Global Journal of Modeling and Intelligent Computing (GJMIC)

Vol. 1, No. 1, January, 2021 ISSN: 2767-1917

Inventory Control of Non-Instantaneous Deteriorating Items with Time-Sensitive Holding Cost and Demand

Praveendra Singh, Indian Institute of Technology Roorkee, India (psingh@ma.iitr.ac.in)
Anshul Kumar, Indian Institute of Technology Roorkee, India (akumar@ma.iitr.ac.in)

ABSTRACT

In a real-life scenario, the holding cost is usually not constant. Constant holding cost is a common assumption in most of the inventory literature. This study formulates a deterministic economic order quantity model in which the demand as well as the holding cost function are time-dependent linear functions. The Particle Swarm Optimization technique is accomplished to find optimal results along with Newton Raphson method. Sensitivity analysis is accomplished to study the numerical outcomes.

Keywords: Deterioration, Linear; Time-dependent demand; Holding cost; Particle Swarm Optimization (PSO).

1. INTRODUCTION

Inventory prediction plays a significant impact on the business as each firm tries to minimize its cost and maximize the revenue. Inventory control is a balance between the total profit of the firm and the costs involving to controlinventory. The order quantity should be chosen in such a manner that it can minimize the total cost associated with inventory. Total variable costs include mainly two components, i.e., the costs of ordering and the cost of holding the inventory. Proper inventory management can reduce the capital tied up in the inventory.

At present, many inventory models have been mathematically formulated for controlling the size of an inventory. Deterioration of an item is a natural process which cannot be ignored in order to make decisions related to inventory management. Deterioration refers to the loss of quality or quantity of an item at any time. Chemicals, eatables, perfumes, pharmaceutical and radioactive substances, electronic equipment, fashion items, are some types of deteriorating items. Some items have no deterioration for a while and then deteriorate with a certain rate. This type of deterioration is called non-instantaneous deterioration. The deterioration of an item plays a negative role in the firm's total profit structure. So, it is necessary to study the effect of deterioration in order to model an inventory problem.

The effect of deterioration on inventory was analyzed by Ghare and Schrader (1963).He assumed that the item has exponential decay. He worked on a modified form of the basic EOQ model. Dave and Patel (1981) studied the effect of linear trends in the demand rate to obtain the optimum replenishment policy for perishable goods. Xu et al. (1990)developed a lot-sizing model for decaying goods with a finite planning horizon by considering the linear time-dependent demand. The quadratic time-sensitive demand under the assumption of finite planning horizon was assumed by Ghosh and Choudhuri (2006)to develop an inventory policy for perishable items. Dye (2007) has considered a price-dependent demand function to obtain economic lot-sizing and pricing policies for decaying items. The author permitted for shortages by considering the waiting time-dependent partial backordering. Alfares (2007)investigated an inventory model with demand as a function of available stock. The holding cost was assumed to be depended on the storage-time. An inventory model for a deteriorating item with finite replenishment rate was studied by Lee at al. (2009). The author considered a two-warehouse model by assuming time-sensitive demand rate. An EOQ model for perishable goods with price and time sensitive demand was developed by Dye and Hsieh (2010). The PSO metaheuristic was employed to solve the optimization problem. Bakker et al. (2012)has reviewed inventory studies for the deteriorating and perishable items. The review is an extension of the review presented by Goyal and Giri (2001). The inventory literature was classified based on the life and demand characteristic of deteriorating items. A two-warehouse EOQ model was developed for deteriorating items by Guchhait et al. (2013). The effect of payment delay was studied by taking displayed stock dependent demand rate. A hybrid PSO variant is used for optimization. Janssen et al. (2016) made an extension to the study of deteriorating inventory literature from

2012 to 2015. The review includes a wide classification of inventory and supply chain studies for deteriorating goods. A deteriorating item inventory model was considered by Singh et al. (2017). In the model, the demand rate was taken to be two-stage time-dependent and time proportional deterioration. Bhunia et al. (2017)studied partially integrated production inventory model with advertisement and price-dependent demand. The interval-valued inventory costs were considered in the model. The PSO metaheuristic was used to illustrate the model. An inventory model for deteriorating items was modelled by Chen et al. (2019). This model considered a price and stock sensitive demand to obtain the suitable ordering policy. Optimal ordering and replenishment decisions are studied by Li et al. (2019)for non-instantaneous deteriorating items. The length of the non-deterioration period was assumed to depend on the preservation technology investment. Tiwari et al. (2020) modelled a lot-sizing model for the perishable items with lot-size dependent trade-credit policy. The shortages are assumed to befully backlogged in this model. Dye (2020)studied an inventory model for deteriorating items by using the psychic stock effect. The price and marketing dependent demand rate was used to model the problem. The EOQ model was investigated by Cardenos-Barron et al. (2020) by considering non-linear stock dependent demand rate and carrying cost. This model was studied by using a trade-credit policy.

In the present investigation, an inventory model for non-instantaneous deteriorating item has been proposed. The demand rate and inventory carrying cost are two-step linear time-dependent functions. The demand rate and inventory carrying cost are constant for the non-deteriorating cycle. For the deterioration period, both the demand and holding costs are taken as linear function of time. The particle swarm optimization (PSO) technique has been implemented to find the numerical outcomes and sensitivity analysis. The present study is systematized as follows: In section 1.1, the preliminaries of PSO is presented. The notations and assumption to formulate the mathematical model are listed in section 2.1 and 2.2, respectively. The description of the EOQ model is presented in section 2.3. The analysis and mathematical formulation have been developed in the section 2.4. Numerical results and sensitivity analysis for the considered model are provided in sections3and 3.1, respectively. The noble features and limitations of the study are discussed in section 4.

1.1 Particle Swarm Optimization(PSO)

It is a metaheuristic approach to optimize computationally hard optimization models and is widely used approach, which depends on the dynamics of swarms. It uses the concept of social communication to solve an optimization problem by choosing the best particle in the solution space. Kennedy and Eberhart (1995)discovered the concept of PSO by considering the behavior of a group of birds. The flock of birds move in order to search a particular place. It includes a group of particles that move in the entire problem space. The generation of the population is random, and search for the solution is done by updating the iterations. A particle carries a velocity and position that is randomly initialized at the beginning of the process.
In an i^{th} generation, the velocity of a particle is given by

$$v_i^{(j)} = v_{i-1}^{(j)} + c_1 rand_1 (p_{best}^{(j)} - X_{i-1}^{(j)}) + c_2 rand_2 (g_{best} - X_{i-1}^{(j)}) \tag{1}$$

The position update equation of particle j in a generation i is

$$X_i^{(j)} = X_{i-1}^{(j)} + v_i^{(j)} \tag{2}$$

where,

c_k	:	Acceleration factors, $k=1,2.$
$rand_k$	:	Random number selected uniformly between $(0,1); k=1,2.$
$p_{best}^{(j)}$	:	Personal best position.
g_{best}	:	Global best position.

The particle initialization is an important element in the implementation of PSO. Shi and Eberhart (1998) gave an idea to include inertia weight to manage exploitation and exploration. Clerc and Kennedy (2002) gave a method to balance exploitation and exploration by presenting constriction factor.

The velocity update equation is then, given by

$$v_i^{(j)} = wv_{i-1}^{(j)} + c_1\, rand_1 (p_{best}^{(j)} - X_{i-1}^{(j)}) + c_2\, rand_2 (\mathrm{g}_{best} - X_{i-1}^{(j)}) \tag{3}$$

where w is inertia weight.

Flow-Chart:

The PSO metaheuristic can be summarized using the flow-chart given below:

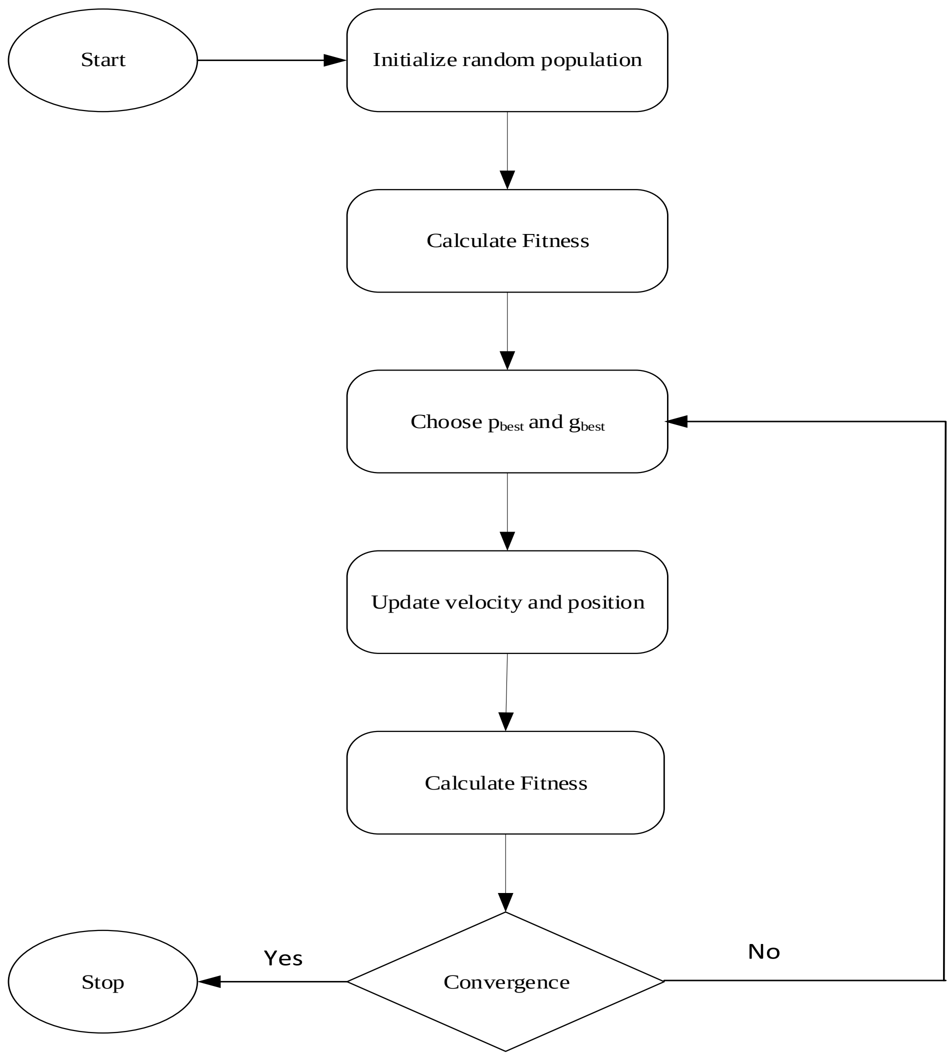

Figure 1: The flow-chart for the particle swarm optimization metaheuristic

2. MATHEMATICAL MODEL

The notations and symbols required for the formulation of the model are given as follows:

2.1 Notations

The symbols to derive the mathematical model are as follows:

θ_0 : Deterioration rate

$\lambda(t)$	:	Demand rate
α	:	Demand component in the cycle $(0, \tau)$
β	:	Linearity constant
$I(t)$	:	The stock at the time t
T	:	Replenishment period
q	:	Initial stock level
C_0	:	Cost of ordering
$h(t)$	:	Holding cost function
h_1	:	Constant holding cost
h_2	:	Constant of linearity for the holding cost function
C_d	:	The deterioration cost for each unit item
τ	:	The time at which the decay starts
TC	:	The total cost function

2.2 Assumptions

The assumptions that are needed to develop the inventory model are as follows:

1. Initially there is no inventory in the system.
2. The demand rate is a linear time dependent function.
3. The deterioration does not occur in the interval (0, τ). After a time τ, the item starts to deteriorate with a constant rate θ_0, where $0 < \theta_0 << 1$.
4. The replacement or repair of the item is not allowed.
5. The planning horizon is infinite.
6. The lead time is negligible.
7. There are no shortages.

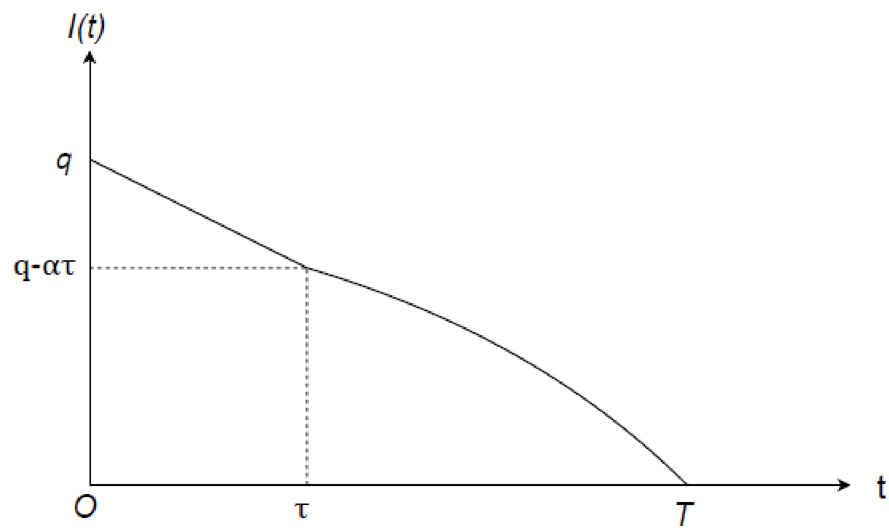

Figure 2: Change in the stock with time

2.3 Model Formulation

The inventory cycle begins at the time $t = 0$ with an initial stock q . Deterioration of the item does not occur in the interval $[0, \tau]$, and the demand rate (α) is constant in this time period. The stock decreases in $[\tau, T]$ with the collective effect of deterioration and demand.

The demand and holding cost functions are defined as:

$$\lambda(t)=\begin{cases}\alpha, & 0\le t\le\tau\\ \alpha+\beta(T-\tau), & \tau\le t\le T\end{cases} \tag{4}$$

and

$$h(t)=\begin{cases}h_1, & 0<t\le\tau\\ h_1+h_2t, & \tau<t\le T\end{cases} \tag{5}$$

From figure 1, the mathematical formulation of the proposed model can be done.

We denote $T_1=T-\tau$ (6)

The stock at a time $t\in[0,\tau]$ is

$$I(t)=q-\alpha t \tag{7}$$

The equation governing the stock level for the period $[0,T_1]$ is:

$$\frac{dI(t)}{dt}+\theta_0 I(t)=-\left(\alpha+\beta(t-\tau)\right),\qquad 0\le t\le T_1 \tag{8}$$

subject to: $\quad I(0)=q-\alpha\tau,$ (9)

2.4The Analysis

The inventory level for $0\le t\le T_1$ is

$$I(t)=\left[q-\alpha\tau-\alpha\left(t+\frac{\theta_0t^2}{2}+\frac{\theta_0{}^2t^3}{6}\right)-\beta\left(\frac{t^2}{2}-\tau t+\theta_0\left(\frac{t^3}{3}-\frac{\tau t^2}{2}\right)+\frac{\theta_0{}^2}{2}\left(\frac{t^4}{4}-\frac{\tau t^3}{3}\right)\right)\right]e^{-\theta_0 t} \tag{10}$$

Since $0<\theta_0<<1,$ the higher powers θ_0 are neglected in the expansion $e^{\theta_0 t}$ to obtain the above solution.

The ordering quantity q by using the condition, $I(T_1)=I(T-\tau)=0$ is obtained as

$$q=\alpha\tau+\alpha\left(t+\frac{\theta_0T_1^2}{2}+\frac{\theta_0{}^2T_1^3}{6}\right)+\beta\left(\frac{T_1^2}{2}-\tau T_1+\theta_0\left(\frac{T_1^3}{3}-\frac{\tau T_1^2}{2}\right)+\frac{\theta_0{}^2}{2}\left(\frac{T_1^4}{4}-\frac{\tau T_1^3}{3}\right)\right) \tag{11}$$

The average total cost consists of (i) ordering cost, (ii) carrying cost, and (iii) deterioration cost.

(i) Cost of ordering: $OC=C_0$

(ii) Cost of holding: $HC=\int_0^T h(t)I(t)\,dt=\int_0^\tau h_1(q-\lambda_1 t)dt+\int_0^{T_1}(h_1+h_2t)I(t)\,dt$

After some algebraic manipulation, we have

$$\begin{aligned}HC=\Bigg[&h_1\left[\frac{1}{2}(\mathrm{q}+(\mathrm{q}-\alpha\tau))\,\tau\right]+(T-\tau)\left(\left(h_1\left(\frac{2(\alpha-\tau\beta)}{\theta_0}+\frac{6\beta}{\theta^2{}_0}\right)+h_2\left(\frac{8(\alpha-\tau\beta)}{\theta_0^2}+\frac{26\beta}{\theta_0^3}\right)\right)\right)e^{-\theta_0(T-\tau)}+(T-\tau)^2\left(h_1\left(\frac{(\alpha-\tau\beta)}{2}+\frac{5\beta}{2\theta_0}\right)+h_2\left(\frac{3(\alpha-\tau\beta)}{\theta_0}\right.\right.\\
&\left.\left.+\frac{25\beta}{2\theta_0^2}\right)\right)e^{-\theta_0(T-\tau)}+(T-\tau)^3\left(h_1\left(\frac{\beta}{2}\right)+h_2\left(\frac{(\alpha-\tau\beta)}{2}+\frac{7\beta}{2\theta_0}\right)\right)e^{-\theta_0(T-\tau)}+(T-\tau)^4\left(h_2\left(\frac{\beta}{2}\right)\right)e^{-\theta_0(T-\tau)}+\left(h_1\left(\frac{3(\alpha-\tau\beta)}{\theta^2{}_0}+\frac{6\beta}{\theta^3{}_0}\right)+h_2\left(\frac{9(\alpha-\tau\beta)}{\theta_0^3}+\frac{26\beta}{\theta_0^4}\right)\right)e^{-\theta_0(T-\tau)}\\
&+(T-\tau)\left(\frac{h_1}{\theta_0}+\frac{h_2}{\theta_0^2}\right)(\alpha-\tau\beta)+(T-\tau)^2\left(h_1\left(\frac{(\alpha-\tau\beta)}{2}+\frac{\beta}{2\theta_0}\right)+h_2\left(\frac{(\alpha-\tau\beta)}{2\theta_0}+\frac{\beta}{2\theta_0^2}\right)\right)+(T-\tau)^3\left(h_1\left(\frac{\beta}{3}+\frac{(\alpha-\tau\beta)\theta_0}{6}\right)+\frac{(\alpha-\tau\beta)\theta_0}{6}\right)+h_2\left(\frac{(\alpha-\tau\beta)}{6}+\frac{\beta}{3\theta_0}\right)\Bigg)\\
&+(T-\tau)^4\left(\frac{h_1\beta\theta_0}{8}+\frac{c_2\beta}{8}\right)-h_1\left(\frac{3(\alpha-\tau\beta)}{\theta_0{}^2}+\frac{6\beta}{\theta_0{}^3}\right)-h_2\left(\frac{9(\alpha-\tau\beta)}{\theta_0{}^3}+\frac{6\beta}{\theta_0{}^4}\right)\Bigg]\end{aligned} \tag{12}$$

(iii) Deterioration cost:

$$DC = C_d \left[q - \alpha\tau - \int_0^{T_1} \left[\alpha + \beta(t-\tau) \right] dt \right]$$

$$= C_d \left[(q-\alpha\tau) + (T-\tau)(\tau\beta-\alpha) - \frac{\beta}{2}(T-\tau)^2 \right] \tag{13}$$

The average total cost TC for inventory cycle [0, T] is

$$TC(T) = \frac{1}{T}[OC + HC + DC]$$

or

$$\begin{aligned} TC(T) = {} & \frac{c_0}{T} + \frac{1}{T}\Bigg[h_1 \left[\frac{1}{2}(\mathrm{q} + (\mathrm{q} - \alpha\tau))\,\tau \right] + (T-\tau)\Bigg(\Bigg(h_1 \left(\frac{2(\alpha-\tau\beta)}{\theta_0} + \frac{6\beta}{\theta^2{}_0} \right) + h_2 \left(\frac{8(\alpha-\tau\beta)}{\theta_0^2} + \frac{26\beta}{\theta_0^3} \right)\Bigg)\Bigg) e^{-\theta_0(T-\tau)} + (T-\tau)^2 \Bigg(h_1 \left(\frac{(\alpha-\tau\beta)}{2} + \frac{5\beta}{2\theta_0} \right) \\ & + h_2 \left(\frac{3(\alpha-\tau\beta)}{\theta_0} + \frac{25\beta}{2\theta_0^2} \right)\Bigg) e^{-\theta_0(T-\tau)} + (T-\tau)^3 \Bigg(h_1 \left(\frac{\beta}{2} \right) + h_2 \left(\frac{(\alpha-\tau\beta)}{2} + \frac{7\beta}{2\theta_0} \right)\Bigg) e^{-\theta_0(T-\tau)} + (T-\tau)^4 \left(h_2 \left(\frac{\beta}{2} \right) \right) e^{-\theta_0(T-\tau)} + \Bigg(h_1 \left(\frac{3(\alpha-\tau\beta)}{\theta^2{}_0} + \frac{6\beta}{\theta^3{}_0} \right) \\ & + h_2 \left(\frac{26\beta}{\theta_0^4} + \frac{9(\alpha-\tau\beta)}{\theta_0^3} \right)\Bigg) e^{-\theta_0(T-\tau)} + (T-\tau)\left(\frac{h_1}{\theta_0} + \frac{h_2}{\theta_0^2} \right)(\alpha-\tau\beta) + (T-\tau)^2 \Bigg(h_1 \left(\frac{(\alpha-\tau\beta)}{2} + \frac{\beta}{2\theta_0} \right) + h_2 \left(\frac{(\alpha-\tau\beta)}{2\theta_0} + \frac{\beta}{2\theta_0^2} \right)\Bigg) + (T-\tau)^3 \Bigg(h_1 \Bigg(\frac{(\alpha-\tau\beta)\theta_0}{6} \\ & + \frac{\beta}{3} \Bigg) + \frac{(\alpha-\tau\beta)\theta_0}{6} \Bigg) + h_2 \left(\frac{(\alpha-\tau\beta)}{6} + \frac{\beta}{3\theta_0} \right)\Bigg) + (T-\tau)^4 \left(\frac{h_1\beta\theta_0}{8} + \frac{c_2\beta}{8} \right) - h_1 \left(\frac{3(\alpha-\tau\beta)}{\theta_0{}^2} + \frac{6\beta}{\theta_0{}^3} \right) - h_2 \left(\frac{9(\alpha-\tau\beta)}{\theta_0{}^3} + \frac{6\beta}{\theta_0{}^4} \right)\Bigg] \\ & + \frac{C_d}{T}\left[(q-\alpha\tau) + (T-\tau)(\tau\beta-\alpha) - \frac{\beta}{2}(T-\tau)^2 \right] \end{aligned} \tag{14}$$

For the minimum value of $TC(T)$, we must have

$$\frac{\partial TC(T)}{\partial T} = 0 \qquad \text{provided} \qquad \frac{\partial^2 TC(T)}{\partial T^2} > 0 \tag{15}$$

The root of equation (15) will give the optimal value of the cycle length. A numerical optimization method can be used to get the optimal inventory cycle length T. Here, PSO metaheuristic will be implemented to get the minimum overall cost.

3. NUMERICAL ILLUSTRATIONS

The proposed inventory model can be useful in the study of food items (eatables) inventory. The following set of cost elements and non-cost parameters are considered to demonstrate the validity and utility of the inventory model:

$h_1 = \$0.50/unit/day,\ C_0 = \$90.00,\ C_d = \$20.0/unit,\ \alpha = 20\,units,\ \beta = 0.8,\ \tau = 0.3\,days, \theta_0 = 0.02, h_2 = 0.06.$

Newton Raphson method gives the optimal value of the inventory cycle as $T^* = 2.8$ days. It is noted that the sufficient optimality condition $\frac{\partial^2 TC(T)}{\partial T^2} = 2.9462 > 0$ is also satisfied. For the chosen default parameter values, we get $TC(T^*) = \$57.9$ and $Q^* = 59.24$ units.

Figure 3 shows the convexity of cost function by taking different values of demand rate. Also, the optimal cost value is increasing as we increase the constant demand rate. The PSO technique is used to optimize the total cost function. The PSO algorithm is coded in MATLAB software. Based on numerical experiments, it is observed that 10 to 15 iterations of PSO with population size 50 are enough to obtain the optimal cycle length. Figure 4 depicts the convergence of Newton Raphson method (NRM) and the particle swarm optimization technique for the proposed example. The optimal solution using Newton Raphson method also provides numerical results to the desired accuracy. By making comparison with NRM, it can be concluded that the efficiency of PSO is good enough to get the optimal solution.

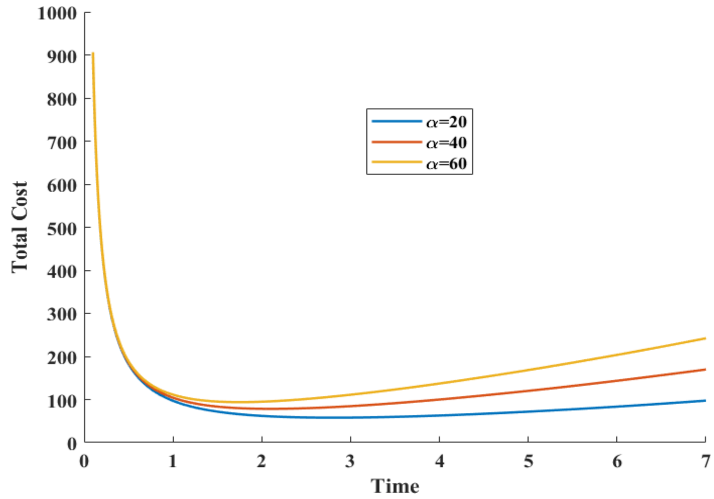

Figure 3: The convex nature of the cost function at different values of constant demand rate

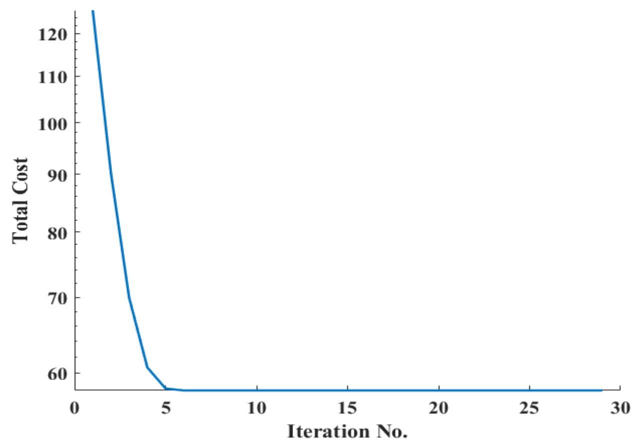

Figure 4(I): Convergence of Newton Raphson method

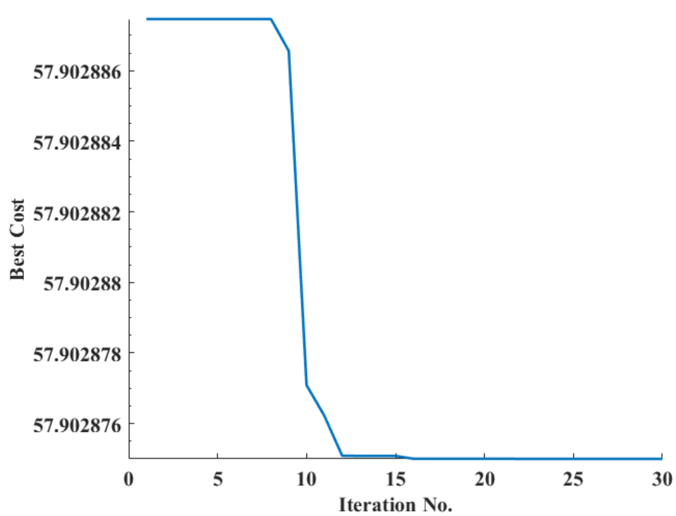

Figure 4(II): Convergence of PSO

3.1 Sensitivity analysis

Table 1: Sensitivity analysis for cost parameters

Cost Parameter	Changein parameter (%)	Optimal Cycle T*	Changein T* (%)	$TC(\mathrm{T}^*)$	Changein $TC(\mathrm{T}^*)$ (%)
h_1	+40	2.5833	-7.88	63.6	+9.91
	+20	2.6873	-4.18	60.83	+5.06
	0	2.8045	0	57.90	0
	-20	2.9389	+4.79	64.82	-5.32
	-40	3.0954	+10.37	51.57	-10.93
C_0	+40	3.2463	+15.75	69.79	+20.53
	+20	3.0370	+8.29	64.06	+10.64
	0	2.8045	0	57.90	0
	-20	2.5427	-9.33	51.17	-11.62
	-40	2.2380	-20.20	43.64	-24.62
C_d	+40	2.6284	-6.30	61.57	+6.34
	+20	2.7133	-3.25	59.78	+3.24
	0	2.8045	0	57.90	0
	-20	2.9080	+3.69	55.94	-3.396
	-40	3.0229	+7.79	53.87	-6.96
h_2	+40	2.7613	-1.54	58.37	+0.82
	+20	2.7829	-0.77	58.14	+0.41
	0	2.8045	0	57.90	0
	-20	2.8281	+0.84	57.66	-0.42
	-40	2.8524	+1.71	57.41	-0.85

Table 2: Sensitivity analysis for non-cost parameters

Non-cost Parameter	Changein parameter (%)	Optimal Cycle T*	Changein T* (%)	$TC(\mathrm{T}^*)$	Changein $TC(\mathrm{T}^*)$ (%)
α	+40	2.4465	-12.76	66.93	+15.59
	+20	2.6079	-7.01	62.60	+8.11
	0	2.8045	0	57.90	0
	-20	3.0532	+8.87	52.75	-8.89
	-40	3.3779	+20.44	47.01	-18.80
β	+40	2.7556	-1.74	58.41	+0.88
	+20	2.7791	-0.90	58.16	+0.44
	0	2.8045	0	57.90	0
	-20	2.8316	+0.96	57.64	-0.45
	-40	2.8593	+1.95	57.37	-0.92
θ_0	+40	2.6137	-6.80	61.75	+6.65
	+20	2.7054	-3.53	59.87	+3.39
	0	2.8045	0	57.90	0
	-20	2.9164	+3.99	55.84	-3.55
	-40	3.0418	+8.46	53.69	-7.28
τ	+40	2.8327	+1.00	56.61	-2.22
	+20	2.8180	+0.48	57.25	-1.13
	0	2.8045	0	57.90	0
	-20	2.7918	-0.45	58.57	+1.16
	-40	2.7791	-0.90	59.26	+2.35

The cost parameters such as holding cost, deterioration cost and setup cost are varied by -40% to 40% for the exploration of sensitivity; the corresponding optimal costs are tabulated in the table 1. The ordering cost and constant holding cost parameters are susceptible, and the coefficient of variable holding cost seems to have an insignificant impact on the optimal cost function value. The non-cost parameters like deterioration rate, demand rate, and non-deteriorating period are varied by -40 % to +40 % to analyze the behavior of these parameters towards the optimal cost function. It is evident that the demand rate will affect the cost function value and can also be seen in table 2. Although deterioration is taken very small, it has a considerable effect on the total cost. Overall, all the parameters are affecting the cost function as well as the inventory cycle length. The changes are relatively consistent, so an approximate guess of cost function can be made by analyzing the sensitivity results.

4. CONCLUSION

An inventory control model with deterministic time sensitive demand is developed for deteriorating items. Demand is constant for the non-deterioration period, and then it is depicted by a linear function of time. The inventory carrying cost function was also taken as time dependent. When an item is introduced in the market for sell, the demand for that item remains constant for a few times, and then it may increase due to the promotion and reviews of that item. The item is considered non-deteriorated for a fixed time period, and after that, it starts deteriorating at a constant rate. The PSO technique is used to find numerical results. It is seen that the PSO facilitates the results with the desired accuracy. It is seen that the variations in the parameters cause a significant impact on the total cost per unit period length. The optimal period length and the order quantity obtained by minimizing the total cost that may be helpful for making the decisions and maximizing the profits of the concerned organization. The proposed model can be further extended by assuming a stochastic demand that approaches to reality more rather than a deterministic one. We can study that case as well, where the demand function of the model may follow some distributions. The constant deterioration rate is far from reality. It may follow some known distribution. The rate of inflation may be involved in the model to overcome the uncertain fluctuations in the global market.

REFERENCES

Alfares, H. K. (2007). Inventory model with stock-level dependent demand rate and variable holding cost. In International Journal of Production Economics,108 (1-2),259–265. DOI: 10.1016/j.ijpe.2006.12.013.

Bakker, M.,Riezebos, J. & Teunter, R. H. (2012). Review of inventory systems with deterioration since 2001. European Journal of Operational Research, 221 (2), 275–284. DOI: 10.1016/j.ejor.2012.03.004.

Bhunia, A. K., Shaikh, A. A. & Cárdenas-Barrón, L. E. (2017). A partially integrated production-inventory model with interval valued inventory costs, variable demand and flexible reliability. In Applied Soft Computing ,55, 491–502. DOI: 10.1016/j.asoc.2017.02.012.

Cárdenas-Barrón L. E., Shaikh A. A., Tiwari S. & Treviño-Garza G. (2020). An EOQ inventory model with nonlinear stock dependent holding cost, nonlinear stock dependent demand and trade credit. Comput Ind Eng 139:105557. https://doi.org/10.1016/j.cie.2018.12.004.

Chen L., Chen X., Keblis M. F. &Li G. (2019). Optimal pricing and replenishment policy for deteriorating inventory under stock-level-dependent, time-varying and price-dependent demand. Comput Ind Eng 135,1294–1299. https://doi.org/10.1016/j.cie.2018.06.005.

Clerc, M.& Kennedy, J. (2002). The particle swarm - explosion, stability, and convergence in a multidimensional complex space. In IEEE Trans. Evol. Computat, 6 (1),58–73. DOI: 10.1109/4235.985692.

Dave, U. & Patel, L. K. (1981). (T, Si) Policy inventory model for deteriorating items with time proportional demand. In Journal of the Operational Research Society, 32 (2),137–142. DOI: 10.1057/jors.1981.27.

Dye, C. Y. (2007): Joint pricing and ordering policy for a deteriorating inventory with partial backlogging. In Omega, 35 (2),184–189. DOI: 10.1016/j.omega.2005.05.002.

Dye C. Y. &Hsieh T. P. (2010). A particle swarm optimization for solving joint pricing and lot-sizing problem with fluctuating demand and unit purchasing cost. Comput Math with Appl,60, 1895–1907. https://doi.org/10.1016/j.camwa.2010.07.023.

Dye C. Y. (2020). Optimal joint dynamic pricing, advertising and inventory control model for perishable items with psychic stock effect. Eur J Oper Res, 283, 576–587. https://doi.org/10.1016/j.ejor.2019.11.008.

Ghare P. M.& Schrader G. H. (1963). A model for exponentially decaying inventory system, International Journal of Production Research, 21,449–460.

Ghosh, S. K. & Chaudhuri, K. S. (2006). An EOQ model with a quadratic demand, time-proportional deterioration and shortages in all cycles. In International Journal of Systems Science, 37 (10),663–672. DOI: 10.1080/00207720600568145.

Goyal, S. K.& Giri, B. C. (2001). Recent trends in modelling of deteriorating inventory. In European Journal of Operational Research, 134 (1) 1–16. DOI: 10.1016/S0377-2217(00)00248-4.

Guchhait P., Maiti M. K.& Maiti M. (2013). Two storage inventory model of a deteriorating item with variable demand under partial credit period. Appl Soft Comput,13, 428–448. https://doi.org/10.1016/j.asoc.2012.07.028.

Janssen, L., Claus, T. &Sauer, J. (2016). Literature review of deteriorating inventory models by key topics from 2012 to 2015. In International Journal of Production Economics, 182, 86–112. DOI: 10.1016/j.ijpe.2016.08.019.

Kennedy, J. & Eberhart, R. (1995). Particle swarm optimization. In: 1995 IEEE international conference on neural networks. IEEE. Neural Networks Council: IEEE.

Lee, C. C.&Hsu, S. L. (2009). A two-warehouse production model for deteriorating inventory items with time-dependent demands. In European Journal of Operational Research, 194 (3),700–710. DOI: 10.1016/j.ejor.2007.12.034.

Li, G., He, X., Zhou, J.& Wu, H. (2019). Pricing, replenishment and preservation technology investment decisions for non-instantaneous deteriorating items. In Omega,84, 114–126. DOI: 10.1016/j.omega.2018.05.001.

Shi, Y.& Eberhart, R. (1998). A modified particle swarm optimizer. In: 1998 IEEE International Conference on Evolutionary Computation proceedings. IEEE World Congress on Computational Intelligence, May 4-May 9, 1998, Anchorage, Alaska, USA.

Singh, T., Mishra, Pandit J.& Pattanayak, H. (2017). An optimal policy for deteriorating items with time-proportional deterioration rate and constant and time-dependent linear demand rate. In J Ind Eng Int,13 (4), 455–463. DOI: 10.1007/s40092-017-0198-6.

Tiwari S., Cárdenas-Barrón L. E.& Shaikh A. A., Goh M. (2020). Retailer's optimal ordering policy for deteriorating items under order-size dependent trade credit and complete backlogging. Comput Ind Eng 139:105559. https://doi.org/10.1016/j.cie.2018.12.006.

Xu, H & Wang, H. P. (1990): An economic ordering policy model for deteriorating items with time proportional demand. In European Journal of Operational Research, 46 (1),21–27. DOI: 10.1016/0377-2217(90)90294-L.