply chain from the supplier to manufacturer/retailer to the customers. They also involved the influence of the emission of the carbon on the production process. The research study derives some significant conclusions regarding a decline in the emission of carbon due to an increase in the order size. A supply chain model for the retailer and the supplier is formulated by [5] where the optimality of the refilling time and cost is determined. In a fuzzy environment an analysis on the flood management is done by [6]. An optimal value of time period with partially back order is determined with a check in the optimal value to the total cost of the system is done by [7]. Furthermore taking deterioration of weibull nature [8] modeled a problem for minimum cost valuation in an inventory problem. Under the impact of inflation [9] presented a study with trade credit in determining the most favorable cost value. An ordering period with the minimum value of cost for the retailer is determined in the research work done by [10]. In addition to, an inventory framework proceeding in the direction of saving the environment is done by [11]. To come to a more accurate solution to an inventory assignment, [12] presented a study by fuzzifying the cost parameters which are subjected to the uncertainty prevailing in the market. [13] worked on the concept...
of reworking on the imperfect goods which are unavoidable to any company. To sustain a profitable situation a proper screening and re-manufacturing process is to be followed so as to provide assistance in green technology. They studied on the reduction of the carbon dioxide gases and sustained the business along with saving the environment in maximizing the profit. [14] modeled an inventory problem to reduce the emission of carbon and attain the sustainability in environment.

2 Presumptions and Symbols

Presumptions
1. Demand is constant in nature.
2. The time lag in placing and receiving an order is zero.
3. The inventory problem without shortages.
4. Green inventory proceeds with the prevention of the waste disposals thus saving the environment from pollution.
5. Fuzzifying the parameters so as to remove the unpredicted behaviour of the values.

Symbols
1. $C_{or}$ = Fixed costs per order
2. $e$ = coefficient of carbon-sensitivity
3. $b$ = emission of carbon per unit from the product
4. $p$ = time of potential demand in a lot
5. $F$ = Fixed Demand
6. $P$ = Production
7. $C_{hl}$ = Holding inventory cost per product
8. $C_{pr}$ = Production Inventory cost
9. $\gamma_o$ = Pollution rate factor
10. $C_{po}$ = Cost incurred in pollution control
11. $z$ = Deterministic cost per transport
12. $d_s$ = travelling distance per trip
13. $\pi$ = fraction of demand defective and returned
14. $v_o$ = Average rate of velocity
15. $C_{fp}$ = Fixed pollution control cost
16. $C_{om}$ = Fixed maintenance and operation cost in controlling pollution
17. $C_{lc}$ = Cost of labour required in packaging
18. $C_p$ = Material cost in packaging
19. $\alpha$ = fraction of waste in a lot received
20. $\beta$ = Disposal of waste cost
21. $\beta_o$ = Fixed cost of disposal
22. $N_o$ = Quantity of parcels produced
23. $C_g$ = Fixed amount of money invested in green inventory system

3 Preliminary

The parameters in the inventory model are fuzzified using heptagonal fuzzy number. Applying the creditability formula for the heptagonal number we have:

$$C_r(A) = \frac{a+2b+2c+2d+2e+2f+g}{6}$$
4 Mathematical Formulation

The total cost for the inventory model is determined by summing the ordering cost, holding cost, production cost, the various pollution control cost and the green packaging cost.

Ordering Cost per cycle: $C_{or} + C_{pr} \frac{P + (P^2)*C_{hl}}{2*F}$

Amount of waste items in the lot received in a cycle = $\beta_o + \beta * P * (a + \pi)$ Cost of controlling pollution = $C_{fp} + C_{om} * \gamma_o * P$

Cost of Green packaging cost = $(C_{lc} + C_p) * N_o$

Cost of trips/logistics = $2z + 2*\delta * d_s v_e$

Case 1: Crisp Inventory Model

The total cost of the system is

$$C_{or} + C_{pr} * P + \frac{P^2 + C_{hl}}{2*F} + 2z + 2 \delta * \frac{d_z}{v_e} + \beta_o + \beta * P * (\alpha + \pi) + C_{fp} + C_{om} * \gamma_o * P + (C_{lc} + C_p) * N_o + C_g$$

Total cost per unit TC is

$$C_{or} * \frac{P}{F} + C_{pr} * \frac{P}{F} + \frac{P^2 + C_{hl}}{2*F} * \frac{P}{F} + 2z * \frac{P}{F} + 2 \delta * \frac{d_z}{v_e} * \frac{P}{F} + \beta_o * \frac{P}{F} + \beta * P * (\alpha + \pi) + C_{fp} * \frac{P}{F} + C_{om} * \gamma_o * P * \frac{P}{F} + (C_{lc} + C_p) * N_o * \frac{P}{F} + C_g * \frac{P}{F}$$

To determine the optimal order quantity differentiating the above equation with respect to P.

We get

$$p^2 = \frac{2z(p-e+b)+(C_{or}+2z+2\delta \frac{d_z}{v_e}+C_{fp}+\beta_o+(C_{lc}+C_p)\gamma_o+C_g)}{C_{hl}}$$

Case 2: Fuzzy Inventory Model

The following cost parameters are fuzzified in order to remove the inexactness in their value and to come up to a more accurate solution to the inventory problem.

$$C_{or}=(4,6,8,10,11,12,13), C_{hl}=(5,6,7,15,18,20,21), C_{pr}=(10,11,12,50,50.5,51,52), \beta=1.2,3,4,5,6,7, C_{fp}=(10,15,18,22,40,42,43), C_{om}=(1,2,3,4,5,6,7), C_{lc}=(1,2,3,4,5,5,6), C_{p}=(0.5,1,1.5,2,2.5,3,3.5), \beta_o=(0.1,0.2,0.3,0.4,0.8,1.1,1.2), \beta_o=(0.2,0.3,0.5,0.6,1,1.1,1.2), C_g=(150,180,190,210,300,305,310)$$

Fuzzified Total cost $\hat{T}C$ is determined by the above mentioned fuzzy parameters from the cost equation.

5 Numerical Example

For the crisp model the values to the parameters are taken as in the research work done by ritha and a comparative study is performed to analyze the change in the cost value.

The values to the parameters are as follows:

$$C_{or} = 10, e = 1, b = 10, p = 100, F = (p-b*e), C_{hl} = 20, C_{pr} = 50, \gamma_o$$
\[ z = 5, d_i = 250, \pi = 0.2, \nu_c = 180, C_{fp} = 40, C_{om} = 4, C_{lc} = 3, C_p = 2, \alpha = 0.5, \beta = 0.8, \beta_o = 1, N_o = 1, C_g = 300. \]

Using these values the optimal order quantity \( Q^* = 57.5 \) and the total cost \( (TC) = \text{Rs.}5520 \)

For the fuzzy model, the values as specified for the fuzzy variables are taken and the optimal order quantity and the total cost is derived.

\[
\begin{align*}
\tilde{C}_{o} &= 18.16, \quad \tilde{C}_{hl} = 25.33, \quad \tilde{C}_{p} = 68.75, \quad \tilde{x} = 7.6, \quad \tilde{C}_{fp} = 54, \quad \tilde{C}_{om} = 7.6, \quad \tilde{C}_{lc} = 7.08, \\
\tilde{C}_{p} &= 2.8, \quad \tilde{\beta} = 1.2, \quad \tilde{\beta}_o = 1.3, \quad \tilde{C}_g = 470
\end{align*}
\]

\( \tilde{Q}^* = 63.6 \) units and the fuzzified cost value is

\[ \tilde{T}^{}C = \text{Rs.}8031.59 \]

6 Comparative study

The cost as compared with the solution provided by [14] has increased. The following graph shows the increase in its valuation.

The cost value as obtained from the set of crisp values to every parameter is not realistic as it does not considers the uncertainty of the market. The values to any parameter can never be fixed and so the solution obtained with these crisp value does not provide a correct model to the inventory problem.

As seen with the fuzzification of the parameters the cost value increases and now incorporates the current market conditions in the fuzzy inventory model. The rise in the cost value is obvious as the valuation in the parameters increases. This will depend upon the market scenarios present in the environment which will lead to the increase or decrease in the valuation of the fuzzy parameters and thereby effecting the total cost values.

Similar trend can be seen for the optimal order quantity as seen in the following graph:

Figure 1: Comparison of crisp and fuzzy cost values

Figure 2: Comparison of EOQ in crisp and fuzzy models
7 Conclusion

The selection of environmentally friendly or ecological products and services minimizes the environmental impact. It needs a business to deal with the environmental consequences of a product at all stages such as raw materials, manufacturing, transport, storage, storage and disposal of the product. The product is based on the principle of pollution prevention which helps to reduce human health and risks. The environment becomes safer with the Green products, that are generally made in a way that uses fewer natural resources, with sustainable forests. They may be less involved in their production and less threatening or Toxic substances. In this model, the cost of the ecological inventory with the pollution control strategy applied to carbon-sensitive products is implemented. Also the fuzzification of the various cost parameters lead to a more realistic solution to the inventory problem.

References