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Two Storage Facilities Inventory Model under Varying Deterioration Rates for Defective and Repairable Items with Price and Time Dependent Demand

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ABSTRACT

Many times it happens that 100% good quality items are not produced or ordered. We say them as defective items. Again some of defective items may not be repairable, where as some may be repairable. Here an inventory models is formulated for defective and repairable items under variable deterioration and two storage facilities. Price and time dependent demand function is considered.Time dependent storage cost is considered. Supporting numerical illustration is provided and likewise for parameters, post-optimality analysis is also carried out.

Keywords: Defective items, Inventory model, Price dependent demand, Repairable items, Time dependent demand, Two storage facilities, Varying Deterioration

1. INTRODUCTION

One of the key factors whose impact on inventory of items cannot be ignored is deterioration. In past many authors have done research work related to deteriorating items inventory models. A stock level model was formulated by Shah and Jaiswal [1]. Fixed deterioration was taken into consideration. A stock dependent inventory model was constructed by Gupta and Vrat [2]. Total average cost was taken as function of stock level and size of replenishment. Corrections in Gupta and Vrat's [2] model was done by Mandal and Phaujdar [3]. They assumed instantaneous replenishment with no shortages and demand as linearly increasing function with current inventory level. When demand depends on price, a deteriorating items inventory model was obtained by Mukhopadhyay et al. [4]. They have taken time proportional deterioration rate. With the assumption that demand depend on selling price, formulation of a stock level deteriorating items model was done by Patra et al. [5]. Other items such as storage cost, deterioration, ordering cost were taken as functions of time. A price dependent demand function inventory model for deteriorating items was formulated by Routray et al. [6]. By maximizing profit function they have obtained optimal order quantity. Under varying deterioration an inventory model was formulated by Patel and Sheikh [7]. Time dependent Stocking cost was considered. An inventory model under generalized exponential decreasing demand was formulated by Aliyu and Sani [8]. Rate of deterioration was considered as linear. Storage cost was taken as constant. An inventory model for non-instantaneous deteriorating items was formulated by Sundararajan and Prabha [9] when demand of item depends on price and time of item. Partially backlogs were allowed under negative exponential rate.

An inventory received are good quality items, is assumed most of the times. But many times, all items received are not of good quality items and we say them to be defective items. Lee and Rosenblatt [10] developed defective items inventory model for finding optimal ordering policy. When production process is not perfect, an inventory model was formulated by Cheng [11]. Item's demand was considered as function of production cost per unit. Salameh and Jaber [12] considered defective quality items model in which after 100% screening, defective items were separated and at lower price these defective items are sold as a single lot. A defective items production inventory model was discussed by Goyal and Barron [13]. Patel and Patel [14] developed an imperfect quality items inventory model under delay in payments. When received items are of imperfect quality under storage facilities at two locations, inventory model was developed by Jaggi et al. [15]. A multiple production setups inventory model when items are of defective type and defective items having salvage value was established by Uthayakumar and Sekar [16]. A linear demand inventory model for defective items in which some items can be repairable, was considered by Yadav and Kumar [17]. Gothi et al. [18] formulated a linear demand and exponential type deterioration of items inventory model in which received items having defects but some of them can be repairable.

Additional items are procured by retailers beyond capacity of their Warehouse (OW) for getting advantage of price discounts. Storage facility in Rented Warehouse (RW) is better, so unit storage cost in RW is more than unit storage cost in OW of an item. It is the arrangement made for additional stock for storing excess goods. A two warehouses deteriorating items inventory model was proposed by Sarma [19]. An inventory model was proposed by Pakkala and Achary [20] under two storage facilities location with fixed rate of demand. They have taken rate of replenishment as finite and completely backlogged shortages were taken into consideration. A stock level model under two storage facilities locations for perishable items was formulated by Benkherouf [21]. A price dependent demand two storage facilities location inventory model was formulated by Jaggi and Verma [22]. Backorders were permitted and completely backlogged. A pricing decision under two storage facilities location model was considered by Sana et al. [23]. Yu et al. [24] gave two warehouses deteriorating items inventory model with decreasing rental over time. A ramp type demand and fixed storage cost deteriorating items inventory model for two warehouses was formulated by Kumar et al. [25]. A linear demand and time dependent storage cost inventory model under two warehouses was developed by Sheikh and Patel [26]. An inventory model for deteriorating items under inflation and time dependent demand with two storage facilities was discussed by Singh et al. [27]. Shortages were permitted and partial backlogged.

For defective and repairable items under different deterioration rates, an inventory model is formulated with two storage facilities location. Price and time related demand pattern is considered. Backlogged are not permitted. Time dependent storage cost is considered. Model is justified with numerical example. For parameters, post-optimality computations are also carried out.

2. NOTATIONS AND ASSUMPTIONS

Notations

Model is developed considering following notations considered:

$D(t, p)$: $a + bt - \rho p$, where $a > 0$, $0 < b < 1$, $p > 0$, $\rho > 0$
HC(OW) : OW has time varying holding cost ($h_1 + j_1 t$, $h_1 > 0$, $0 < j_1 < 1$)
HC(RW): RW has time varying holding cost ($h_2 + j_2 t$, $h_2 > 0$, $0 < j_2 < 1$)
CO : Charge of ordering
CD : Charge of deterioration
c : Purchasing cost of one unit of item
p : Selling price of one unit of item
d : % items of defective type
1-d : % of perfect items
d_1 : Items for repairing (in %)
λ : Rate of screening
SR : Revenue from sales
z : Unit cost of screening
p_d : Unit selling price of defective items
t_1 : Screening time
m : Repairable item's per unit transportation cost
T : Inventory cycle time
$I_0(t)$: OW inventory level
$I_r(t)$: RW inventory level
Q : Initial order quantity
t_r : RW zero inventory position
W : OW storage capacity
θ : Rate of deterioration during $\mu_1 < t < \mu_2$, $0 < \theta < 1$
θt : Deterioration charge for period of $\mu_2 \le t \le T$, $0 < \theta < 1$
π : Per unit profit (total)

Assumptions

Underlying assumptions have been considered for developing the model.

- Demand of item depends on price and time.
- Product has countless and immediate replenishment rate.
- Zero lead time is considered.
- There are no shortages of items.

- During screening process, demand occurs but is less than screening rate (λ) i.e. $a+bt-\rho p<\lambda$
- Deterioration of items and defective items are independent.
- Some defective items are repairable items.
- In each cycle, no repairing or replacement of deteriorated items.
- Only one item is taken for analysis.
- Varying holding cost is considered.
- Screening machine takes very less time for inspection of items for verification means we say that screening rate (λ) is sufficiently large.
- Unlimited capacity in RW and finite W units capacity in OW.
- RW goods are first used and then OW goods are consumed.
- Unit storage cost of item in RW is higher than unit storage of item in OW.

3. Modelling and Analysis

Items of amount Q are received initially. An amount of d units (in %) are defective among Q items and out of these defective items, repairable items are d_1%. These units, at rate of λ per unit time as shown in figure below go through screening process during time 0 to t_1. Items which are found to be perfect are separated and from remaining Q – dQ = Q(1-d) perfect quality items, own warehouse (OW) capacity W is first fulfilled and remaining perfect quality items Q(1-d) – W are stored in rented warehouse. Demand occurred during 0 to t_1 will be fulfilled from these perfect quality items stored in rented warehouse. Moreover from these defective items repairable items are separated and sent for repairing to manufacturer and goods of defective quality as one lot sold at reduced price during end of phase. Level of inventory at t_1 is $I(t_1)$. In RW inventory becomes zero at time t_r because of demand and OW inventory remains W. During interval (t_r,μ_1), OW inventory depletes due to demand, during interval (μ_1, μ_2), because of demand as well as deterioration for rate θ, OW inventory depletes. In interval (μ_2, T), due to deterioration rate and demand, inventory level depletes in OW. At end of cycle, warehouses inventory becomes nil.

Here $t_1 = \frac{Q}{\lambda}.$ (1)

and we put restriction for defective percentage (d) as:

$$d \le 1-\frac{(a+bt-\rho p)}{\lambda}. \quad (2)$$

Level of inventory for a cycle is shown below:

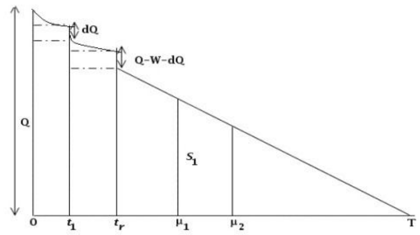


Figure 1

Following differential equations represent respective levels of inventory in RW and OW:

$$\frac{dI_r(t)}{dt} = -(a+bt-\rho p), \quad 0 \le t \le t_r \quad (3)$$

$$\frac{dI_0(t)}{dt} = 0, \quad 0 \le t \le t_r \quad (4)$$

$$\frac{dI_0(t)}{dt} = -(a+bt-\rho p), \quad t_r \le t \le \mu_1 \quad (5)$$

$$\frac{dI_0(t)}{dt} + \theta I_0(t) = -(a+bt-\rho p), \quad \mu_1 \le t \le \mu_2 \quad (6)$$

$$\frac{dI_0(t)}{dt} + \theta t I_0(t) = -(a+bt-\rho p), \quad \mu_2 \le t \le T \quad (7)$$

initial conditions taken are $I_0(0) = W$, $I_0(\mu_1) = S_1$, $I_0(t_r)=W$, $I_r(0)=Q-W$, $I_r(t_r)=0$, $I_0(T)=0$.

Their solutions are given by

$$I_r(t) = (Q - W) - \left(at - \rho pt + \frac{1}{2}bt^2\right) \quad (8)$$

$$I_0(t) = W \quad (9)$$

$$I_0(t) = S_1 + (a - \rho p)(\mu_1 - t) + \frac{1}{2}b\left(\mu_1^2 - t^2\right) \quad (10)$$

$$I_0(t) = \begin{bmatrix} a(\mu_1 - t) - \rho p(\mu_1 - t) + \frac{1}{2}a\theta\left(\mu_1^2 - t^2\right) - \frac{1}{2}\rho p\theta\left(\mu_1^2 - t^2\right) + \frac{1}{2}b\left(\mu_1^2 - t^2\right) \\ + \frac{1}{3}b\theta\left(\mu_1^3 - t^3\right) - a\theta t(\mu_1 - t) + \rho pt(\mu_1 - t) - \frac{1}{2}b\theta t\left(\mu_1^2 - t^2\right) \end{bmatrix} + S_1\left(1 + \theta(\mu_1 - t)\right)$$

(11)

$$I_0(t) = \begin{bmatrix} a(T - t) - \rho p(T - t) + \frac{1}{6}a\theta\left(T^3 - t^3\right) - \frac{1}{6}\rho p\theta\left(T^3 - t^3\right) + \frac{1}{2}b\left(T^2 - t^2\right) + \frac{1}{8}b\theta\left(T^4 - t^4\right) \\ - \frac{1}{2}a\theta t^2(T - t) + \frac{1}{2}\rho p\theta t^2(T - t) - \frac{1}{4}b\theta t^2\left(T^2 - t^2\right) \end{bmatrix} \quad (12)$$

(higher powers of θ are not considered)

dQ is defective items separated at time t_1 after screening process.
Therefore between $t_1 \le t \le T$, effective inventory is:

$$I_r(t) = Q(1-d) - W - (a - \rho p)t - \frac{1}{2}bt^2. \quad (13)$$

Substituting t = tr in (13) gives

$$Q = \frac{1}{(1-d)}\left[W + (a - \rho p)t_r + \frac{1}{2}bt_r^2\right] \quad (14)$$

In equations (9) and (10) substituting t=tr gives

$$I_0(t_r) = W \quad (15)$$

$$I_0(t_r) = S_1 + (a - \rho p)(\mu_1 - t_r) + \frac{1}{2}b\left(\mu_1^2 - t_r^2\right) \quad (16)$$

So from equations (15) and (16), we have

$$S_1 = W - (a - \rho p)(\mu_1 - t_r) - \frac{1}{2}b\left(\mu_1^2 - t_r^2\right) \quad (17)$$

Under the assumption that for repairing, repairable items of amount d_1% sent to manufacturer and before completion of cycle ($\mu_2 \le t \le T$), we receive back items after repairing. These repaired items before completion of cycle, are sold at original price. For sending to manufacturer and receiving back items repaired causes transportation cost. During $\mu_2 \le t \le T$, the stock level is:

$$I_0(t) = \begin{bmatrix} a(T - t) - \rho p(T - t) + \frac{1}{6}a\theta\left(T^3 - t^3\right) - \frac{1}{6}\rho p\theta\left(T^3 - t^3\right) + \frac{1}{2}b\left(T^2 - t^2\right) \\ + \frac{1}{8}b\theta\left(T^4 - t^4\right) - \frac{1}{2}a\theta t^2(T - t) + \frac{1}{2}\rho p\theta t^2(T - t) - \frac{1}{4}b\theta t^2\left(T^2 - t^2\right) \end{bmatrix} + d_1Q$$

(18)

Substituting in equations (11) and (18) $t = \mu_2$, we get

$$I_0(\mu_2) = \begin{bmatrix} a(\mu_1 - \mu_2) - \rho p(\mu_1 - \mu_2) + \frac{1}{2}a\theta\left(\mu_1^2 - \mu_2^2\right) - \frac{1}{2}\rho p\theta\left(\mu_1^2 - \mu_2^2\right) + \frac{1}{2}b\left(\mu_1^2 - \mu_2^2\right) \\ + \frac{1}{3}b\theta\left(\mu_1^3 - \mu_2^3\right) - a\theta t(\mu_1 - \mu_2) + \rho pt(\mu_1 - \mu_2) - \frac{1}{2}b\theta t\left(\mu_1^2 - \mu_2^2\right) \end{bmatrix} + S_1\left(1 + \theta(\mu_1 - \mu_2)\right) \quad (19)$$

$$I_0(\mu_2) = \begin{bmatrix} a(T - \mu_2) - \rho p(T - \mu_2) + \frac{1}{6}a\theta\left(T^3 - \mu_2^3\right) - \frac{1}{6}\rho p\theta\left(T^3 - \mu_2^3\right) + \frac{1}{2}b\left(T^2 - \mu_2^2\right) \\ + \frac{1}{8}b\theta\left(T^4 - \mu_2^4\right) - \frac{1}{2}a\theta\mu_2^2(T - \mu_2) + \frac{1}{2}\rho p\theta\mu_2^2(T - \mu_2) - \frac{1}{4}b\theta t^2\left(T^2 - \mu_2^2\right) \end{bmatrix} + d_1Q. \quad (20)$$

So from equations (19) and (20), we have

$$T = \frac{1}{b\left(\theta\mu_2^2 d+2-2d-\theta\mu_2^2\right)}\left(\begin{array}{l} 2ad+a\theta\mu_2^2-a\theta\mu_2^2 d-2a \\ + \sqrt{\begin{array}{l} -8b^2d\theta t_r^2\mu_1+8b^2d\theta t_r^2\mu_2+4a^2d^2-8a^2d+4a^2+8bW+4b^2t_r^2+2b^2\theta\mu_2^2dd_1t_r^2+4b^2\theta\mu_2^2dt_r^2 \\ -4b^2\theta^2\mu_2^3d\mu_1^2-4b\theta\mu_2^2d^2at_r-2b^2\theta\mu_2^2d^2t_r^2+8b\theta^2\mu_2^2dW\mu_1-8b\theta^2\mu_2^3dW-4b\theta^2\mu_2^2da\mu_1^2 \\ +4b\theta\mu_2^2dd_1W-4b\theta\mu_2^2d^2W-8bda\theta\mu_2^2+8bd^2W\theta\mu_1-8bd^2W\theta\mu_2-4bd^2a\theta\mu_1^2-16bda\theta t_r\mu_1 \\ +16bda\theta t_r\mu_2+4bd^2a\theta t_r\mu_2^2-4b^2d^2\theta\mu_2\mu_1^2+8bd^2a\theta t_r\mu_1-8bd^2a\theta t_r\mu_2+4b^2d^2a\theta t_r^2\mu_1 \\ -4b^2d^2\theta t_r^2\mu_2-8bdd_1at_r+8b^2d\theta\mu_2\mu_1^2-16bdW\theta\mu_1+16bdW\theta\mu_2+8bda\theta\mu_1^2+8bd^2W+8abt_r \\ +4d_1b^2t_r^2+8bd_1W-2b^2\theta\mu_2^2t_r^2+8ab\theta t_r\mu_1-8ab\theta t_r\mu_2-4ab\theta t_r\mu_2^2t_r-4ab\theta^2\mu_2^2t_r\mu_1+4ab\theta^2\mu_2^3t_r \\ -2b^2\theta^2\mu_2^2t_r^2\mu_1+2ab\theta^2\mu_2^2d^2\mu_1^2+8ab\theta^2\mu_2^2dt_r\mu_1-8ab\theta^2\mu_2^3dt_r-4b^2\theta^2\mu_2^3dt_r^2-2b\theta^2\mu_2^4d^2a \\ +4b^2\theta^2\mu_2^2dt_r^2\mu_1-4ab\theta\mu_2^2d_1t_r-2b^2\theta\mu_2^2d_1t_r^2-4b\theta^2\mu_2^2W\mu_1+2ab\theta^2\mu_2^2\mu_1^2-4b\theta\mu_2^2d_1W+4b\theta^2\mu_2^2W \\ +2b^2\theta^2\mu_2^3\mu_1^2+8a^2d\theta\mu_2^2-4a^2d^2\theta\mu_2^2-2a^2\theta^2\mu_2^4d+a^2\theta^2\mu_2^4d^2-16abdt_r-4b^2dd_1t_r^2+8bd^2at_r \\ -8bdd_1W+4ab\theta\mu_2^2+4\theta b^2t_r^2\mu_1-4\theta b^2t_r^2\mu_2+8abd_1t_r-4b^2\theta\mu_2\mu_1^2+8bW\theta\mu_1-8bW\theta\mu_2-4ab\theta\mu_2^2 \\ -2ab\theta^2\mu_2^4+2b^2\theta^2\mu_2^3t_r^2-4b\theta\mu_2^2W-8b^2dt_r^2-4b\theta^2\mu_2^2d^2W\mu_1+4ab\theta^2\mu_2^4d+4b\theta^2\mu_2^3d^2W \\ +8ab\theta\mu_2^2dt_r+8b\theta\mu_2^2dW+2b^2\theta^2\mu_2^3d^2\mu_1^2-4b\theta^2\mu_2^2d^2at_r\mu_1+4b\theta^2\mu_2^3d^2at_r-2b^2\theta^2\mu_2^2d^2t_r^2\mu_1 \\ +2b^2\theta^2\mu_2^3d^2t_r^2+4ab\theta\mu_2^2dd_1t_r+a^2\theta^2\mu_2^4-4a^2\theta\mu_2^2-16bdW+4b^2d^2t_r^2 \end{array}} \end{array}\right)$$

(21)

Above equation (21) shows that T is not a decision variable, since it is function of W and t_r.

Total profit consists of:

(i) Charge of ordering (CO) = B (22)

(ii) Charge of screening cost (CSr) = z Q (23)

(iii) Charge of transportation cost (CT) = m Q (24)

$$\text{(iv) } HC(OW)=\left[\int_0^{t_r}(h_1+j_1t)\, I_0(t)\,dt+\int_{t_r}^{\mu_1}(h_1+j_1t)\, I_0(t)\,dt+\int_{\mu_1}^{\mu_2}(h_1+j_1t)\, I_0(t)\,dt+\int_{\mu_2}^{T}(h_1+j_1t)\, I_0(t)\,dt\right] \quad (25)$$

$$\text{(v) } HC(RW)=\left[\int_0^{t_1}(h_2+j_2t)\, I_r(t)\,dt+\int_{t_1}^{t_r}(h_2+j_2t)\, I_r(t)\,dt\right] \quad (26)$$

$$\text{(vi) } CD = c\left(\int_{\mu_1}^{\mu_2}\theta I_0(t)\,dt+\int_{\mu_2}^{T}\theta t I_0(t)\,dt\right) \quad (27)$$

(vii) SR = Revenue generated during the cycle + Revenue from defective units + Revenue from units repaired

$$= p\left(\int_0^T (a+bt-\rho p)dt\right)+p_d(d-d_1)Q-p(d-d_1)Q = p\left(aT-\rho pT+\frac{1}{2}bT^2\right)+p_d(d-d_1)Q-p(d-d_1)Q$$

(28)

(by not considering higher powers of θ)

Total profit (π) of a cycle is:

$$\pi=\frac{1}{T}\left[SR-CO-CSr-CT-HC(RW)-HC(OW)-CD\right] \quad (29)$$

Putting value in equation (29) from equations (22) to (28) provides total profit per unit. Profit in terms of t_r and p, can be obtained by putting values of S_1 and T from equation (17) and (21), and $\mu_1 = v_1T$ and $\mu_2 = v_2T$ in equation (29). From equation (29) considering differentiation in regard to t_r and p, and putting zero in resulting terms, we get

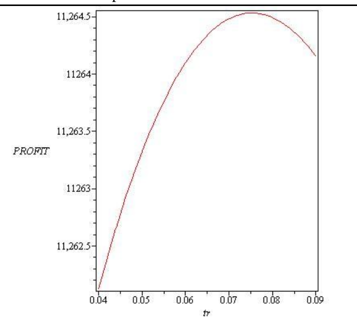
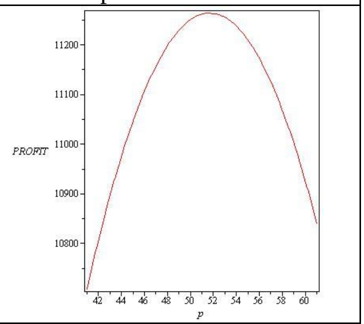
i.e. $\frac{\partial\pi(t_r,p)}{\partial t_r}=0,\ \frac{\partial\pi(t_r,p)}{\partial p}=0,$ (30)

provided it satisfies the condition

$$\begin{vmatrix} \dfrac{\partial \pi^2(t_r, p)}{\partial t_r^2} & \dfrac{\partial \pi^2(t_r, p)}{\partial t_r \, \partial p} \\ \dfrac{\partial \pi^2(t_r, p)}{\partial p \, \partial t_r} & \dfrac{\partial \pi^2(t_r, p)}{\partial p^2} \end{vmatrix} > 0. \qquad (31)$$

4. NUMERICAL ILLUSTRATION

Taking B = 100, W = 95, a = 500, b = 0.05, c = 25, d = 0.05, d_1 = 0.03, p_d= 15, λ=10000, θ=0.05, ρ=5, h_1 = 2, j_1=0.04, h_2 = 6, j_2=0.08, z = 0.40, m = 70, v_1=0.30, v_2=0.50, in suitable terms. Resulting values are: t_r* = 0.0753, p* = Rs. 51.6771, Profit*= Rs. 11264.5333 and Q*=119.1513.
Above numerical also satisfies condition of equation (31). Concavity of profit function is shown in graphs below.

t_r and Profit	p and Profit
	
Graph 1	Graph 2

5 POST-OPTIMALITY ANALYSIS

Study of one parameter at a time, post-optimality results of above illustration is done here.

Table 1
Post-optimality Analysis

Parameter	%	t_r	p	Profit	Q
a	+20 %	0.0853	61.6537	16481.7776	126.1946
	+10 %	0.0809	56.6650	13750.5947	122.7096
	-10%	0.0677	46.6900	9023.6336	115.4321
	-20%	0.0575	41.7039	7027.9372	111.5897
θ	+20 %	0.0714	51.6783	11258.9189	118.1589
	+10 %	0.0733	51.6777	11261.7188	118.6424
	-10%	0.0773	51.6765	11267.3626	119.6602
	-20%	0.0793	51.6759	11270.2070	120.1691
h_1	+20 %	0.0654	51.6877	11241.9682	116.6297
	+10 %	0.0703	51.6823	11253.2063	117.8777

	-10%	0.0801	51.6720	11275.9462	120.3742
	-20%	0.0849	51.6671	11287.4423	121.5973
h_2	+20%	0.0645	51.6890	11262.7695	116.4004
	+10%	0.0695	51.6834	11263.5945	117.6738
	-10%	0.0821	51.6698	11265.6141	120.8839
	-20%	0.0903	51.6613	11266.8756	122.9738
B	+20%	0.1008	51.7401	11221.4344	125.6034
	+10%	0.0882	51.7092	11242.6944	122.4173
	-10%	0.0620	51.6434	11287.0022	115.7796
	-20%	0.0482	51.6080	11310.1599	112.2763
ρ	+20%	0.0749	43.3445	9229.3573	122.3343
	+10%	0.0751	47.1320	10154.3118	120.8969
	-10%	0.0754	57.2322	12621.7770	116.9722
	-20%	0.0756	64.1763	14318.6761	114.2542
λ	+20%	0.0754	51.6766	11264.6905	119.1769
	+10%	0.0753	51.6768	11264.6190	119.1514
	-10%	0.0752	51.6774	11264.4285	119.1257
	-20%	0.0751	51.6777	11264.2975	119.1002

Calculation of table 1 shows that increase or decrease in values of profit and order quantity occurs when parameter 'a' increases/ decreases.
Also when parameter h_1 increases/ decreases, then total profit and order quantity decrease/ increase.
Moreover, when increase/decrease in parameters B and h_2 occur, then profit also shows decrease/increase and order quantity shows increase/ decrease.
Total profit and order quantity show very minor change in values when value of parameter θ changes.
Total profit and order quantity show almost no change in values when value of parameter λ changes.

6 CONCLUSION

For defective and repairable items development of model is done in this paper with two warehouses under time and price dependent demand situation. Post-optimality computations for parameters are done which show that due to variation in parameter values, there is corresponding variation in order quantity and profit.

References

[1] Y.K. Shah and M.C. Jaiswal (1977): An order level inventory model for a system with constant rate of deterioration; Opsearch, Vol. 14, pp.174-184.
[2] R. Gupta and P. Vrat (1986). Inventory model for stock dependent consumption rate. Opsearch, Vol. 23, pp. 19-24.
[3] B.N. Mandal and S. Phaujdar (1998): A note on inventory model with stock dependent consumption rate; Opsearch, Vol. 26, pp. 43-46.
[4] R.N. Mukhopadhyay, R.N. Mukherjee and K.S. Chaudhary (2004): Joint pricing and ordering policy for deteriorating inventory; Computers and Industrial Engineering, Vol. 47, pp. 339-349.
[5] S.K. Patra, T.K. Lenka and P.C. Ratha (2010): An order level EOQ model for deteriorating items in a single warehouse system with price depended demand in nonlinear (quadratic) form; International J. of Computational and Applied Mathematics, Vol. 5, pp. 277-288.
[6] S.S. Routray, S. Mishra, S.K. Paikray and U.K. Misra (2015): A model on deteriorating items with price dependent demand rate; Int. J. of Recent Research in Applied Studies, Vol. 25, No. 2, pp. 44-49.
[7] R. Patel and S.R. Sheikh (2015): Inventory model with different deterioration rates under linear demand and time varying holding cost; International J. Mathematics and Statistics Invention, Vol. 3, No. 6, pp. 36-42.
[8] I. Aliyu, and B. Sani (2018): An inventory model for deteriorating items with generalised exponential decreasing demand, constant holding cost and time-varying deterioration rate; American J. Oper. Res., Vol. 8, pp. 1-16.
[9] R. Sundararajan and M. Prabha (2019): An inventory model for non-instantaneous deteriorating items with multivariate demand and backlogging under inflation; Journal of Management Analytics, Vol. 6, No.3, 2019, pp. 302-322.
[10] H.L. Lee. and M.J. Rosenblatt (1985): Optimal inspection and ordering policies for products with imperfect quality; IIE Transactions, Vol. 17, No. 3, pp. 284-289.
[11] T.C.E. Cheng (1991): An economic quantity model with demand dependent unit production cost and imperfect production process; IIE Transactions, Vol. 23, pp. 23-28.
[12] M.K. Salameh and M.Y. Jaber (2000): Economic production quantity model for items with imperfect quality; J. Production Eco., Vol. 64, pp. 59-64.
[13] S.K. Goyal and L.E.C.Barron (2002): Note on economic production quantity model for item with imperfect quality – a practical approach; Int. J. Prod. Eco., Vol. 77, pp. 85-87.
[14] S.S. Patel and R.D. Patel (2012) : EOQ model for weibull deteriorating items with imperfect quality and time varying holding cost under permissible delay in payments; Global J. Mathematical Science: Theory and Practical, Vol. 4, No. 3, pp. 291-301.
[15] C.K. Jaggi, S. Tiwari and A. Shafi, A. (2015): Effect of deterioration on two warehouse inventory model with imperfect quality; Computers and Industrial Engineering, Vol. 88, pp. 378-385.
[16] R. Uthayakumar and T. Sekar (2017): A multiple production setups inventory model for imperfect items considering salvage value and reducing environmental pollution; Oper. Res. And Appl.: An International Journal, Vol. 4, No. 1, pp. 1-16.
[17] R.K. Yadav and R. Kumar (2014): An inventory model for repairable items with linear demand; IOSR Journal of Mathematics, Vol. 10, No. 6, pp. 1-6.
[18] U.B. Gothi, M. Joshiand K. Parmar (2017): An inventory model of repairable items with exponential deterioration and linear demand rate; IOSR Journal of Mathematics, Vol. 13, No. 3, pp. 75-82.
[19] K.V.S. Sarma (1987):A deterministic inventory model for deteriorating items with two storage facilities", Euro. J. O.R., Vol. 29, pp. 70-72.
[20] T.P.M. Pakkala and K.K. Achary (1992): A deterministic inventory model for deteriorating items with two warehouses and finite replenishment rates; Euro. J. Oper. Res., Vol. 57, pp. 71-76.
[21] L. Benkherouf (1997): A deterministic order level inventory model for deteriorating items with two storage facilities; International J. Prod. Eco., Vol. 48, pp. 167-175.
[22] C.K. Jaggi and P. Verma (2008): Joint optimization of price and order quantity with shortages for a two warehouse system; TOP, Vol. 16, pp. 195-213.
[23] S.S. Sana, S.K. Mondal, B.K. Sarkar and K. Chaudhari (2011): Two warehouse inventory model on pricing decision; International J. of Management Science and Engineering Management, Vol. 6(6), pp. 467-480.
[24] J.C.P. Yu, S.J. Cheng, M. Padilan and H.M. Wee (2012): A two warehouse inventory model for deteriorating items with decreasing rental over time; Proc. of the Asia Pacific Industrial Engineering & Management Systems Conference, (Eds.) V. Kachitvichyyanukul, H.T. Luong and R. Pitakaso, pp. 2001-2010
[25] V. Kumar, A. Sharma and C.B. Gupta (2015): Two warehouse partial backlogging inventory model for deteriorating items with ramp type demand; Innovative Systems Design and Engineering, Vol. 6, No. 2, pp. 86-97.
[26] S.R. Sheikh and R.D. Patel (2017): Two warehouse inventory model with different deterioration rates under linear

demand and time varying holding cost; Global J. Pure and Applied Maths., Vol.13, pp.1515-1525.
[27] S. Singh, S. Sharma and S.R. Pundir (2018): Two-warehouse inventory model for deteriorating items with time dependent demand and partial backlogging under inflation; International Journal of Mathematical Modelling & Computations, Vol. 08, No. 02, pp. 73- 88.

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