RESEARCH REVIEW JOURNALS
Volume-04
Issue-03
March-2019

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com[UGC Listed Journal]

An EOQ Model When Quantity Received Uncertain With Planned Shortages and Equivalent Holding Cost and Shortages Cost

[*1]Raina Pandya & [2]Chirag J Trivedi

[1]*Research scholar, statistic Department, Gujarat University, Ahmedabad(India)*
[2]*Head & Associate professor, statistic Department, R.J.Tibrewal Commerce College, Ahmedabad (India)*

ARTICLE DETAILS

Article History
Published Online: 13 March2019

Keywords
EOQ, back-ordering, Shortage cost, equivalent holding cost and shortage cost, quantity received uncertain

[*]Corresponding Author
Email:: pandyaraina88[at]gmail.com

ABSTRACT

In this deterministic inventory classical EOQ model, here assumed that the lead time is fix and the quantity which received uncertain and the planned shortages with equivalent holding beside shortages cost. The basic EOQ model extends above satisfies the determination to manage problem as much as possible. Beside the backorders are filled immediately. In this paper order quantity depend upon maximum and average inventory. an EOQ model is define by minimize total cost of an inventory, additionally provide a numerical example with simple EOQ formula and also show the effect of backorder on quantity with appropriate graph.

1. Introduction

An EOQ model is most favorite and smart research attention. For number of years, researchers extend the deterministic EOQ model with various conditions and combustions. The quantity plays a main role in inventory management. It happen sometimes the requisitioned quantity and ordered quantity does not matches and lose it future demand. The stringent and simple assumption taken in this model is that shortages planned and stock out are permitted.

Silver (1976) has derive an inventory EOQ model, in which the quantity ordered and received are uncertain and hence a random variable which traditionally known as random input with defined mean and variance. Karlo and Gohil (1982) have extended these results with shortages. Noori and Keller (1992) developed a probabilistic model under random input. Yano (1995) gave review of article on the inventory model when quantity received by random input. An EOQ for planned shortages model seen in many few books - Anderson 2009; Gupta 2008; to construct this model both terms carry the meaning but back ordering is more suitable as it deal with the cost of back ordering, hence in the paper shortage cost (C_2) is used. Some author use term "back ordering" while many author use "planned shortages" . Hu W. S. Kim, and A. Banerjee (2009) define model of shortages cost with the waiting time. Kharde B., G. VkhePatil and K Nandukar (2011) clarify alternative carrying cost which appropriate for the different inventory classical EOQ model.

In traditional EOQ model, inventory holding cost is important. In the past many researches have carried out their research on holding cost with different situations. An attempt is made to developed an EOQ model using equivalent holding and shortages cost while shortages have planned when quantity received is uncertain, which is supported by a hypothetical numerical example.

2. Assumptions AND Notations

1. The demand for the item is certain, constant and continuous
2. Lead time is fixed
3. Holding cost (C_1) per unit per unit is constant and does not change for different order quantity.
4. Shortages cost (C_2) is also known and constant.
5. Ordering cost (C_3) per order is constant for any number of quantity orders
6. Discount is not permitted
7. The replenishment for order quantity (Q) is conclusion variable and when shortages level reaches planned shortages level in one lot.
8. The unit cost C does not depend upon the quantity order or received.
9. The quantity requisitioned does not necessity match with the quantity received.

Here, quantity requisitioned Q and Y is the quantity received the Y as random variable

- E(Y) = b Q and ----------------------------(1)
- $V(Y) = \sigma_\circ^2 + (\sigma_1^2 + b^2)Q^2$----------------------------(2)
- Where, b > 0 is the bias factor and $\sigma_\circ^2,\ \sigma_1^2 > 0$ are constant.

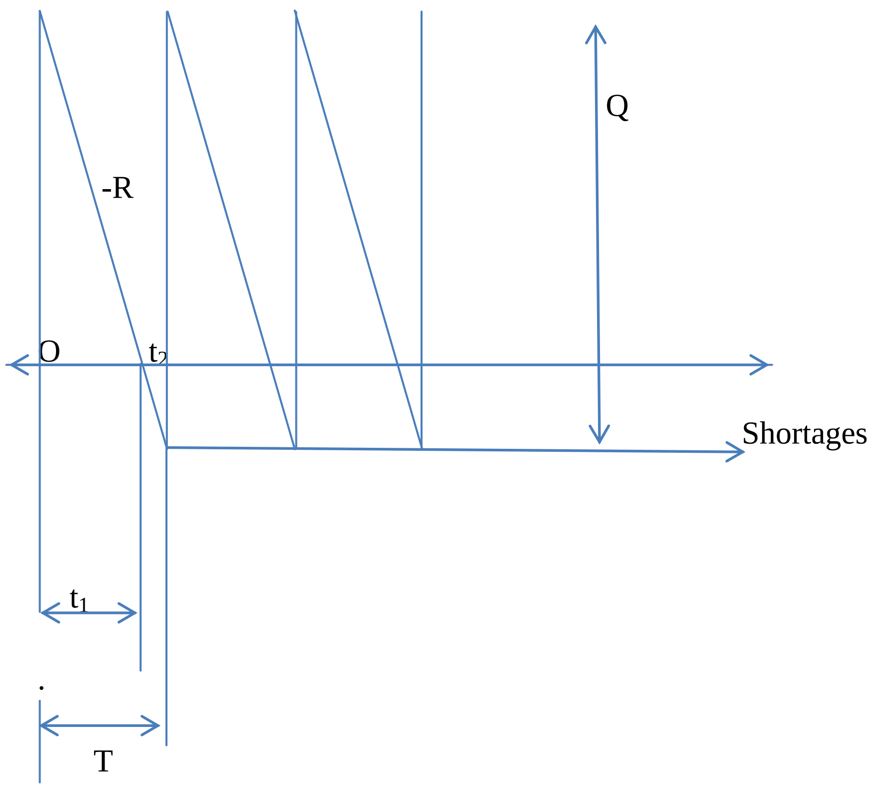
10. Shortages are permissible and backordering cost per unit is known and is constant.

Notations

Q = the order quantity; per order
Q* = Economic order quantity; per order
T (Q) = Annual inventory Cost
R = Inventory fix rate
tp = Period of positive Inventory
tn = Period of negative Inventory
LT = Lead time
Fb = Factor of equivalent holding cost and backorder or shortages cost per unit per year
EC1C2 = Equivalent Holding and shortages cost when Backorder are Permitted under random input
M = maximum Inventory Level; units
S = maximum shortages level or maximum backorder quantity units.
Y= Actual received quantity between two successive order
D = Annual demand in units
N = Number of quantity received per unit
Q-S = Shortages before quantity added.

3. Mathematical model

The basic model can be described by using the following diagram.



We analyze one cycle, an EOQ is an uncertainty, we take the quantity interval between two successive orders for Planned Shortages.

3.1 Holding cost:-

Inventory decreases at the rate of R units per time unit and the Order quantity is Q during the time interval t_1

Maximum Inventory $= \mathrm{bQ} - \mathrm{S} = \mathrm{Rt}_1$

Average Inventory with uncertain quantity (Y) during $t_1 = \frac{Rt_1 Y}{2} = \frac{(bQ-S)\,\mathrm{Y}}{2}$

M=Rt_1, bQ =RYT, here, $T = t_1 + t_2$

$$\frac{M}{bQ} = \frac{Rt_1}{RYT} = \frac{t_1}{YT}$$

$t_1 = \frac{MYT}{bQ} = \frac{Y(bQ-S)T}{bQ}$-------------------------------------(3)

$$N = \frac{1}{T} = NT = 1$$

$C_1(Q)$ = (Average Inventory) ×(Inventory holding cost per unit per year)

$=\left[\frac{(bQ-S)Y}{2}\right] C_1 t_1$

Annual Holding cost:

C_1 (Q) = (Holding cost per year) ×(Expected quantity)

$$= \left[\frac{(bQ-S)Y}{2}\right] C_1 t_1$$

$= \left[\frac{(bQ-S)Y}{2}\right] C_1 \left[\frac{Y(bQ-S)T}{bQ}\right] N = \frac{Y^2(bQ-S)^2 C_1}{2bQ}$ --------------------------- (4)

3.2 Shortages cost:

Quantity under shortages (y_2), during these time the interval t_2 the demand occurs at the rate R.

Maximum shortages= $S = Rt_2$

Average shortages with uncertain quant during $t_2 = \frac{Rt_2Y}{2} = \frac{SY}{2}$

S $=Rt_2$, bQ $=RYT$, here, $T = t_1 + t_2$

$\frac{S}{bQ} = \frac{Rt_2}{RYT} = \frac{t_2}{YT}, t_2 = \frac{SYT}{bQ}$

Shortages during back order:

C_2 (Q) = (Average shortages cost) ×(shortages cost/expected back order quantity)

$$C_2(Q) = \frac{S}{2} C_2 t_2$$

Here, C_2 is shortages cost per unit per year, expected quantity y_2

Annual shortages cost:

C_2 (Q) = (shortages cost/expected received quantity) ×(expected received quantity/per year)

$$= \frac{S}{2} C_2 t_2 N$$

$$= \frac{S}{2} C_2 \left[\frac{SYT}{bQ}\right] N$$

$= \frac{S^2 Y C_2}{2bQ}$ ---------------------------- (5)

3.3 Ordering cost:

Quantity order per year = $\frac{D}{bQ}$

Annual ordering cost:

C_3 (Q) = (Order/quantity) ×(ordering cost/quantity)

$= \frac{D}{bQ} C_3$---------------------------- (6)

Hence the total cost K(Y) for the system of planned shortages when quantity received uncertain is given as:

$K(Y) = \frac{Y^2(bQ-S)^2 C_1}{2bQ} + \frac{S^2 Y C_2}{2bQ} + \frac{D}{bQ} C_3$---------------------------- (7)

Now, assuming Y to be normally distributed with

$$E(Y) = b\,Q \text{ and } V(Y) = \sigma_\circ^2 + (\sigma_1^2 + b^2)Q^2$$

Using equation 1 & 2,

$E\left(T(Y)\right) = \frac{E(Y)}{R} = \frac{bQ}{R}$--------------------------- (8)

$E\left(K(Y)\right) = \frac{C_1(bQ-S)^2(\sigma_\circ^2+(\sigma_1^2+b^2)Q^2)}{2bQ} + \frac{C_2 S^2 bQ}{2bQ} + \frac{C_3 D}{bQ}$ ---------------------------- (9)

Total expected cost is given by

$TEC(Q) = \frac{E(K(Y))}{E(T(Y))}$

$= \frac{1}{bQ}[C_1\sigma_\circ^2(bQ-S)^2 + C_3 DR] + C_1(\sigma_1^2 + b^2)Q + C_2 S^2$ ----- (10)

For optimization Q=Q* is obtained by

$\frac{\partial TEC(Q)}{\partial Q}$ = 0 gives $Q^* = \sqrt{\frac{C_1(bQ-S)^2\sigma_\circ^2+C_2S^2+2C_3DR}{C_1(\sigma_1^2+b^2)}}$-------------------------- (11)

Here, suppose shortages are constant

$Q^* = \sqrt{\frac{C_1(bQ-S)^2\sigma_\circ{}^2+2C_3DR}{C_1(\sigma_1{}^2+b^2)}}$---------------------------- (12)

Then total expected cost TEC (Q*) equation is decreased to Zero

$TEC(Q^*) = \sqrt{\frac{C_1(\sigma_1{}^2-b^2)(C_1\sigma_\circ{}^2(bQ-S)^2)+C_2S^2+2C_3DR}{b}}$---------------------------- (13)

The total expected cost obtained by equation is minimum iff,

$\frac{\partial TEC(Q^*)}{\partial Q^*} = \frac{1}{b}\sqrt{\frac{C_1{}^3(\sigma_1{}^2+b^2)^3}{(C_1\sigma_\circ{}^2)+2C_3DR}} > 0$ ---------------------------- (14)

3.4 Particular cases:

When variance is directly proportional to quantity order i.e. $\sigma_\circ=0$, $\sigma_1>0$

Here equation (12) $Q^* = \sqrt{\frac{2C_3DR}{C_1+(\sigma_1{}^2+b^2)}}$ ---------------------------- (15)

And optimality completion equation (13) reduces,

$TEC(Q^*)\sqrt{\frac{C_2S^2+2C_3DR}{b}}$ - --------------------------- (16)

Now, to minimize the total cost, partial derivative with Q and S should be Zero.

Taking derivatives of T (Q) with respect to S and equating it to Zero.

$$\frac{\partial T(Q)}{\partial s} = \frac{\partial}{\partial S}\left(\frac{C_1(bQ-S)^2}{2bQ}+\frac{C_2S^2}{2bQ}+\frac{C_3D}{bQ}\right)$$

$$= -\frac{2(bQ-S)C_1}{2bQ}+\frac{C_2(2S)}{2bQ}+0$$

Equating it to Zero,

$$0 = -\frac{(bQ-S)C_1}{bQ}+\frac{C_2S}{bQ}$$

$$0 = -(bQ-S)C_1+C_2S$$

$$= bQC_1+C_1S+C_2S$$

$$bQC_1 = C_1S+C_2S = S(C_1+C_2)$$

$$\frac{bQ}{S} = \frac{C_1+C_2}{C_1}$$

$S^* = \frac{bQ^*C_1}{C_1+C_2}$ ---------------------------- (17)

This is the optimum condition of S, when quantity received uncertain:

Hence, S is replaced by optimum S*

Now, we have $\frac{bQ}{S^*} = \frac{C_1+C_2}{C_1}$ ---------------------------- (18)

$\frac{S^*}{bQ} = \frac{C_1}{C_1+C_2}$- --------------------------- (19)

Equation (18) isdefined as new factor of back order,

$F_b = \frac{C_2}{C_1+C_2}$ ---------------------------- (20)

Factor of back order is depends uponC_1&C_2. It is physically constant for this EOQ Model.

Equation (19) substituting LHS and RHS from 1,

$1-F_b = 1-\frac{C_2}{C_1+C_2} = \frac{C_1}{C_1+C_2}$ ---------------------------- (21)

From Equation (18) and (20),

$$1-F_b = \frac{C_1}{C_1+C_2} = \frac{S^*}{bQ}$$

$$S^* = (1-F_b)bQ$$

$F_b = \frac{bQ-S^*}{bQ} = \frac{M^*}{bQ}$- --------------------------- (22)

$$\therefore M^* = F_b bQ$$

Equivalent holding & shortages cost: $(E\ C_1C_2)$

Here, Take total annual holding shortages cost,

$$C_1(Q)+C_2(Q) = \frac{(bQ-S)^2C_1}{2bQ}+\frac{C_2S^2}{2bQ}$$

Substituting for S*

$$C_1(Q)+C_2(Q) = \frac{(bQ-(1-Fb)bQ)^2C_1}{2bQ}+\frac{C_2((1-Fb)bQ)^2}{2bQ}$$

$$C_1(Q)+C_2(Q) = \frac{((bQ)^2-(1-Fb)^2C_1}{2bQ}+\frac{C_2(bQ)^2(1-Fb)^2}{2bQ}$$

$$C_1(Q)+C_2(Q) = \frac{bQ}{2}(1-(1-Fb))^2C_1+C_2(bQ)^2(1-Fb)^2$$

$$C_1(Q) + C_2(Q) = \frac{bQ}{2}[(Fb)^2C_1 + C_2(1 - Fb)^2]$$

Putting the value of Fb & 1-Fb from equation (20) & (21),

$$C_1(Q) + C_2(Q) = \frac{bQ}{2}\left[\left(\frac{C_2}{C_1 + C_2}\right)^2 C_1 + C_2\left(\frac{C_1}{C_1 + C_2}\right)^2\right]$$

$$C_1(Q) + C_2(Q) = \frac{bQ}{2}\left[\frac{C_1C_2{}^2 + C_1{}^2C_2}{(C_1 + C_2)^2}\right]$$

$$C_1(Q) + C_2(Q) = \frac{bQ}{2}\left[\frac{C_1C_2(C_1 + C_2)}{(C_1 + C_2)^2}\right]$$

$$C_1(Q) + C_2(Q) = \frac{bQ}{2}\left[\frac{C_1C_2}{C_1 + C_2}\right]$$

$$C_1(Q) + C_2(Q) = \frac{bQ}{2}C_1\left[\frac{C_2}{C_1 + C_2}\right]$$

$C_1(Q) + C_2(Q) = \frac{bQ}{2}C_1 Fb$---------------------------- (23)

If Fb=1,

$$C_1(Q) + C_2(Q) = \frac{bQ}{2}C_1$$

Now, this EOQ model has no shortages cost. So, we defined by analogy equivalent holding cost $E\,C_1C_2$ for this EOQ model. $EC_1C_2$for EOQ model is product of holding cost and factor of back ordering.

Here, C_1.eb nots equivalent holding cost $E\,C_1C_2$ for EOQ model. So,

$C_1.eb = Fb.C_1$---------------------------- (24)

$C_1.eb$ Is cost, which is having combined cost effect of from Equation (23) & (24). We get equation (25)

$C_1(Q) + C_2(Q) = \frac{bQ}{2}C_1.eb$---------------------------- (25)

Total annual Inventory cost for EC_1C_2 model:

$$T(Q) = C_1(Q) + C_2(Q) + C_3(Q)$$

$$T(Q) = \left(\frac{bQ}{2}\right)(C_1.eb) + \frac{C_3D}{bQ}$$

For minimization of total cost, the partial derivative of the total cost with respect to (Q) it should be Zero.

$$\frac{\partial T(Q)}{\partial Q} = \frac{\partial}{\partial Q}\left[\left(\frac{bQ}{2}\right)(C_1.eb) + \frac{C_3D}{bQ}\right]$$

$=\frac{C_1.eb}{2} + (-1)\frac{C_3D}{bQ^2}$

$=\frac{C_1.eb}{2} - \frac{C_3D}{bQ^2}$

Equating it to Zero,

$$0 = \frac{C_1.eb}{2} - \frac{C_3D}{bQ^2}$$

$$\frac{C_1.eb}{2} = \frac{C_3D}{bQ^2}$$

$$bQ^2 = \frac{2C_3D}{C_1.eb}$$

$$Q^2 = \frac{2C_3D}{b\,C_1.eb}$$

$Q = \sqrt{\frac{2C_3D}{b\,C_1.eb}}$---------------------------- (26)

The value of Q is optimum but to confirm for global minimum, second derivative must be positive,

$$\frac{\partial^2 T(Q)}{\partial^2(Q^2)} = \frac{\partial}{\partial Q}\left[\left(\frac{C_1.eb}{2}\right) + (-1)\frac{C_3D}{bQ^2}\right]$$

$=0 + (-1)(-2)\frac{C_3D}{bQ^3}$

$$= \frac{2C_3D}{bQ^3}$$

Here, all values of RHS are positive.

$$LHS = 2(D)\left(\frac{C_3}{bQ^3}\right) > 0$$

Hence, the quantity Q found is the minimum cost point optimum quantity, denoting as Q*

For $E\,C_1C_2$ model

$Q^* = \sqrt{\frac{2C_3\text{D}}{\text{b C}_1\text{.eb}}}$---------------------------- (27)

Comparing this with traditional EOQ model

$$Q^* = \sqrt{\frac{2C_3\text{D}}{\text{C}_1.}}$$

3.5 Total optimum annual Inventory cost:

$$\text{T}(Q^*) = \text{C}_1(Q^*) + \text{C}_2(Q^*) + \text{C}_3(Q^*)$$

$$\text{T}(Q^*) = \left(\frac{\text{b}Q^*}{2}\right)\text{C}_1.\text{eb} + \frac{C_3\text{D}}{\text{b}Q^*}$$

$$\text{T}(Q^*) = \left(\frac{2C_3\text{D}}{\text{bC}_1.\text{eb}}\right)^{1/2}\left(\frac{\text{C}_1.\text{eb}}{2}\right) + \frac{C_3\text{D}}{b\left(\frac{2C_3\text{D}}{\text{bC}_1.\text{eb}}\right)^{1/2}}$$

$$= \frac{1}{(2)^{1/2}}(C_3\text{D b C}_1.\text{eb})^{1/2} + \frac{1}{(2)^{1/2}}(C_3\text{D b C}_1.\text{eb})^{1/2}$$

$$= [C_3\text{D b C}_1.\text{eb}]^{1/2}\left[\frac{1}{(2)^{1/2}} + \frac{1}{(2)^{1/2}}\right]$$

$$= \sqrt{C_3\text{D b C}_1.eb}\sqrt{2}$$

$$= \sqrt{2C_3\text{D b C}_1.\text{eb}}$$

Annual holding cost:

$$\text{C}_1(Q^*) = \frac{\text{C}_1(\text{b}Q^* - S^*)^2}{2bQ^*}$$

$$\text{C}_1(Q^*) = \text{C}_1\left[\frac{(\text{b}Q^* - S^*)}{2}\right]\left[\frac{(\text{b}Q^* - S^*)}{bQ^*}\right]$$

$$= \text{C}_1\left[\frac{M^*}{2}\right][Fb]$$

$\text{C}_1(Q^*) = \left[\frac{M^*}{2}\right]\text{C}_1.\text{eb}$---------------------------- (28)

Annual shortages cost:

$$C_2(Q^*) = \frac{C_2S^{*^2}}{2bQ^*}$$

$$= \text{C}_2\left[\frac{S^*}{2}\right]\left[\frac{S^*}{bQ^*}\right]$$

$$= \left[\frac{S^*}{2}\right][1 - Fb]$$

$= \left[\frac{S^*}{2}\right]\text{C}_1.\text{eb}$---------------------------- (29)

4. Hypothetical Example

It solved by simple inventory formulas which obtain in mathematical model.

1	D	2000 units per order
2	C_1	25% of Inventory Value per unit per order
3	C_2	15% of Inventory Value per unit per order
4	C_3	10 rs. Per order
5	C	20 rs. Per Unit per order
6	S	30 rs. Per order when shortages maximum
7	b	0.75
8	WD	30 work day in year

1. Holding Cost:-C_1 = (C) (C_1) =(20)(0.25)=5rs. Per unit per year
2. Shortages costC_2 = (C) (C_2) = (20)(0.15) = 3rs. Per unit per year
3. Factor for shortages: $F_b = \frac{C_2}{.C_1 + C_2}$ =0.375
4. Equivalent Holding and shortage cost:$\text{C}_1.\text{eb} = (\text{Fb})(\text{C}_1) = (0.375)(5) = 1.875$ rs unit year
5. EOQ =(Q*) = $\sqrt{\left[\frac{2C_3D}{b.C_1.eb}\right]} = \sqrt{\frac{120000}{1.40625}} = 292.11$ unit per order
6. Optimal back order quantity or optimum maximum shortages:

$S^* = (1 - Fb)bQ^* = 136.92$Unit per order

7. Optimum maximum inventory level:$M^* = FbQ^* = 110$ unit per order
8. Totaloptimum Inventorylevel:$T(Q^*) = \sqrt{2C_3Db.C_1.eb} = 237.17$
9. Optimumholdingcost: $(C_1) = \frac{M^*}{2}C_1.eb = 103.12$
10. Optimumshortagescost: $C_2 = \frac{S^*}{2}C_2.eb = 128.43$ rs per year
11. Optimumorderingcost: $C^3(Q^*) = \frac{C_3D}{bQ*} = 91.32$ rs per year
12. Inventory fix rate per day: $R = \frac{D}{WD} = 66.66$ units/day
13. Timefor positive Inventory: $t_1 = \frac{M^*}{R} = 2$ days
14. Timeforshortages: $t_2 = \frac{S^*}{R} = 2$ days
15. Timebetweentwosuccessiveorder: $T = \frac{S^*}{R} = 4\ days$

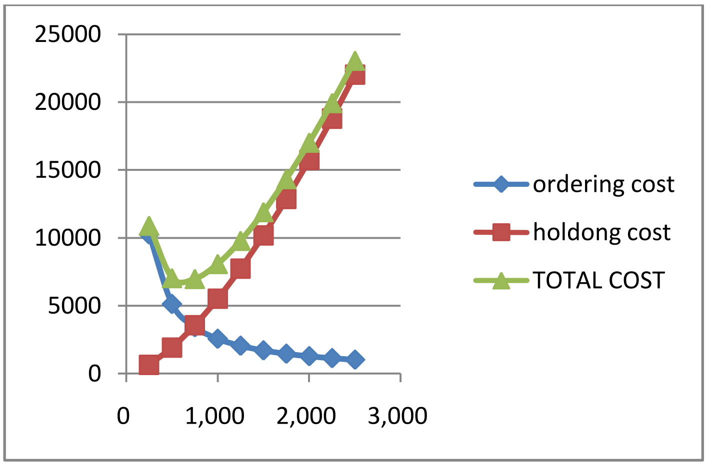
As equal to $t_1 + t_2$

5. Conclusion

In this paper the optimal policy deal with uncertain quantity andthe equivalent holding and shortages cost with planned shortages. It shows that the total cost is minimized and the values may be changed over quantity due to uncertainty. However the profit depends upon the reliable situation and the estimation of quantity.

The below table shows that the effect of the backorder:

Quantity	Ordering Cost	Holding Cost	Total Cost
250	10240	657	10897
500	5120	1921	7041
750	3413	3567	6980
1,000	2560	5520	8080
1,250	2048	7739	9787
1,500	1707	10194	11900
1,750	1463	12864	14327
2,000	1280	15734	17014
2,250	1138	18790	19928
2,500	1024	22022	23046



Sensitivity Analysis:

Demand rate: - D=2000 and units per year
Inventory fix rate: - R=100 units per year
Holding cost: - C_1 =25 per unit per year
Shortages cost: - C_2 =15 per unit per year
Ordering cost: - C_3= 30 per unit
Maximum Shortages: - S= 30 per unit

Variation into Q* and TEC(Q*) with σ_1^2 and b:

σ_1^2 \ b	0.75	0.80	0.85	0.90	0.95
5	239.85	238.19	236.47	234.68	232.84
	3268.74	3164.94	3070.44	2983.93	2904.35
10	174.04	173.42	172.77	172.13	171.49
	3268.74	3164.94	3070.44	2983.93	2904.35
15	143.39	143.03	142.67	142.26	141.85
	3268.74	3164.94	3070.44	2983.93	2904.35
20	124.74	124.51	124.26	124.00	123.73
	3268.74	3164.94	3070.44	2983.93	2904.35
25	111.88	111.71	111.53	111.34	111.14

	3268.74	3164.94	3070.44	2983.93	2904.35

Interpretation:

When b and σ_1^2 are increase for any given value, the optimum order quantity Q* decreases and correspondingTEC(Q*) decrease and remains same any given value.

References

1. Abad P., (2001), "Ideal price and quantity for a dealer with partial backordering". Computers & Operations Research, Volume 28, Issue 1, January 2001, Pages 53-65.
2. Abad P. (2003), "Optimal pricing and lot-sizing under conditions of perishability.
3. Abad P., (2008), "EOQ model of optimum price with order quantity under partial backordering integrate shortage, backorder and missing sale costs", International Journal of research Economics index, Volume 114, Issue 1, July 2008, Pages 179-186.
4. Chang H. "Promote EOQ model define shortages cost and variable study with damage item", Omega, Volume 38, June-August 2010, Pages 233-237.
5. Gupta, P.K. Hira D.S. (2008), "Advance EOQ models", New Delhi, India; S. Chand, 1011-1097.
6. Gok Y., A. Satir, S. Goyal (1988), "A few different outcomes combined replenishment of quantity with stochastic demand and backordering, January 1988, Pages 125-133.
7. GOR, A. S. (1994): "A lot-size inventory for deteriorating quantity under random input", Industrial Engineering Journal, 23, 9-15.
8. Hu W., S. (2009), "An inventory model justifies with partial backordering and continues time waiting "Volume 197, Issue 2, 1 September 2009, Pages 581-587.
9. Kharde B., G. VikhePatil and K. Nandurkar (2011a), "Simplify of Economic Lot Size Model through Equivalent Holding Cost", SVNIT, Surat, 17-19 November 2011.
10. Kharde B., G. VikhePatil, "Inventory EOQ Model of Equivalent Holding Cost", Proceedings of.
11. KALRO, A.H. and GOHIL, M. M., (1982): "A policy inventory explain through partial backlogging with the unsure quantity of random variable", International Journal Of Production Research, 20, 775-786.
12. Narsimhan, (2010), "Analytical inventory structure. Production planning and inventory control", New Delhi, India, Prentice-Hall, 91-111.
13. SHAH, N. H. and SHAH, Y. K; (1992-a): "Clarify an inventory model for decay quantity under random supply network", Industrial Engineering Journal, 21, 13-18.
14. SHAH, N. H. and SHAH, Y. K; (1992-b): "Effective version of economic model with finite production rate for deteriorating items and random input", Research Bulletin, 11, 76-79.
15. SILVER, E. A. (1976): "Demonstrate the invert quantity with random input", INFOR, 14(1), 32-39.

