Research Article

Innovative investigation of stock-sensitive demand induced economic order quantity (EOQ) model for deterioration by means of inconsistent holding cost functions

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Abstract

This study, sets up an EOQ model for spoiling commodities by means of inventory tempt demand. Holding cost is measured as portion of inventory echelon for model I and linearly stock dependent for model II. Mathematical models are also presented for these two models. Next, approximate optimal solution for these models is derived. Optimal solution is obtained with the help of algorithm. Numerical results are established to validate the solution algorithm. Second order approximations are applied for finding closed form outcomes. Sensitivity investigation is provided for variation of several key parameters to validate the model.

Keywords Deterioration · Inventory dependent demand · Linear · Optimality · Ordering cost

1 Introduction

The deterioration is a natural process for any item (living/non-living) in the universe. Most of the commodities deteriorate with time. Deterioration is the method of becoming spoiled or substandard in quality, performance or circumstance. Examples of the deterioration are (1) marble worsening embraces salt crystallization, aqueous termination, microbiological growth, human contact and innovative structure (2) flood condition in the country has deteriorated quickly (3) health of a person deteriorated week by week due to brutal sickness (4) company's financial condition deteriorated due lock off and labor strike.

Inventory management is mostly based on the statement that an item is stock-level undergoes no failure in distinction. Stock-induced method is the actuality of current world, where trader in every phase, commodities to offer stock-level as a means of purchasing the sales. It is observed from several investigations that demand rate depends on available inventory in the store. In most cases customers are attracted by more stock in the warehouse.

2 Literature survey

Levin et al. [1] presented the customers are motivated on the subsistence of inventory in the superstore. Silver and Peterson [2] presented that the sales at trade echelon and inventory displayed both are proportional to each other. Gupta and Vrat [3] first recognized an EOQ model for stock-linked demand in utilization environment. Van der Veen [4] presented an EOQ model for supply induced holding price. Weiss [5] presented the model allowing for holding cost is non linear function of stock-point. Giri and Chaudhuri [6] established EOQ model for unpreserved item for consumption with stock-associated demand and erratic holding cost. Padmanabhan and Vrat [7] established EOQ model for stock-dependent advertising rate under deterioration. Hou [8] developed an EOQ model for stock-dependent expenditure rate under deterioration, shortages and price rises. Datta and Paul [9] considered a system where demand depends on both stock-stage and selling charge. Balkhi and Benkherouf [10] designed an EOQ model by means of inventory linked and time-sensitive demand

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rates for fading objects. Teng et al. [11] recognized a model to allow in favor of (1) a non-ending inventory (2) the inventory capacity is limited (3) the objective is profit maximization and (4) constant deterioration. Yang [12] considered an inventory model under inventory-stimulated demand with shortages. Wu et al. [13] pointed out a most favorable order size for non-instant deteriorating foodstuffs for stock-induced demand and fractional backlogging. Soni and Shah [14] developed a model to establish inventory policy for seller where demand rate is incompletely stable and dependent on stock under progressive credit periods to resolve account. Sicilia et al. [15] considered a deterministic EOQ model for worsening item with time changeable demand and allowable shortages. Other parallel research work in this direction are by Goh [16], Chung and Tsai [17], Modarres and Taimury [18], Rabbani et al. [19], Manna and Chaudhuri [20], Donaldson et al. [21], Ritchie [22], etc.

Khanra et al. [23] designed an EOQ model with variable demand for weakening substances and trade credits. Teng et al. [24] presented a model for non-diminishing time induced demand under permitted delay in payments. Tripathi et al. [25] addressed an EOQ model for failing commodities with stock-linked demand.

In many corporations deterioration of commodities is a genuine problem. Deteriorating inventory administration is one of numerous critical concern that supply chain members are facing since a number of past years. In most of the EOQ models in the literature, rate of weakening of commodities is sighted as an exogenous unpredictable, which is not subject to have power over. In factual market some foodstuff like; green vegetables, fruits, explosive liquids and others loss their originality constantly due to spoilage etc. Deterioration plays a crucial role in all type of business transactions. Maintenance of deteriorating items in its original shape is a big challenge for retailer as well as customer. The majority of items in the world go down over time. Ghare and Schrader [26] established an EOQ model with exponentially decomposing inventory. Tripathi [27] presented an EOQ model in favor of weakening items with linearly increasing demand. Hariga [28] established inventory models for deteriorating objects with increasing demand outline. Dye [29] considered the consequence of skill outlay on refrigeration to get better profit for deteriorating goods. Sarkar et al. [30], Wu et al. [31], Wang et al. [32], Wu et al. [33], Tripathi and Uniyal [34], Tripathi and Shweta [35] etc. developed EOQ models for desertion objects.

The purpose of this effort is to diminish total inventory cost for different holding costs. The results of this research work are expected to help the practitioners for such product while considering the item by means of stock-sensitive demand. Remaining of the paper is planned as follows: Notations and assumption are used in the model are mentioned in Sect. 2. Mathematical formulation is conversed in Sect. 3 followed by optimal solution. Solution algorithm and numerical example are discussed in Sects. 4 and 5 respectively. In Sect. 6 sensitivity analysis is detailed. Conclusion and future research directives are given in Sect. 7.

3 Notations and assumptions

Following notations are used throughout the manuscript:

3.1 Notations

K	Ordering cost/order
c	Cost of item/unit
R	Demand rate
h	Holding cost parameter
$q(t)$	Inventory point at time 't'
θ	Deterioration rate and, $0 \le \theta \le 1$
Q	Order quantity
T	Cycle time
HC	Holding cost
CD	Cost of deterioration
TRC	Total relevant cost/cycle

3.2 Assumptions

In addition following assumptions are made to build up the model proposed in the manuscript:

- Cost of item is independent with the size.
- Lead time is negligible.
- There are instantaneous replenishments.
- All cycles are alike.
- Demand rate is stock-dependent i.e. $R = \alpha + \beta q(t)$, $\alpha > 0$ consumption rate and β is stock-dependent constraint
- Deterioration rate is invariable.
- Holding cost is linked with non-linear inventory linked for model I
- Rate of change of holding cost function is linearly stock-dependent for model II

4 Mathematical formulation

At opening of every cycle, the level of inventory decreases due to customer's requirement. Inventory depleted due to demand and deterioration and becomes zero at the end of cycle time. Inventory level $q(t)$ is represented by subsequent differential equation (Fig. 1).

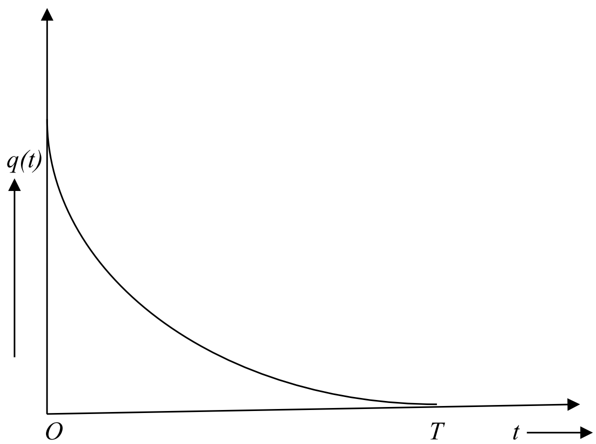

Fig. 1 $I(t)$ versus time t

$$\frac{d\{q(t)\}}{dt} + \theta q(t) = -R, \quad 0 \le t \le T \tag{1}$$

Cost of deterioration during [0, T] is:

$$DC = c\left[Q - \int_0^T \{\alpha + \beta q(t)\}dt\right] = c\left\{Q - \frac{\alpha\theta T}{\theta+\beta} - \beta\left(Q + \frac{\alpha}{\theta+\beta}\right)\left(\frac{1 - e^{-(\theta+\beta)T}}{\theta+\beta}\right)\right\} \tag{6}$$

Taking second order approximation for exponential term, Eq. (6), becomes

$$DC = c\left\{Q - (\alpha + \beta Q)T + \frac{\beta T^2}{2}(\alpha + (\theta+\beta)Q)\right\} \tag{7}$$

Therefore, total relevant cost/cycle:

TRC = (ordering cost + holding cost + cost of deterioration)/T

$$= \frac{1}{T}\left[K + \frac{hQ^{n+1}}{n+1} + c\left\{Q - (\alpha + \beta Q)T + \frac{\beta T^2}{2}(\alpha + (\theta+\beta)Q)\right\}\right] \tag{8}$$

Using Eqs. (4), (8) becomes

$$TRC = \frac{2K\alpha^2}{Q\{2\alpha - (\theta+\beta)Q\}} + \frac{2h\alpha^2 Q^n}{(n+1)\{2\alpha - (\theta+\beta)Q\}} + \frac{2c\alpha^2}{\{2\alpha - (\theta+\beta)Q\}} - c(\alpha + \beta Q) + \frac{c\beta Q\{2\alpha - (\theta+\beta)Q\}\{\alpha + (\theta+\beta)Q\}}{4\alpha^2}. \tag{9}$$

With condition $q(0) = Q$. Solution of Eq. (1) is given by:

$$q(t) = \left(Q + \frac{\alpha}{\theta+\beta}\right)e^{-(\theta+\beta)t} - \frac{\alpha}{\theta+\beta} \tag{2}$$

Using $q(T) = 0$, Eq. (2), becomes:

$$T = \frac{1}{\theta+\beta}\log\left\{1 + \frac{(\theta+\beta)Q}{\alpha}\right\} \tag{3}$$

Taking second order approximation of logarithm, (3), reduces to:

$$T = \frac{Q}{2\alpha^2}\{2\alpha - (\theta+\beta)Q\} \tag{4}$$

4.1 Model I: non linear inventory induced holding cost

In this present model, it is presumed that holding cost for an amount $dq(t)$ of the product up to time 't' is $h\{q(t)\}^n dq(t)$, where 'n' is any positive integer and greater than one. Thus

$$HC = \int_0^Q h\{q(t)\}^n dq(t) = \frac{hQ^{n+1}}{n+1} \tag{5}$$

4.2 Model II: linear inventory—induced holding cost

In this case, holding cost rate is considered linearly-inventory dependent:

$$\frac{d(HC)}{dt} = h\{\alpha + \beta I(t)\} \tag{10}$$

Holding cost (HC) is obtained by integrating (10) with limit 't' from $t = 0$ to T, (level of inventory decreases with time), then

$$HC = h\alpha T + \frac{h\beta}{(\theta+\beta)}\left\{\left(Q + \frac{\alpha}{\theta+\beta}\right)\left(1 - e^{-(\theta+\beta)T}\right) - \alpha T\right\} = \frac{h}{(\theta+\beta)}\left\{\alpha\theta T + \beta\left(Q + \frac{\alpha}{\theta+\beta}\right)\left(1 - e^{-(\theta+\beta)T}\right)\right\} \tag{11}$$

$$TRC = \frac{1}{T}\left[K + \frac{h}{(\theta+\beta)}\left\{\alpha\theta T + \beta\left(Q + \frac{\alpha}{\theta+\beta}\right)\left(1 - e^{-(\theta+\beta)T}\right)\right\} + c\left\{Q - \frac{\alpha\theta T}{\theta+\beta} - \beta\left(Q + \frac{\alpha}{\theta+\beta}\right)\left(\frac{1 - e^{-(\theta+\beta)T}}{\theta+\beta}\right)\right\}\right] \tag{12}$$

Second order approximations have been used for exponential terms on the right hand side of (12), it becomes

$$TRC = \frac{1}{T}\left[K + hT\left\{\alpha + \beta Q - \frac{\beta T}{2}(\alpha + (\theta+\beta)Q)\right\} + c\left\{Q - (\alpha+\beta Q)T + \frac{\beta T^2}{2}(\alpha + (\theta+\beta)Q)\right\}\right] \tag{13}$$

Using Eqs. (4), (13) reduces to

$$TRC = \frac{2K\alpha^2}{Q\{2\alpha - (\theta+\beta)Q\}} + (h-c)(\alpha+\beta Q) + \frac{(h-c)\beta Q\{2\alpha - (\theta+\beta)Q\}\{\alpha + (\theta+\beta)Q\}}{4\alpha^2} + \frac{2c\alpha^2}{\{2\alpha - (\theta+\beta)Q\}} \tag{14}$$

5 Optimal solution for models I and II

5.1 Model I

Right hand side of (9) is a function of '*Q*', optimal value of $Q = Q^*$, is obtained by solving $\frac{d(TRC)}{dQ} = 0$, which minimizes *TRC*. Differentiating (9) w.r.t. '*Q*', twice, it becomes

$$\begin{aligned}\frac{d(TRC)}{dQ} = &-\frac{4K\alpha^2\{\alpha - (\theta+\beta)Q\}}{Q^2\{2\alpha - (\theta+\beta)Q\}^2} + \frac{2h\alpha^2 Q^{n-1}\{2n\alpha - (n-1)(\theta+\beta)Q\}}{(n+1)\{2\alpha - (\theta+\beta)Q\}^2}\\ &+ \frac{2c\alpha^2(\theta+\beta)}{\{2\alpha - (\theta+\beta)Q\}^2} - \frac{c\beta}{4\alpha^2}\left\{2\alpha^2 + 2\alpha(\theta+\beta) - 3(\theta+\beta)^2Q^2\right\}\end{aligned} \tag{15}$$

and (see Fig. 2)

$$\begin{aligned}\frac{d^2(TRC)}{dQ^2} = &\frac{4K\alpha^2\left[4\alpha^2 - 3(\theta+\beta)Q\{2\alpha - (\theta+\beta)Q)\}\right]}{Q^3\{2\alpha - (\theta+\beta)Q\}^3}\\ &+ \frac{2h\alpha^2Q^{n-2}\left[n(n-1)\{2\alpha - (\theta+\beta)Q\}^2 + 2(\theta+\beta)Q\{2n\alpha - (n-1)(\theta+\beta)Q\}\right]}{(n+1)\{2\alpha - (\theta+\beta)Q\}^3}\\ &+ \frac{4c\alpha^2(\theta+\beta)^2}{\{2\alpha - (\theta+\beta)Q\}^3} + \frac{3c\beta(\theta+\beta)^2Q}{2\alpha^2} > 0\end{aligned} \tag{16}$$

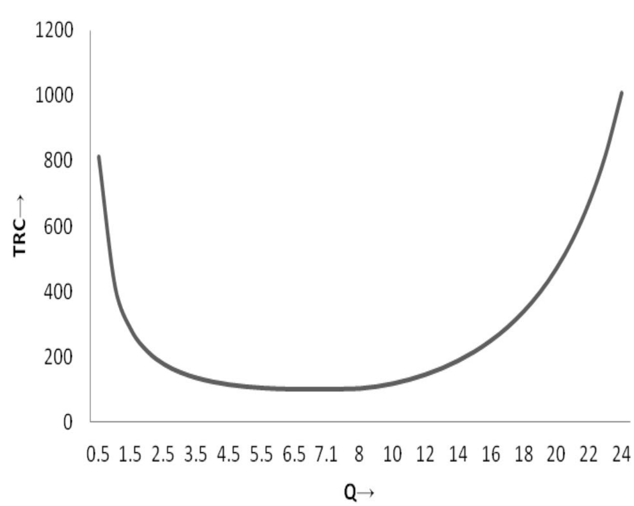

Fig. 2 '*Q*' versus *TRC* for model I

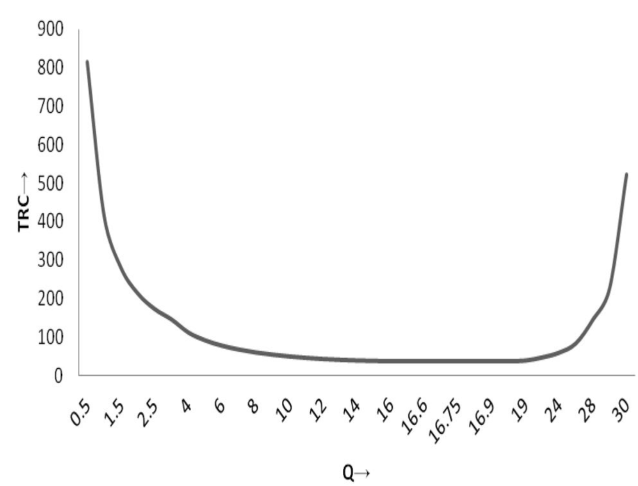

Fig. 3 '*Q*' versus *TRC* for model II

Putting $\frac{d(TRC)}{dQ}=0$, we get

$$4K\alpha^2\{\alpha-(\theta+\beta)Q\}-\frac{2h\alpha^2Q^{n+1}\{2n\alpha-(n-1)(\theta+\beta)Q\}}{(n+1)}-2c\alpha^2Q^2(\theta+\beta)+\frac{c\beta Q^2\{2\alpha-(\theta+\beta)Q\}^2\left\{2\alpha^2+2\alpha(\theta+\beta)-3(\theta+\beta)^2Q^2\right\}}{4\alpha^2}=0 \tag{17}$$

Solving Eq. (17) for Q, optimal value of $Q=Q^*$, is obtained.

5.2 Model II

Right hand side of above Eq. (14) is a function of 'Q', Optimal $Q=Q^*$ is obtained by solving $\frac{d(TRC)}{dQ}=0$, which minimizes TRC. Differentiating (14) w.r.t. 'Q' two times, then

$$\frac{d(TRC)}{dQ}=-\frac{4K\alpha^2\{\alpha-(\theta+\beta)Q\}}{Q^2\{2\alpha-(\theta+\beta)Q\}^2}+(h-c)\beta+\frac{(h-c)\beta\left\{2\alpha^2-3(\theta+\beta)^2Q^2+2\alpha(\theta+\beta)Q\right\}}{4\alpha^2}+\frac{2c\alpha^2(\theta+\beta)}{\{2\alpha-(\theta+\beta)Q\}^2}. \tag{18}$$

and (see Fig. 3)

$$\frac{d^2(TRC)}{dQ^2}=\frac{4K\alpha^2\left[4\alpha^2-3(\theta+\beta)Q\{2\alpha-(\theta+\beta)Q)\}\right]}{Q^3\{2\alpha-(\theta+\beta)Q\}^3}+\frac{(h-c)\beta(\theta+\beta)\{\alpha-3(\theta+\beta)Q\}}{2\alpha^2}+\frac{4c\alpha^2(\theta+\beta)^2}{\{2\alpha-(\theta+\beta)Q\}^3}>0 \tag{19}$$

Putting Eq. (18) to zero, we get

$$4K\alpha^2\{\alpha-(\theta+\beta)Q\}-(h-c)\beta Q^2\{2\alpha-(\theta+\beta)Q\}^2-2c\alpha^2Q^2(\theta+\beta)-\frac{(h-c)\beta Q^2\left\{2\alpha^2-3(\theta+\beta)^2Q^2+2\alpha(\theta+\beta)Q\right\}\{2\alpha-(\theta+\beta)Q\}^2}{4\alpha^2}=0. \tag{20}$$

Solving Eq. (20) for 'Q', optimal Q^* is obtained.

From the above formulation, we derive following solution algorithm to derive approximate optimal values T^*, Q^* and TRC^*.

6 Solution algorithm

Step 1 Initialize the constraints
Step 2 Calculate *TRC* from Eqs. (9) and (14) for different values of *Q*
Step 3 Repeat the above steps for all possible values of '*Q*', minimum *TRC* is obtain From Eqs. (9) and (14) for models I and II separately. *TRC** values constitute optimal solution for both models
Step 4 *T** is obtained by substituting *Q** into Eq. (4)
Step 5 stop.

7 Numerical example

In the present section computational results are presented for optimal behavior of *Q**, *T**, and *TRC**. Following table is developed to demonstrate the results for models I and II presented in this study with the following parameters $K = \$ 200$/order, $a = 2$, $c = \$ 10.00$/unit, $h = \$ 0.50$/unit, $n = 2$ and $\theta = 0.03$.

Numerical results shown in Table 1, we obtain optimal values for model I are *Q** (optimal order quantity) = 7.0 units, *T** = 2.70,647 years, *TRC** = $ 101.873, and optimal alternative for model *II* are Q* = 16.7 units, *T** = 3.81804 years, *TRC** = $ 36.6386. From Table 1, it is clear that *TRC* is convex function with respect to *Q* i.e. $\frac{d^2(TRC)}{dQ^2} > 0$ (in the following figures between *TRC* and *Q* are convex, it shows that *TRC* will be minimum for *Q*). It means that the value of *Q** is obtained on solving $\frac{d(TRC)}{dQ} = 0$, minimizes *TRC** for all *Q*. Figures for both cases are given below:

Table 1 Numerical results of models I and II

Model I			Model II		
Q	*T**	*TRC**	*Q*	*T**	*TRC**
0.5	0.245938	813.638	0.5	0.245938	813.650
1.0	0.483750	414.483	1.0	0.483750	414.302
1.5	0.713438	282.212	1.5	0.713438	279.624
2.0	0.935000	216.833	2.0	0.935000	212.619
2.5	1.148440	178.356	2.5	1.148440	172.286
3.0	1.353750	153.458	3.0	1.353750	145.293
3.5	1.550940	136.436	4.0	1.740000	111.336
4.0	1.740000	124.446	5.0	2.093750	90.7585
4.5	1.920940	115.914	6.0	2.415000	76.9047
5.0	2.093750	109.902	7.0	2.703750	66.9304
5.5	2.258440	105.820	8.0	2.960000	59.4206
6.0	2.415000	103.281	9.0	3.183750	53.5965
6.5	2.563440	102.025	10.0	3.375000	48.9984
7.0*	**2.703750***	**101.873***	11.0	3.533750	45.3418
7.1	2.706470	101.880	12.0	3.660000	42.4460
7.5	2.835940	102.700	13.0	3.753750	40.1954
8.0	2.960000	104.422	14.0	3.815000	38.5188
9.0	3.183750	110.343	15.0	3.843750	37.3771
10.0	3.375000	119.409	16.0	3.840000	36.7572
11.0	3.533750	131.622	16.5	3.825940	36.6450
12.0	3.660000	147.150	16.6	3.822150	36.6388
13.0	3.753750	166.310	**16.7***	**3.81804***	**36.6380***
14.0	3.815000	189.573	16.75	3.815860	36.6397
15.0	3.843750	217.581	16.8	3.813600	36.6427
16.0	3.840000	251.195	16.9	3.808840	36.6530
17.0	3.803750	291.551	17.0	3.803750	36.6688
18.0	3.735000	340.191	19.0	3.633750	38.2462
19.0	3.633750	399.167	22.0	3.135000	46.5095
20.0	3.500000	471.338	24.0	2.640000	58.7871
21.0	3.333750	560.745	26.0	2.015000	83.1931
22.0	3.135000	673.289	28.0	1.260000	144.237
23.0	2.903750	817.924	29.0	0.833750	226.443
24	2.64	1008.91	30	0.375	521.146

The bold date numbers show the optimal values of Q, T and TRC

8 Sensitivity analysis

8.1 Sensitivity analysis for model I

In the present section computational results are presented for optimal behavior of *Q**, *T**, and *TRC** for variation of *n* and β. Parameter values for models I and II are taken as $K = \$ 200$/order, $a = 2.0$, $c = \$ 10.00$/unit, $h = \$ 0.5$/unit, and $\theta = 0.03$.

From Table 2, following suggestions can be made.

From Table 2, it can be seen that (1) Increase of stock-dependent constraints, results decrease in order quantity, cycle time and increase in total relevant cost, keeping 'n' fixed. (2) Increase of '*n*', results decline in order quantity, cycle time and increase in total relevant cost, keeping 'β' unchanged.

8.2 Sensitivity analysis for model II

We take the similar stricture values as in model I. Table 3, shows the approximate values of Q*, *T**, and *TRC** with effect of β.

From Table 3, following deduction can be drawn.

Enlarge of 'β' results, decline in most favorable order quantity, cycle time and strengthen in optimal total relevant cost.

Table 2 Outcome of *Q**, *T** and *TRC** with variation of '*n*' and '*β*'

n	β								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2									
*Q**	6.95311	5.73663	4.70692	3.91758	3.32509	2.87554	2.52728	2.25144	2.02844
*T**	2.69094	1.92218	1.43956	1.13387	0.93007	0.78661	0.68081	0.59981	0.53590
*TRC**	108.844	131.550	164.926	200.817	238.247	276.587	315.472	354.696	394.138
3									
*Q**	4.49699	4.19343	3.83711	3.45738	3.08787	2.75292	2.46256	2.21629	2.00878
*T**	1.91987	1.59115	1.31121	1.08619	0.91225	0.77965	0.67792	0.59853	0.53530
*TRC**	134.689	157.390	183.797	213.723	246.294	281.996	318.909	356.873	395.509
4									
*Q**	3.35013	3.23872	3.10169	2.93836	2.75216	2.55144	2.34794	2.15296	1.97410
*T**	1.49269	1.31779	1.15400	1.00510	0.87428	0.76307	0.67093	0.59557	0.53402
*TRC**	164.987	184.144	206.227	231.379	259.658	290.913	324.734	360.546	397.771
5									
*Q**	2.73937	2.68428	2.61720	2.53596	2.43895	2.32576	2.19821	2.06099	1.92094
*T**	1.24774	1.13499	1.02605	0.92231	0.82539	0.73691	0.65817	0.58980	0.53151
*TRC**	190.667	207.903	227.495	249.633	274.504	302.228	332.775	365.892	401.132
6									
*Q**	2.37030	2.33760	2.29840	2.25123	2.19455	2.12682	2.04696	1.95497	1.85278
*T**	1.09385	1.01170	0.93129	0.85321	0.77821	0.70720	0.64114	0.58096	0.52733
*TRC**	212.113	228.181	246.235	266.453	289.035	314.174	342.001	372.523	405.553
7									
*Q**	2.12620	2.10439	2.07857	2.04786	2.01111	1.96706	1.91435	1.85176	1.77872
*T**	0.98964	0.92488	0.86107	0.79852	0.73760	0.67882	0.62277	0.57012	0.52156
*TRC**	230.083	245.374	262.403	281.330	302.341	325.635	351.399	379.758	410.718
8									
*Q**	1.95391	1.93817	1.91975	1.89803	1.87222	1.84140	1.80444	1.76007	1.70705
*T**	0.91492	0.86109	0.80785	0.75538	0.70389	0.65368	0.60511	0.55863	0.51477
*TRC**	245.269	260.010	276.313	294.323	314.210	336.163	360.378	387.030	416.226
9									
*Q**	1.82629	1.81429	1.80036	1.78405	1.76482	1.74198	1.71465	1.68177	1.64211
*T**	0.85895	9.81251	0.76648	0.72095	0.67607	0.63202	0.58905	0.54744	0.50758
*TRC**	258.228	272.560	288.325	305.656	324.702	345.655	368.691	394.004	421.753
10									
*Q**	1.72821	1.71866	1.70766	1.69488	1.67989	1.66218	1.64108	1.61574	1.58509
*T**	0.81557	0.77441	0.73354	0.69304	0.65299	0.61352	0.57479	0.53702	0.50047
*TRC**	269.395	283.410	298.762	315.570	333.729	354.151	376.270	400.525	427.097

Table 3 Effect of '*β*' on *Q**, *T** and *TRC**

β	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
*Q**	13.122	7.8703	5.6339	4.3919	3.6004	3.0514	2.6481	2.3392	2.0949
*T**	3.7630	2.1543	1.5083	1.1592	0.9414	0.7925	0.6842	0.6019	0.5373
*TRC**	39.961	73.762	111.16	149.69	188.75	228.09	267.60	307.22	346.92

9 Conclusion and future research

A deterministic inventory models is developed for deteriorating objects under stock sensitive demand. Sensitivity analysis is presented to find the nature of optimal order quantity, cycle time and total relevant cost. From managerial point of view the following results: (1) increase of '*n*' results increase of total inventory cost and (2) increase of stock-dependent constraints results augment in total inventory cost.

This model can be generalized for credit sensitive demand, stochastic demand, price dependent demand and time-linked demand can be probable areas for the future research. Some other reasonable restriction like the warehouse.

Compliance with ethical standards

Conflict of interests The author declare that they have no competing interests.

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