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EOQ and EPQ Inventory Models for Pollution Control with Integration of Environmental Cost

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ABSTRACT
The industrial processes have the potential to discharge the pollution to land, air and water. This pollution can cause a health risk to the public as well as damage the environment. In order to prevent this pollution, industrial process are strictly regulated to minimize the pollution and to manage their environmental impacts. Environmental costs are used to monetary values spent for environment to retain the nature. Many of the researchers have defined different types of environmental costs which are considered by the production sectors for promoting environmental sustainability. Successful production run depends on effective inventory management. In those days, the inventory models support the production system, but in these days the inventory models have to be formulated to initiate environmental friendly production structure to prevent the industrial pollution. This paper aims in formulating a new EOQ and EPQ inventory models which encompassing the costs of production and transportation along with the associated costs of mitigating the environmental effects under permissible delay in payment.

Keywords Inventory · production quantity model · sunk cost · Permissible delay in payment · pollution prevention · environmental remediation.

1 Introduction

Industrial pollution is becoming a major issue in many developing countries. Industrial emissions consist of various environmental unfriendly pollutants released into the atmosphere during primary and secondary production processes. It results in environmental degradation and imposes heavy costs on society as well as on human health and safety. There is no efficient approach used by many industrial sectors for proper waste disposal and drainage of their harmful effluent. The industrial sector should have responsibility to dispose waste in the proper manner. Pollution control has become the primary concerns of the environment today.

A sunk cost refers to fund that has already been spent and which cannot be recovered. A manufacturing firm may have a number of sunk costs such as the cost of machinery, equipment and the lease expense on the factory. Sunk costs are executed from a sell-or-process, which is a concept that applies to products that can be sold as they are or can be processed further. Pollution Prevention cost is cost built for industry to reduce environmental impact, such as equipment or facilities attached to an emissions terminus for the purpose of preventing pollution. Environmental remediation cost is set aside to compensate for environmental damage caused by business activities. The primary goal of this expense is to restore the natural environment to its original state and to cover environmental conservation-related damages. It can be mitigated by implementing effective environmental conservation measures.

The rest of the paper is structured as follows: Section 2 presents the literature review. Section 3 explains the mathematical formulation of the proposed model. Section 4 illustrates a numerical example and Section 5 concludes the paper.

2 Literature Review

The economic order quantity (EOQ) inventory model was first developed by Harris in 1913, which consists of ordering costs and holding costs. This model was later extended to economic production quantity model by Taff in the year 1918. These two models were modified by several researchers based on the needs of the production management with the incorporation of shortage, discount, price-break, switching, environmental conservation and other associated factors of business management. But in recent days the production sectors have begun to focus much on environmental sustainability. Salameh et al. (2000) introduced an economic production quantity model for items with imperfect quality. Dobos et al. (2006) discussed a production mode with quality consideration. Richter introduced the waste disposal problem in economic order quantity model. Jaber (2009) developed the production, remanufacture and waste disposal with lost sale. Arindum Mukhopadhyay et al. (2014) examined an economic production quantity models for imperfect items with pollution costs. Tao et al. (2010) discussed a green cost based economic production quantity model. Nivetha Martin (2015) extended the normal production quantity model into bio-friendly EPQ inventory model incorporating the cost of green energy to create

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light pollution free society. She also explained the optimization of an inventory model enclosing environmental costing. Antonitte Vinoline (2019) explored an integrated inventory model with shortages and screening process under condition of permissible delay in payments. Taleizadeh (2008) introduced Sustainable economic production quantity models for inventory systems with shortage. Ritha (2014) developed environmentally Sustainable Inventory Models with the Incorporation of Environmental Costs. Zadjafar et al. (2018) expanded a sustainable inventory model by considering environmental ergonomics and environmental pollution. Shah et al. (2021) explained the impact of industrial pollution on our society. Carter introduced transportation costs in inventory management and he also explained associated transportation costs matter in Production. Mohammed Reza Monazzam et al. (2021) discussed the effect of cycling development as a non-motorized transport on reducing air and noise pollution. Socially responsible inventory models were first initiated by Maurice Bonney, based on his research works Nivetha Martin developed integrated Eco-friendly inventory models with the inclusion of environmental conservation costs for promoting ecological sustainability. This research work is also intends to frame an inventory model which consists of the cost of environmental detection, pollution prevention and environmental remediation.

3 Mathematical Formulation

To develop the proposed model, the following notations and assumptions are defined throughout this paper.

3.1 Notation

D_1	Demand per unit of time
P	Production rate
X	D_1 / P
$1-X$	The fraction of time the production process spends actually idling
T_1	Cycle time
A	Setup cost per production run
P_1	Unit Production cost
h	Holding cost per unit of time
F	Maintenance cost per cycle
L	Cost of labor per cycle
P_e	Purchase cost of the equipment
D_e	Depreciation cost per cycle
a	Fixed cost per trip
b	Variable cost per unit transported per distance travelled
α	Proportion of demand returned
γ_0	Fixed cost to dispose waste to the environment
γ	Cost to dispose waste to the environment
θ	Proportion of waste produced per lot Q
F_c	Fuel cost
S_e	Costs of switching to cleaner fuels
d	Distance travelled
$LCA(T)$	Life cycle assessment technology cost
G_b	Green branding Cost
E_d	Environmental detection cost
E_p	Payments for permits and licenses to use environmental assets
E_R	Environmental remediation cost
P_c	Pollution Prevention cost
M_1	The trade credit period

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S_1	Selling price unit per item
I_1	Interest which can be earned per year
I_2	Interest charges per investment in inventory per year

3.2 Assumptions

1. Demand is known.
2. Production rate is greater than the demand rate to avoid shortages.
3. Production runs to replenish inventory are made at regular intervals.
4. Depreciation is the function of use.
5. Fixed credit period M_1 is permitted.
6. When $T_1 \geq M_1$, the settled account at $T_1 = M_1$. The buyer has the profit and larger stock of items in interest charges. When $T_1 \leq M_1$, the settled account at $T_1 = M_1$. The buyer need not have to pay any interest charges $I_2 \geq I_1$.
7. The materials converted using LCA technology is reused as raw materials in manufacturing.
8. Waste management focuses on waste reduction, pollution prevention, recycle and disposal.
9. The pollution prevention cost is used to reduce the emission from the production process.
10. Environmental remediation cost enhances the awareness among the public to preserve our environment.

3.3 Mathematical Model

Transportation supports trade activities in the business, which enhances the economy and degrades the environment. The effects of transportation and production run in the industries are worse and should be mitigated. As transportation and production process causes several damages to both environment and human beings in many ways, compensation must be undertaken by the persons responsible for it. To accomplish the act of compensation these environmental damages must be directly converted into monetary units. This result in the introduction of environmental detection cost, pollution prevention cost and environmental remediation cost are used as a reflection of social responsibility. It is the cost which is not determined by market based on economic principle demand and supply law; rather it is a process of assigning monetary value to the environmental damages. Therefore, these practices enhances to reduce the unwanted transportation and to promote pollution free environment. In order to maintain a production system with environment sustainability an Economic production quantity model is formulated as follows:

EPQ cost per unit of time = $\dfrac{AD_1}{Q} + \dfrac{hQ(1-X)}{2}$

Production cost per cycle = PD_1

Maintenance cost per cycle = $\dfrac{D_1}{Q} M_c$

Sunk cost = $\dfrac{D_1}{Q}(L + P_e - D_e)$

Transportation cost = $\dfrac{2aD_1}{Q} + bdD_1(1+\alpha)$

Fuel cost = $\dfrac{D_1}{Q} F_c d$

Costs of switching to cleaner fuels = $\dfrac{D_1}{Q} S_e$

Life cycle assessment technology cost = $\dfrac{D_1}{Q} LCA(T)$

Green branding cost = $\dfrac{D_1}{Q} G_b$

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Waste produced by the inventory system per cycle = $\frac{D_1}{Q}\gamma_0 + \gamma(\theta+\alpha)D_1$

Environmental detection cost = $\frac{D_1}{Q}E_d$

Payments for permits and licenses to use environmental assets = $\frac{D_1}{Q}E_p$

Environmental remediation cost = $\frac{D_1}{Q}E_R$

Pollution prevention cost = $\frac{D_1}{Q}P_c$

In three cases, consider the stock of items for interest charges and store the stock per year.

Case 1: $0 < T_1 < D_1$

Interest charges per year = $\frac{P_1 I_2 D_1 T_1}{2}$

Interest earned per year is zero.

Case 2: $D_1 \le T_1 \le M_1$

In this case, the item has no interest charges paid.

Interest earned per year = $D_1 I_1 S_1 (M_1 - \frac{T_1}{2})$

Case 3: $M_1 \le T_1$

Interest charges per year = $\frac{P_1 I_2 D_1 (T_1 - M_1)^2}{2T_1}$

Interest earned per year = $\frac{D_1 M_1^2 S_1 I_1}{2T_1}$

The EOQ inventory model with environmental cost

The total cost per unit of time

$$TC(Q) = \frac{AD_1}{Q} + \frac{hQ}{2} + PD_1 + \frac{D_1}{Q}M_c + \frac{D_1}{Q}(L + P_e - D_e) + \frac{2aD_1}{Q} + bdD_1(1+\alpha) + \frac{D_1}{Q}F_c d$$
$$+ \frac{D_1}{Q}S_e + \frac{D_1}{Q}LCA(T) + \frac{D_1}{Q}G_b + \frac{D_1}{Q}\gamma_0 + \gamma(\theta+\alpha)D_1 + \frac{D_1}{Q}E_d + \frac{D_1}{Q}E_p + \frac{D_1}{Q}E_R + \frac{D_1}{Q}P_c$$

Case 1: $0 < T_1 < D_1$

$$TC_1(Q) = \frac{AD_1}{Q} + \frac{hQ}{2} + PD_1 + \frac{D_1}{Q}M_c + \frac{D_1}{Q}(L + P_e - D_e) + \frac{2aD_1}{Q} + bdD_1(1+\alpha) + \frac{D_1}{Q}F_c d$$
$$+ \frac{D_1}{Q}S_e + \frac{D_1}{Q}LCA(T) + \frac{D_1}{Q}G_b + \frac{D_1}{Q}\gamma_0 + \gamma(\theta+\alpha)D_1 + \frac{D_1}{Q}E_d + \frac{D_1}{Q}E_p + \frac{D_1}{Q}E_R + \frac{D_1}{Q}P_c + \frac{P_1 I_2 D_1 T_1}{2}$$

$$TC_1(Q)=\frac{AD_1}{Q}+\frac{hQ}{2}+PD_1+\frac{D_1}{Q}M_c+\frac{D_1}{Q}(L+P_e-D_e)+\frac{2aD_1}{Q}+bdD_1(1+\alpha)+\frac{D_1}{Q}F_cd$$
$$+\frac{D_1}{Q}S_e+\frac{D_1}{Q}LCA(T)+\frac{D_1}{Q}G_b+\frac{D_1}{Q}\gamma_0+\gamma(\theta+\alpha)D_1+\frac{D_1}{Q}E_d+\frac{D_1}{Q}E_p+\frac{D_1}{Q}E_R+\frac{D_1}{Q}P_c+\frac{P_1I_2Q}{2}$$

To find the optimal order quantity, the above equation is differentiated with respect to Q and is equated to zero.

$$\frac{\partial TC_1(Q)}{\partial Q}=0$$

$$\frac{-D_1}{Q^2}(A+M_c+(L+P_e-D_e)+2a+F_cd+S_e+LCA(T)+G_b+\gamma_0+E_d+E_p+P_c+E_R)+\frac{h}{2}+\frac{P_1I_2}{2}=0$$

The optimal order quantity is derived as Q^*

$$Q^*=\sqrt{\frac{2D_1(A+M_c+(L+P_e-D_e)+2a+F_cd+S_e+LCA(T)+G_b+\gamma_0+E_d+E_p+P_c+E_R)}{h+P_1I_2}}$$

Case 2: $D_1\le T_1\le M_1$

$$TC_2(Q)=\frac{AD_1}{Q}+\frac{hQ}{2}+PD_1+\frac{D_1}{Q}M_c+\frac{D_1}{Q}(L+P_e-D_e)+\frac{2aD_1}{Q}+bdD_1(1+\alpha)+\frac{D_1}{Q}F_cd+\frac{D_1}{Q}S_e$$
$$+\frac{D_1}{Q}LCA(T)+\frac{D_1}{Q}G_b+\frac{D_1}{Q}\gamma_0+\gamma(\theta+\alpha)D_1+\frac{D_1}{Q}E_d+\frac{D_1}{Q}E_p+\frac{D_1}{Q}E_R+\frac{D_1}{Q}P_c-D_1I_1S_1(M_1-\frac{T_1}{2})$$

$$TC_2(Q)=\frac{AD_1}{Q}+\frac{hQ}{2}+PD_1+\frac{D_1}{Q}M_c+\frac{D_1}{Q}(L+P_e-D_e)+\frac{2aD_1}{Q}+bdD_1(1+\alpha)+\frac{D_1}{Q}F_cd+\frac{D_1}{Q}S_e$$
$$+\frac{D_1}{Q}LCA(T)+\frac{D_1}{Q}G_b+\frac{D_1}{Q}\gamma_0+\gamma(\theta+\alpha)D_1+\frac{D_1}{Q}E_d+\frac{D_1}{Q}E_p+\frac{D_1}{Q}E_R+\frac{D_1}{Q}P_c-D_1I_1S_1(M_1-\frac{Q}{2D_1})$$

To find the optimal order quantity, the above equation is differentiated with respect to Q and is equated to zero.

$$\frac{\partial TC_2(Q)}{\partial Q}=0$$

$$\frac{-D_1}{Q^2}(A+M_c+(L+P_e-D_e)+2a+F_cd+S_e+LCA(T)+G_b+\gamma_0+E_d+E_p+P_c+E_R)+\frac{h}{2}+\frac{I_1S_1}{2}=0$$

The optimal order quantity is derived as Q^*

$$Q^*=\sqrt{\frac{2D_1(A+M_c+(L+P_e-D_e)+2a+F_cd+S_e+LCA(T)+G_b+\gamma_0+E_d+E_p+P_c+E_R)}{h+I_1S_1}}$$

Case 3: $M_1\le T_1$

$$TC_3(Q)=\frac{AD_1}{Q}+\frac{hQ}{2}+PD_1+\frac{D_1}{Q}M_c+\frac{D_1}{Q}(L+P_e-D_e)+\frac{2aD_1}{Q}+bdD_1(1+\alpha)+\frac{D_1}{Q}F_cd+\frac{D_1}{Q}S_e+\frac{D_1}{Q}LCA(T)$$
$$+\frac{D_1}{Q}G_b+\frac{D_1}{Q}\gamma_0+\gamma(\theta+\alpha)D_1+\frac{D_1}{Q}E_d+\frac{D_1}{Q}E_p+\frac{D_1}{Q}E_R+\frac{D_1}{Q}P_c+\frac{P_1I_2D_1(T_1-M_1)^2}{2T_1}-\frac{D_1M_1^2S_1I_1}{2T_1}$$

$$TC_3(Q)=\frac{AD_1}{Q}+\frac{hQ}{2}+PD_1+\frac{D_1}{Q}M_c+\frac{D_1}{Q}(L+P_e-D_e)+\frac{2aD_1}{Q}+bdD_1(1+\alpha)+\frac{D_1}{Q}F_cd+\frac{D_1}{Q}S_e+\frac{D_1}{Q}LCA(T)$$
$$+\frac{D_1}{Q}G_b+\frac{D_1}{Q}\gamma_0+\gamma(\theta+\alpha)D_1+\frac{D_1}{Q}E_d+\frac{D_1}{Q}E_p+\frac{D_1}{Q}E_R+\frac{D_1}{Q}P_c+\frac{P_1I_2Q}{2}+\frac{P_1I_2D_1^2M_1^2}{2Q}-P_1I_2D_1M_1-\frac{D_1^2M_1^2S_1I_1}{2Q}$$

To find the optimal order quantity, the above equation is differentiated with respect to Q and is equated to zero.

$$\frac{\partial TC_3(Q)}{\partial Q}=0$$

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$$\frac{-D_1}{Q^2}(A+M_c+(L+P_e-D_e)+2a+F_cd+S_e+LCA(T)+G_b+\gamma_0+E_d+E_p+P_c+E_R)$$
$$+\frac{h}{2}+\frac{P_1I_2}{2}-\frac{P_1I_2D_1^2M_1^2}{2Q^2}+\frac{D_1^2M_1^2S_1I_1}{2Q^2}=0$$

$$Q^*=\sqrt{\frac{2D_1(A+M_c+(L+P_e-D_e)+2a+F_cd+S_e+LCA(T)+G_b+\gamma_0+E_d+E_p+P_c+E_R)+D_1^2M_1^2(P_1I_2-S_1I_1)}{h+P_1I_2}}$$

The EPQ inventory model with environmental cost

The total cost per unit of time

$$TC(Q)=\frac{AD_1}{Q}+\frac{hQ(1-X)}{2}+PD_1+\frac{D_1}{Q}M_c+\frac{D_1}{Q}(L+P_e-D_e)+\frac{2aD_1}{Q}+bdD_1(1+\alpha)+\frac{D_1}{Q}F_cd$$
$$+\frac{D_1}{Q}S_e+\frac{D_1}{Q}LCA(T)+\frac{D_1}{Q}G_b+\frac{D_1}{Q}\gamma_0+\gamma(\theta+\alpha)D_1+\frac{D_1}{Q}E_d+\frac{D_1}{Q}E_p+\frac{D_1}{Q}E_R+\frac{D_1}{Q}P_c$$

Case 1: $0<T_1<D_1$

$$TC_1(Q)=\frac{AD_1}{Q}+\frac{hQ(1-X)}{2}+PD_1+\frac{D_1}{Q}M_c+\frac{D_1}{Q}(L+P_e-D_e)+\frac{2aD_1}{Q}+bdD_1(1+\alpha)+\frac{D_1}{Q}F_cd$$
$$+\frac{D_1}{Q}S_e+\frac{D_1}{Q}LCA(T)+\frac{D_1}{Q}G_b+\frac{D_1}{Q}\gamma_0+\gamma(\theta+\alpha)D_1+\frac{D_1}{Q}E_d+\frac{D_1}{Q}E_p+\frac{D_1}{Q}E_R+\frac{D_1}{Q}P_c+\frac{P_1I_2D_1T_1}{2}$$

$$TC_1(Q)=\frac{AD_1}{Q}+\frac{hQ(1-X)}{2}+PD_1+\frac{D_1}{Q}M_c+\frac{D_1}{Q}(L+P_e-D_e)+\frac{2aD_1}{Q}+bdD_1(1+\alpha)+\frac{D_1}{Q}F_cd$$
$$+\frac{D_1}{Q}S_e+\frac{D_1}{Q}LCA(T)+\frac{D_1}{Q}G_b+\frac{D_1}{Q}\gamma_0+\gamma(\theta+\alpha)D_1+\frac{D_1}{Q}E_d+\frac{D_1}{Q}E_p+\frac{D_1}{Q}E_r+\frac{D_1}{Q}P_c+\frac{P_1I_2Q}{2}$$

To find the optimal order quantity, the above equation is differentiated with respect to Q and is equated to zero.

$$\frac{\partial TC_1(Q)}{\partial Q}=0$$

$$\frac{-D_1}{Q^2}(A+M_c+(L+P_e-D_e)+2a+F_cd+S_e+LCA(T)+G_b+\gamma_0+E_d+E_p+P_c+E_R)+\frac{h(1-X)}{2}+\frac{P_1I_2}{2}=0$$

The optimal order quantity is derived as Q^*

$$Q^*=\sqrt{\frac{2D_1(A+M_c+(L+P_e-D_e)+2a+F_cd+S_e+LCA(T)+G_b+\gamma_0+E_d+E_p+P_c+E_R)}{h(1-X)+P_1I_2}}$$

Case 2: $D_1\le T_1\le M_1$

$$TC_2(Q)=\frac{AD_1}{Q}+\frac{hQ(1-X)}{2}+PD_1+\frac{D_1}{Q}M_c+\frac{D_1}{Q}(L+P_e-D_e)+\frac{2aD_1}{Q}+bdD_1(1+\alpha)+\frac{D_1}{Q}F_cd+\frac{D_1}{Q}S_e$$
$$+\frac{D_1}{Q}LCA(T)+\frac{D_1}{Q}G_b+\frac{D_1}{Q}\gamma_0+\gamma(\theta+\alpha)D_1+\frac{D_1}{Q}E_d+\frac{D_1}{Q}E_p+\frac{D_1}{Q}E_R+\frac{D_1}{Q}P_c-D_1I_1S_1(M_1-\frac{T_1}{2})$$

$$TC_2(Q)=\frac{AD_1}{Q}+\frac{hQ(1-X)}{2}+PD_1+\frac{D_1}{Q}M_c+\frac{D_1}{Q}(L+P_e-D_e)+\frac{2aD_1}{Q}+bdD_1(1+\alpha)+\frac{D_1}{Q}F_cd+\frac{D_1}{Q}S_e$$
$$+\frac{D_1}{Q}LCA(T)+\frac{D_1}{Q}G_b+\frac{D_1}{Q}\gamma_0+\gamma(\theta+\alpha)D_1+\frac{D_1}{Q}E_d+\frac{D_1}{Q}E_p+\frac{D_1}{Q}E_R+\frac{D_1}{Q}P_c-D_1I_1S_1(M_1-\frac{Q}{2D_1})$$

To find the optimal order quantity, the above equation is differentiated with respect to Q and is equated to zero.

$$\frac{\partial TC_2(Q)}{\partial Q} = 0$$

$$\frac{-D_1}{Q^2}(A + M_c + (L + P_e - D_e) + 2a + F_c d + S_e + LCA(T) + G_b + \gamma_0 + E_d + E_p + P_c + E_R) + \frac{h(1-X)}{2} + \frac{I_1 S_1}{2} = 0$$

The optimal order quantity is derived as Q^*

$$Q^* = \sqrt{\frac{2D_1(A + M_c + (L + P_e - D_e) + 2a + F_c d + S_e + LCA(T) + G_b + \gamma_0 + E_d + E_p + P_c + E_R)}{h(1-X) + I_1 S_1}}$$

Case 3: $M_1 \le T_1$

$$TC_3(Q) = \frac{AD_1}{Q} + \frac{hQ(1-X)}{2} + PD_1 + \frac{D_1}{Q}M_c + \frac{D_1}{Q}(L + P_e - D_e) + \frac{2aD_1}{Q} + bdD_1(1+\alpha) + \frac{D_1}{Q}F_c d + \frac{D_1}{Q}S_e + \frac{D_1}{Q}LCA(T)$$
$$+ \frac{D_1}{Q}G_b + \frac{D_1}{Q}\gamma_0 + \gamma(\theta + \alpha)D_1 + \frac{D_1}{Q}E_d + \frac{D_1}{Q}E_p + \frac{D_1}{Q}E_R + \frac{D_1}{Q}P_c + \frac{P_1 I_2 D_1 (T_1 - M_1)^2}{2T_1} - \frac{D_1 M_1^2 S_1 I_1}{2T_1}$$

$$TC_3(Q) = \frac{AD_1}{Q} + \frac{hQ(1-X)}{2} + PD_1 + \frac{D_1}{Q}M_c + \frac{D_1}{Q}(L + P_e - D_e) + \frac{2aD_1}{Q} + bdD_1(1+\alpha) + \frac{D_1}{Q}F_c d + \frac{D_1}{Q}S_e + \frac{D_1}{Q}LCA(T)$$
$$+ \frac{D_1}{Q}G_b + \frac{D_1}{Q}\gamma_0 + \gamma(\theta + \alpha)D_1 + \frac{D_1}{Q}E_d + \frac{D_1}{Q}E_p + \frac{D_1}{Q}E_R + \frac{D_1}{Q}P_c + \frac{P_1 I_2 Q}{2} + \frac{P_1 I_2 D_1^2 M_1^2}{2Q} - P_1 I_2 D_1 M_1 - \frac{D_1^2 M_1^2 S_1 I_1}{2Q}$$

To find the optimal order quantity, the above equation is differentiated with respect to Q and is equated to zero.

$$\frac{\partial TC_3(Q)}{\partial Q} = 0$$

$$\frac{-D_1}{Q^2}(A + M_c + (L + P_e - D_e) + 2a + F_c d + S_e + LCA(T) + G_b + \gamma_0 + E_d + E_p + P_c + E_R)$$
$$+ \frac{h(1-X)}{2} + \frac{P_1 I_2}{2} - \frac{P_1 I_2 D_1^2 M_1^2}{2Q^2} + \frac{D_1^2 M_1^2 S_1 I_1}{2Q^2} = 0$$

The optimal order quantity is derived as Q^*

$$Q^* = \sqrt{\frac{2D_1(A + M_c + (L + P_e - D_e) + 2a + F_c d + S_e + LCA(T) + G_b + \gamma_0 + E_d + E_p + P_c + E_R) + D_1^2 M_1^2 (P_1 I_2 - S_1 I_1)}{h(1-X) + P_1 I_2}}$$

4 Numerical Example

Consider the following parameters to illustrate the proposed model.

D_1	1000 units/time	I_1	0.1/year
P	1200 units/time	I_2	0.15/year
A	\$ 150	γ_0	\$ 1/unit
h	\$ 15/unit	γ	\$ 0.8/unit
M_c	\$ 80/unit	θ	0.5
L	\$ 250/person	F_c	\$101/litre
P_e	\$ 1,50,000	S_e	\$ 12/unit
D_e	\$ 35,000	$LCA(T)$	\$ 4/unit
a	\$ 30/unit	G_b	\$ 30/unit
b	\$ 3/unit	E_d	\$ 280/unit
α	0.2	E_p	\$ 120/unit
d	150 Km		

E_R	$ 320/unit	M_1	0.1 year
P_c	$ 950/unit	S_1	$ 10/unit
P_1	$ 4		

Using the above data, we obtain the optimal solution as

Table 1 EOQ Inventory Model

	Q^* **(in units)**	$TC(Q)$ **(in $)**
Case 1	4120.1039	1804833.621
Case 2	4068.2767	1807586.565
Case 3	4120.0728	1804775.563

Table 2 EPQ Inventory Model

	Q^* **(in units)**	$TC(Q)$ **(in $)**
Case 1	9241.7582	1769214.071
Case 2	8697.7201	1775255.229
Case 3	9241.6884	1769153.855

5 Conclusion

This paper especially highlights the aspects of environmental costing and prevention of pollution. The formulated inventory model reflects the existing monetary expenditure of the conservation of the environment. This Paper also stresses on the need for considering the environmental costing features in product production to reduce pollution. The formulated inventory model can be extended with the incorporation of several associated factors in terms of monetary values. This model helps to reduce the pollution and to create a healthier environment for our future generation.

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