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Inventory model with trade credit policy and carbon emission preservation technology

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ABSTRACT

This study develops an integrated inventory model that incorporates preservation technology, trade credit policy, inflation effects, and carbon emission tax considerations to optimize supply chain performance. Preservation technology is introduced to reduce product deterioration, thereby extending shelf life and improving consumption efficiency, while trade credit policies provide financial flexibility for retailers. The model reflects the growing influence of regulatory frameworks and technological advancements on inventory management, highlighting how these factors shape future commercial applications. By combining financial mechanisms with sustainability measures, the proposed framework offers a holistic approach to inventory control. The model is formulated mathematically and solved using MAPLE software, enabling precise evaluation of inventory costs under varying cycle lengths. Numerical examples validate the model's applicability, demonstrating significant reductions in overall supply chain costs when preservation and credit policies are effectively integrated. Sensitivity analysis further explores the impact of key parameters-including deterioration rate, inflation, preservation cost, and carbon emission taxes-providing managerial insights into their role in inventory decisions. The findings confirm that integrating sustainability measures with financial and operational policies enhances cost efficiency, supports environmental responsibility, and strengthens supply chain resilience in modern business contexts.

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1. INTRODUCTION

Inventory management is a fundamental function for all organizations, ensuring the efficient control of materials from acquisition to sale while minimizing excess stock and avoiding shortages. Inventory is generally defined as the stock of idle resources held for future use, and its scope varies across industries. Manufacturing firms typically manage inventories of raw materials, components, sub-assemblies, tools, semi-finished goods, and finished products, while service organizations such as banks, hospitals, and educational institutions maintain inventories of consumables, brochures, or other operational items [1]-[3].

Within the broader framework of supply chain management, inventory plays a pivotal role in balancing demand and supply. Supply chain modeling has long been employed to establish organized systems, yet modern businesses face increasingly complex and unpredictable demands that require agile and adaptive strategies. Research in inventory modeling seeks to provide decision-making tools that improve system performance, but designing effective control mechanisms remains challenging. Existing models often

address structural complexities but fail to fully capture uncertainties inherent in today's dynamic business environment [4]-[6].

This paper contributes to this discourse by proposing a comprehensive inventory model that integrates preservation technology, trade credit, inflation, and carbon emission policies. The structure of the study is as follows: Section 2 presents the literature review; Section 3 defines notations and assumptions; Section 4 formulates the inventory model; Section 5 develops the solution procedure together with theoretical results, special cases, sensitivity analysis, and managerial insights; and Section 6 concludes with key findings and outlines future research directions.

2. LITERATUR REVIEW

Decaying or deterioration is a very impractical fact in inventory systems. economic order quantity (EOQ), economic production quantity (EPQ), and economic growing quantity (EGQ) are the models in the inventory system. Mathematical modeling of deterioration began with the EOQ model and was introduced by Whiten in 1957. Ghare and Schrader [1] extended the fundamental EOQ model with some assumptions and created a ladder for new-generation researchers in the same field by providing effective and impressive results. Research is growing exponentially as the scope and form of supply chain inventory business grows from time to time. In recent years it has been based on technology and some environmental situations. At present there is tough competition to survive in the market, members of the supply chain must integrate their business to enhance their efficiency, satisfying customers more efficiently and lowering the inventory cost. In a non-integrated supply chain, players have different motives, and the objective of the supplier or retailer may conflict with the objective of the supply chain. When the decisions of the supply chain are inconsistent or non-coordinated, the supply chain will lose its competitive advantage. Goyal [2] first developed an integrated inventory model to determine the optimal joint inventory policy for a single supplier and a single retailer. Abad and Jaggi [3] combined the concept of an integrated inventory model and trade credit policy and established a supplier-retailer integrated system in which the supplier offers trade credit to the retailer. Afterward, an integrated inventory model with various trade credit policies can be found in [4]. Buzacott [5] developed an EOQ model with inflation and showed that with inflation the carrying cost in EOQ depends on pricing policy and provides a new concept. Teng [6] obtained an EOQ model for an item under situations of permissible delay in payments. Bhunia and Shaikh [7] developed an inventory model for decayed items, having demand as a function of selling price and deterioration rate as a linear function of time. Jaggi *et al.* [8] have also pioneered an EOQ model on retailers' ordering policy under inflationary conditions. The authors investigated the defective items and their impact on retailers' ordering policy for decayed items under inflation with variations of time. Teng *et al.* [9] concluded some valuable marks by relating his model with trade credit and lot size policies in EPQ and mentioned that trade credit policy increases the sales as well as opportunity cost and default risk. Shah and Chaudhari [10] by deriving optimum policies with some realistic conditions. They analyzed a supply chain comprising of manufacturer, distributor, and retailer and favored the settlement of accounts during the allowable credit period. Datta [11] analyzed a production-inventory model with some conditions under the carbon tax system and concluded some valuable points and its effects on the environment, GDP, and optimum profit. Jayaswal *et al.* [12] the researchers discovered significant although contingent findings that are associated with retailers' ordering policy. They validated their conclusions via the use of numerical examples. Shah *et al.* [13] Examined a scenario in which demand is contingent upon both time and credit period. They included credits and other policies into the quadratic demand and supply cycle for deteriorated items. Pan *et al.* [14] Created a viable manufacturing inventory model to minimize carbon emissions. In addition, they implemented an integrated strategy including production, replenishment, distribution, and technology to minimize carbon emissions and maximize net profit within the system. Khanna *et al.* [15] Constructed a mathematical model and optimized the retailer's overall cost. The demand was regarded as being reliant on stock, and the carrying cost was thought to be of a variable nature over time. A supply chain model was designed to minimize energy usage and eliminate waste by [16]. A non-linear mathematical model is defined to determine the minimal overall cost. Mishra *et al.* [17] Conducted research on green technologies and created a supply chain inventory model that incorporates a payment system to address shortages and surpluses. An EOQ model was also created for perishable products by [18]. The developers implemented a two-tier credit and financing strategy, taking into account the impacts of learning. They provided a detailed explanation of the policy using numerical examples. Shah *et al.* [19] Developed an EPQ model to analyse the impact of dependability and inflation on perishable items. The model also incorporates a two-level credit policy. In addition, they have reduced the overall cost function. Alamri *et al.* [20] created an EOQ model that incorporates learning effects and carbon emissions, taking into consideration the specific conditions of naturally deteriorating items. The authors also deliberated on its influence on numerous sectors associated with it. Kumar *et al.* [21] an inventory management policy that involves advance payments and post-payment

strategies for degraded inventory. They explained their solutions using both crisp and fuzzy models. Through the implementation of green subsidies and the use of emission reduction technology. Rudias *et al.* [22] Created an inventory model and determined that the level of subsidy intensity directly correlated with the level of green practices. Zhang *et al.* [23] presented an inventory model that integrates a carbon constraint mechanism and expands upon the EOQ framework. A similar [24] developed a fuzzy inventory model especially for fast- and slow-growing commodities, including baby carrots and maize, accounting for limits on deterioration within a single period to ascertain the maximum inventory level per period. Three issues that can occur in an inventory system with expanding items were noted by [25]. In order to evaluate whether or whether shortages are economically desirable and, hence, more beneficial than situations in which they are not permitted by [26] created an inventory model for growing commodities that takes into consideration planned shortages and defective quality. A three-echelon supply chain inventory management model for growing commodities, which consists of a processing factory, a farming operation, and a retail outlet accountable for satisfying consumer demand, was presented by [27]. Jaggi *et al.* [8] examined and corrected the conceptual and mathematical problems found again by [17] and suggested an EOQ model for a seasonal commodity that was degrading, taking into account demand as a function of stock and selling price. Demand models based on price have been widely employed by researchers. San-José *et al.* [28], for example, looked at an inventory model for products whose demand-represented by a bivariate function-depends on price as well as time. In the context of various carbon emission regulatory schemes, Ruidas *et al.* [29] developed a production inventory model that took probable defective products into account. They made the assumption that demand would decrease linearly with product selling price. A thorough integrated inventory model with a focus on profit maximization was presented by [30]. Deteriorating goods experience constant mass loss or usefulness, but preservation technology can help the damaged item to be consumed. Retailers with direct customer relationships can reduce stock spoilage through good warehouses. Manufacturers' storage systems have a higher deterioration rate by [31]. Pathak *et al.* [32] The two-warehouse inventory model, utilizing supply and demand, offers a pricing strategy for perishable goods, allowing partial backlogs and improving operational effectiveness and customer satisfaction. Cheng and Chen [33] This paper analyzes inventory models with compounding interest, generating an approximated closed-form optimal solution, ensuring the original optimal solution's existence, highlighting the second derivative's usefulness. It included sustainable techniques including discrete setup cost reduction, predictable lead time, and taking environmental considerations into account. The selling price, the carrying cost per unit (which varies linearly over time), and, in an all-units discount scenario, the per-unit buying price all have an impact on the product's demand. The study integrates preservation technology, trade credit, inflation, and carbon emission taxes into a unified inventory model, optimizing supply chain costs and reducing costs using MAPLE.

3. ASSUMPTIONS AND NOTATION

To proceed with the process of developing this mathematical model, it is essential to make use of the assumptions and notations that have been developed. Table 1, which contains all of the necessary details, contains a listing of the notations that are utilized in the model that is being proposed.

3.1. Assumptions

i) The demand rate is an increasing function of time with exponential, ii) Deterioration at a constant rate, iii) The replenishment rate gets instantaneous., iv) Shortages are not permitted, v) Infinite sections make up the time horizon., vi) The costs associated with holding inventory and placing orders dependent on the shipment, vii) Rate of the inflation rate is allowed, viii) Credit policy is allowed, ix) Existence of preservation technology.

3.2. Notations

i) The demand rate is $R(t) = R_0 e^{\alpha t}$ where $\alpha = 0$ and initially I0 >0, ii) Preservation cost/ton unit items are P1, iii) Carrying inventory cost is defined as HC, v) The carbon emission factor for fuels is denoted by Fc, v) The valuable amount of electricity utilized by ec, vi) The carbon emission cost CE = Fc· ec. vii) The cost of inventories for each cycle ∅ (T), viii) In the case i, for the cycle M ≤ T is ∅ 1(T). ix) For case ii, when M > T is ∅ 2(T), x) The rate of inflation is R, xi) Ordering cost per order is C(t) = $ceRT$ and it is defined as $C(t) = \left(c_1 + \frac{c_2}{\beta}\right)$, xii) The highest possible stock level at t = 0 is S, xiii) Total cycle length is T, xiv) The Learning parameter of learning is β, xv) Number of shipments of the stock is ns, xvi) The rate of interest earned is $Ie.$, xvii) The rate of interest paid Ip, xviii) The trade-credit period is denoted by M, xix) The deterioration rate is θ ($0 < \theta < 1$), xx) The holding cost is defined by $H(t) = \left(h_1 + \frac{h_2}{\beta}\right)$.

4. ASSUMPTIONS AND NOTATION

The Inventory level begins at t = 0 with the initial level of inventory $S = Imax$ units. Its level reduces due to demand as well as deterioration. The demand rate is exponentially decreasing with respect to time. The instantaneous level I(t) at any time t during the cyclic period is governed by the following as (1).

$$\frac{dI(t)}{dt} + \theta I(t) = -R(t)\ 0 \le t \le T \tag{1}$$

With boundary conditions: (0) = $Imax = S$, $I(T) = 0$ and $D(t) = D0e+\xi t$. The solution of the (1) is (2).

$$I(t) = \frac{-R_0}{(\theta+\alpha)}\left[(\theta+\alpha)t - (\theta+\alpha)T + \frac{\alpha^2 t^2}{2!} + \frac{\theta^2 t^2}{2!} + \frac{(\theta+\alpha)^2 T^2}{2!} - (\theta+\alpha)T * \theta t\right] \tag{2}$$

The maximum inventory level is (3).

$$I_{max} = S - \frac{-R_0}{(\theta+\alpha)}\left[-(\theta+\alpha)T + \frac{(\theta+\alpha)^2 T^2}{2!}\right] \tag{3}$$

The inventory under trade credit period concerning time is given in Figure 1 whereas inventory under trade credit for case 1 is illustrated in Figure 2. Case 1: when $M \le$ T.

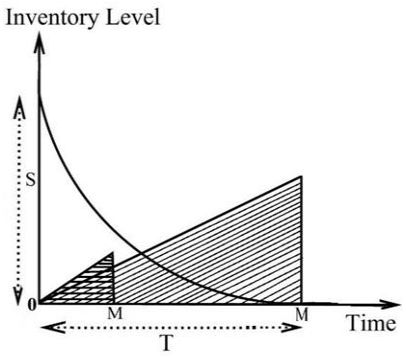

Figure 1. Inventory under trade credit period with time

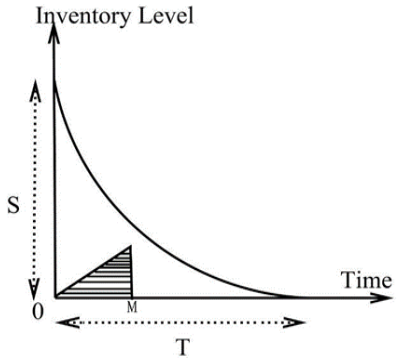

Figure 2. For case 1 the inventory under trade credit

The whole cost of inventory for each cycle is (4).

$$\emptyset(T) = \frac{1}{T}\left[OC + HC + DC + PV + CE + I_p - I_e\right] \tag{4}$$

The cost of ordering each cycle is (5).

$$OC = C(t)(e^{RT} - 1)\left[\frac{1}{RT} + \frac{RT}{4} - \frac{1}{2}\right] \tag{5}$$

The deterioration cost is defined as *DC = C_D * No. of decaying units*$DC = C_D\left[I_{max} - \int_0^T R(t)dt\right]$ (6).

$$DC = C_D\left[\frac{-R_0}{(\theta+\alpha)}\left(-(\theta+\alpha)T + \frac{(\theta+\alpha)^2 (T)^2}{2!}\right)\right] \tag{6}$$

The holding cost of the modeling $HC = D_0 h \sum_{p=0}^{n-1} c_0 e^{pRt}\left[\int_0^T R(t)dt\right]$ (7).

$$HC = D_0 h \sum_{p=0}^{n-1} c_0 e^{pRt}\left[\frac{-R_0}{(\theta+\alpha)}\left((\theta+\alpha)\frac{(T)^2}{2} + \left(-\frac{(\theta+\alpha)}{2} + \frac{(\alpha)^2}{6} - \frac{(\theta+\alpha)}{2}\theta\right)T^3 + (\theta+\alpha)^2\frac{(T)^4}{4}\right)\right] \tag{7}$$

The carbon emission cost $CE = D_0 D f_c e_c * HC$ (8).

$$CE = D_0 D f_c e_c \sum_{p=0}^{n-1} c_0 e^{pRt}$$

$$\left[\frac{-R_0}{(\theta+\alpha)}\left((\theta+\alpha)\frac{(T)^2}{2}+\left(-\frac{(\theta+\alpha)}{2}+\frac{(\alpha)^2}{6}-\frac{(\theta+\alpha)}{2}\theta\right)T^3+(\theta+\alpha)^2\frac{(T)^4}{4}\right)\right] \quad (8)$$

The preservation cost of the model is,

$$PV = p_1 T \quad (9)$$

after putting all the values from the (5) to (9), then the (4) is developed into $\emptyset(T) = \frac{1}{T}\left[OC + HC + DC + PV + CE + I_p - I_e\right]$,

$$\emptyset(T) = \frac{1}{T}\Bigg[C(t)(e^{RT}-1)\left[\frac{1}{RT}+\frac{RT}{4}-\frac{1}{2}\right]+ D_0 h\sum_{p=0}^{n-1} c_0 e^{pRt}\left[\frac{-R_0}{(\theta+\alpha)}\left((\theta+\alpha)\frac{(T)^2}{2}+\left(-\frac{(\theta+\alpha)}{2}+\frac{(\alpha)^2}{6}-\frac{(\theta+\alpha)}{2}\theta\right)T^3+(\theta+\alpha)^2\frac{(T)^4}{4}\right)\right]+C_D\left[\frac{-R_0}{(\theta+\alpha)}\left(-(\theta+\alpha)T+\frac{(\theta+\alpha)^2(T)^2}{2!}\right)\right]+p_1 T + D_0 D f_c e_c \sum_{p=0}^{n-1} c_0 e^{pRt}\left[\frac{-R_0}{(\theta+\alpha)}\left((\theta+\alpha)\frac{(T)^2}{2}+\left(-\frac{(\theta+\alpha)}{2}+\frac{(\alpha)^2}{6}-\frac{(\theta+\alpha)}{2}\theta\right)T^3+(\theta+\alpha)^2\frac{(T)^4}{4}\right)\right]+I_p-I_e\Bigg] \quad (10)$$

Now, for finding the values of the rate of interest paid and rate of interest gained the modeling is converted into two cases of the trade credit i.e in (11).

$$\emptyset(T) = \begin{cases}\emptyset_1(T)\ when\ M \le T\\ \emptyset_2(T)\ when\ M > T\end{cases} \quad (11)$$

For the scenario of the interest gained from the period *0 to M* and the interest paid from *M to T* are given as (12).

$$I_e = p_0 I_e\left[\int_0^T R(t)tdt\right]$$
$$I_e = p_0 I_e D_0\left[\frac{M(e)^{\alpha M}}{\alpha}-\frac{1}{(\alpha)^2}((e)^{\alpha M}-1)\right] \quad (12)$$

And the value of $I_p = p_0 I_p\left[\int_0^T I(t)dt\right]$,

$$I_p = p_0 I_p\left[\left(\left(1-T+\frac{(\theta+\alpha)(T)^2}{2}-T\theta\right)(\theta+\alpha)\frac{(T)^2}{2}\right)-\left(\left(1-T+\frac{(\theta+\alpha)(T)^2}{2}\right)(\theta+\alpha)\frac{(M)^2}{2}\right)+\left(((\alpha)^2-(\theta)^2)\frac{T^3-M^3}{6}\right)\right] \quad (13)$$

then from these two equations, the cost of inventory can be written in (12) to find the value of the function.

$$\emptyset_1(T) = \frac{1}{T}\Bigg[C(t)(e^{RT}-1)\left[\frac{1}{RT}+\frac{RT}{4}-\frac{1}{2}\right]+D_0 h\sum_{p=0}^{n-1} c_0 e^{pRt}\left[\frac{-R_0}{(\theta+\alpha)}\left((\theta+\alpha)\frac{(T)^2}{2}+\left(-\frac{(\theta+\alpha)}{2}+\frac{(\alpha)^2}{6}-\frac{(\theta+\alpha)}{2}\theta\right)T^3+(\theta+\alpha)^2\frac{(T)^4}{4}\right)\right]+C_D\left[\frac{-R_0}{(\theta+\alpha)}\left(-(\theta+\alpha)T+\frac{(\theta+\alpha)^2(T)^2}{2!}\right)\right]+p_1 T + D_0 D f_c e_c\sum_{p=0}^{n-1} c_0 e^{pRt}\left[\frac{-R_0}{(\theta+\alpha)}\left((\theta+\alpha)\frac{(T)^2}{2}+\left(-\frac{(\theta+\alpha)}{2}+\frac{(\alpha)^2}{6}-\frac{(\theta+\alpha)}{2}\theta\right)T^3+(\theta+\alpha)^2\frac{(T)^4}{4}\right)\right]+p_0 I_p\left[\left(\left(1-T+\frac{(\theta+\alpha)(T)^2}{2}-T\theta\right)(\theta+\alpha)\frac{(T)^2}{2}\right)-\left(\left(1-T+\frac{(\theta+\alpha)(T)^2}{2}\right)(\theta+\alpha)\frac{(M)^2}{2}\right)+\left(((\alpha)^2-(\theta)^2)\frac{T^3-M^3}{6}\right)\right]-p_0 I_e D_0\left[\frac{M(e)^{\alpha M}}{\alpha}-\frac{1}{(\alpha)^2}((e)^{\alpha M}-1)\right]\Bigg] \quad (14)$$

The Inventory level for the second scenario is shown in Figure 3 and the graph for convexity for case 1 is plotted in Figure 4. Case 2: When M > T.

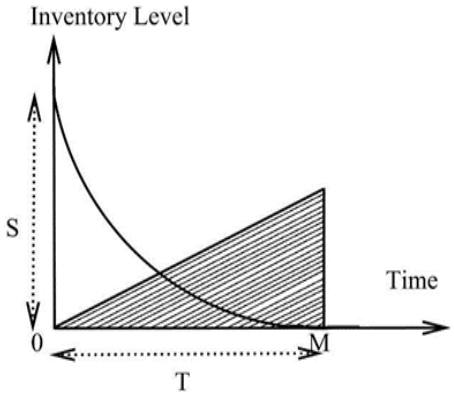

Figure 3. Inventory level for the second scenario

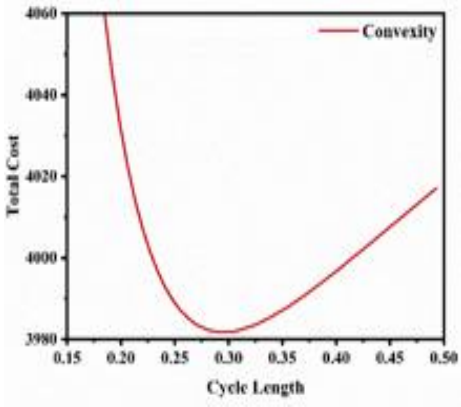

Figure 4. Convexity graph for the case 1

Interest earned for this scenario is calculated as (15) $I_e = p_0 I_e \left[\int_0^T R(t)tdt\right] + p_0 I_e R(t)(M-T)$.

$$I_p = p_0 I_e D_0 \left[\left(\left(\frac{(T)(e)^{\alpha T}}{\alpha}\right) - \frac{1}{(\alpha)^2}((e)^{\alpha T} - 1)\right)\right] + p_0 I_e D_0 (e)^{\alpha T}(M-T)] \quad (15)$$

Here there is no interest paid by the buyer. Hence, it is zero in (16).

$$\emptyset_2(T) = \frac{1}{T}[C(t)(e^{RT} - 1)\left[\frac{1}{RT} + \frac{RT}{4} - \frac{1}{2}\right] + D_O h \sum_{p=0}^{n-1} c_0\, e^{prt}\left[\frac{-R_0}{(\theta+\alpha)}\left((\theta+\alpha)\frac{T^2}{2} + \left(-\frac{(\theta+\alpha)}{2} + \frac{(\alpha)^2}{6} - \frac{(\theta+\alpha)}{2}\theta\right)T^3 + (\theta+\alpha)^2\frac{(T)^4}{4}\right)\right] + C_D\left[\frac{-R_0}{(\theta+\alpha)}\left(-(\theta+\alpha)T + \frac{(\theta+\alpha)^2(T)^2}{2!}\right)\right] + p_1 T + D_0 D f_c e_c \sum_{p=0}^{n-1} c_0\, e^{prt}\left[\frac{-R_0}{(\theta+\alpha)}\left((\theta+\alpha)\frac{T^2}{2} + \left(-\frac{(\theta+\alpha)}{2} + \frac{(\alpha)^2}{6} - \frac{(\theta+\alpha)}{2}\theta\right)T^3 + (\theta+\alpha)^2\frac{(T)^4}{4}\right)\right] - p_0 I_e D_0 \left[\left(\left(\frac{(T)(e)^{\alpha T}}{\alpha} - \frac{1}{(\alpha)^2}((e)^{\alpha T} - 1)\right)\right] + p_0 I_e D_0 (e)^{\alpha T}(M-T)\right] \quad (16)$$

To find the inventory cost will be minimum. The condition of $d\Phi_1(t)/dt = 0$ & $d\Phi_2(t)/dt = 0$ which gives the if $T^* = T_1$ for case 1 and $T^* = T_2$ for case 2. These functions are solved on MAPLE software to check their convexity. Then find the convexity of the total inventory cost with its numerical example and sensitivity analysis with the help of the graph also.

5. NUMERICAL SOLUTION

An example that takes into account for the model under supply chain with the preservation technology is to be considered as Ie = 0.14, Ip = 0.20, Θ = 0.01, α = 0.1, R0 = 100, R = 0.01, M = 15⁄365, $p0$ = 20, $c0$ = 15, H =1, β = 0.23, $h1$ = 2, $h2$ = 1, $c1$ = 9, $c2$ = 2, n = 8, ec = 1.44, Fe = 0.0026. $p1$ = 0.50.

These values for the case 1 M≤T then the most optimal duration of a cycle (T8) is 0.345 years, therefore the lowest cost of inventory is 4000.

Similarly, for the case 2 R0 = 100, Ie = 0.14, Ip = 0.20, Θ = 0.20, α = 0.1, R=0.01, M= 36⁄365, $P0$ = 20, $c0$ = 15, H = 1, β = 0.23, $h1$ = 2, $h2$ = 1, $c1$ = 9, $c2$ = 2, n = 8, Fe = 0.0026, $p1$ = 0.50.

The optimal cycle length for case 2 is 0.077 years, and the lowest cost of inventory is 3500.

The graph for convexity for case 2 is plotted in Figure 5

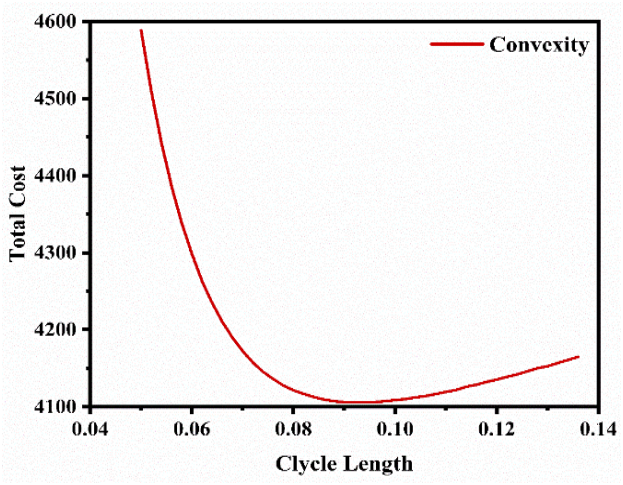

Figure 5. Convexity graph for the case 2

Sensitivity analysis. Since the majority of the input parameters in previous research had already undergone sensitivity analyses, only a limited number of input factors in the current investigation, specifically those that are exclusive to the study, were subjected to sensitivity analysis. Several findings from the analysis are shown in the given table for the Effect of parameters with their total cost and cycle length. Tables 1-7 show that changes in the considered parameters affect the total cost and cycle length, with higher carbon emission tax, preservation cost, inflation rate, and interest rates generally increasing the total cost, while more shipments and longer credit duration reduce the total cost.

Table 1. Effect of carbon emission tax

C_e	Cycle length(T*)	Total cost ψ_1 (T^*)
1.47	0.2976	4005
1.48	0.2976	4008
1.49	0.2976	4015

Table 2. Effect of the number of shipments

Shipment	Cycle length(T*)	Total cost ψ_1 (T^*)
1	0.2979	4661
2	0.2976	4401
2	0.2975	4270

Table 3. Effect of credit duration

Credit period (M)	Cycle length(T*)	Total cost ψ_1 (T^*)
5	0.7717	4096
10	0.4612	4066
15	0.2976	4006

Table 4. Effect of preservation cost

Preservation cost (p)	Cycle length(T*)	Total cost ψ_1 (T^*)
0.16	0.2976	4006
10.11	0.2976	4007
20.21	0.2976	4008

Table 5. Effect of inflation rate

Inflation rate (R)	Cycle length(T*)	Total cost ψ_1 (T^*)
0.02	0.2976	4006
0.03	0.2975	4022
0.04	0.2975	4040

Table 6. Effect of deterioration rate

Deterioration rate (ϕ)	Cycle Length(T*)	Total cost ψ_1 (T^*)
0.03	0.2976	4005
0.04	0.2861	3962
0.05	0.2698	3904

Table 7. Effect of interest earned and interest paid

Interest earned	Interest paid	Cycle length(T*)	Total cost ψ_1 (T^*)
0.16	0.13	0.2974	4006
0.18	0.15	0.2633	4051
0.20	0.17	0.2361	4194

We obtain additional useful findings from the tables above, which are explained:

1. The table demonstrates that rising carbon emission taxes result in an increase in overall cost, despite the fact that cycle duration is quite short.
2. According to the table, cycle length and total inventory cost decreased as the number of shipments increased.
3. As the credit duration grows, both the cycle length and total cost decrease.
4. As the cost of preservation grows, the length of the cycle remains constant, increasing the total cost.
5. Similarly, increasing inflation results in a decrease in cycle length and an increase in total cost.
6. Finally, it is found that while the rate of degradation rises, the cycle duration and overall cost drop.
7. Increasing both interests earned, and interest paid also results in decreasing cycle lengths while increasing total costs at the end of the table.

With the numerical examples and sensitivity analysis, it is observed that case 1 provides the optimal solution for this model and that the cycle length in case II is larger than the values in case 1.

6. CONCLUTION

The proposed inventory model underscores the critical role of inventory management in supply chain systems, providing accurate forecasting tools that support sales and marketing in preparing for future requirements. By integrating preservation technology, trade credit, inflation, and carbon emission considerations, the model offers a comprehensive framework that enhances decision-making and reduces overall inventory costs. The results demonstrate that increasing shipments significantly lowers total inventory costs, making the approach particularly beneficial for ordering policies. Moreover, learning rates are shown to exert a strong influence on cost behavior, highlighting the importance of incorporating dynamic learning effects into inventory strategies. While the current model achieves notable success, several avenues remain for further development. Future research could explore the impact of learning on processing and inspection activities, assess the effectiveness of alternative shipment policies such as power-of-two strategies, and extend the framework to include stochastic demand parameters, rework systems, and additional environmental factors. Addressing these unresolved inquiries will broaden the applicability of the model, enhance sustainability, and strengthen its relevance in modern supply chain management.

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