Onion Inventory Model

H.P.Umap

Associate Professor, Department of Statistics, Yashavantrao Chavan Institute of Science, Satara., Maharashtra (India)

Abstract *- In this paper an EOQ model for onion is developed to obtain the total inventory cost and optimum order quantity in deterministic environment. Demand is considered to be selling price dependent. Deterioration rate, set-up cost and shortage cost are assumed to be deterministic in nature. Shortages are allowed and partially backlogged. Solution procedure is illustrated by a numerical example. The sensitivity analysis of the optimum solution with respect to the changes in deterioration rate is also discussed.*

Keywords – *EOQ (Economic Ordered Quantity), Crisp, sensitivity analysis.*

I. INTRODUCTION

The word inventory means physical stock of goods. Almost every business must carry out some inventory for smooth and efficient running of its operation. Uncontrolled inventory may increase the total inventory cost, automatically price of the commodity increases and demand decreases. Hence a sound scientific control on inventory is an absolute necessity. In inventory control the problem is to take decisions that how much should be stocked and when should be produced / ordered. The total inventory cost involved three types of costs such as holding costs, set-up cost and shortage cost.

Demand is the most essential parameter of inventory policy. Demand can be estimated by using historical data. Deterioration is one the most important parameter in inventory management. Commodities like food grains, vegetables, fruits, chemicals etc. are deteriorate during their storage period. Therefore the loss due to deterioration cannot be ignored while determining the optimum inventory policy.

In this paper an inventory model is developed for 'onion'. Onion is one of the most important items in vegetable market. Storage of onion is very risky, laborious and costly. An uncontrolled stock of onion results in big loss. Hence it is necessary to control on loss due to deterioration.

A. Deterioration of onion

Deterioration of onion depends upon various parameters such as temperature, storage method, quality of onion and maintenance during storage period.

B. .Demand of onion

Onion is one of the most essential vegetable in daily meal. Hence generally it has demanded uniformly in all seasons. In shortage period prices of onion increases and hence demand decreases. It shows demand of onion depends upon its current price. So demand is the linear function of selling price. Hence it can be represented as 'a-bp', where a and b are any constants.

C. Review of literature

Certain models have been developed in the area of deteriorating inventories by considering the demand rate to be constant, stock-dependent, time-dependent, ramp type or selling price dependent. A significant research has been done with constant demand. Cohen M.A used constant demand rate to obtain an ordering policy in [3]. Giri B.C., Pal S., Goswami A. and Chudhari K.S.and Datta T.K. and Pal A.K. are developed an EOQ models with stock-dependent demand in ([5],[4]). Hariga M.,Chang H.J., Dye C.Y. and Teng J.T., Yang H.L. and Ouyang L.Y.taken time-varying demand in ([6],[2],[7]) where Wu K.S., Ouyang L.Y. used ramp type demand in [9] and Wee H.M. used selling price dependent demand in [8]. Recently, Bhunia A.K. and Maiti M. are used the demand depend upon selling price, frequency of advertisement and linear trend in time in [1] to develop inventory model for deteriorating items.

In this paper demand is considered to be selling price dependent. Deterioration rate, set-up cost and shortage cost are considered as deterministic in nature. Shortages are allowed and partially backlogged. An EOQ model for onion is developed and illustrated by a numerical example. The sensitivity analysis of the optimum solution with respect to the changes in the different parameter values is also discussed.

II. ASSUMPTIONS

1. The scheduling period is constant and no lead-time.
2. Demand rate R is dependent linearly on the unit selling price i.e.,
3. Shortages are allowed and partially backlogged.
4. Deteriorating rate is age specific failure rate.

III. NOTATIONS

T : Scheduling time of one cycle.

R : Demand rate per unit time; $R = a\text{-}bp$. where a, b are non-negative constants.

θ : Deterioration rate.

Q(t) : Inventory level at time t.

C_H : Total Holding cost per cycle.
C_1 : Holding cost per unit.
C_S : Total Shortage cost per cycle.
C_2 : Shortage cost per unit.
S_d : Total deteriorating units.
C_D : Total deteriorating cost per cycle.
C_d : Deteriorating cost per unit.
P : Selling price per unit.
S : Initial stock level.
S_1 : Maximum shortage level.
TIC : Total inventory cost per cycle.

IV. Figure

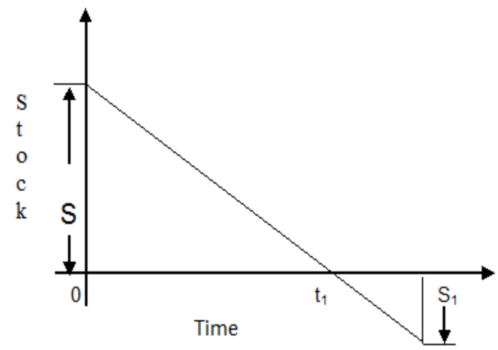

Fig: An inventory policy with shortages

V. Mathematical Model

The initial stock level is S at time t = 0, then inventory level decreases due to demand mainly and partially by deterioration. The stock reaches to zero level at t = t_1. Then shortages occur and accumulate to the level S_1 at t = T.

The differential equation describing the state of inventory in the interval (0 , t_1) is given by

$$\frac{d}{dt}Q(t)+\theta Q(t)=-(a-bp)\,;\;0\le t\le t_1 \qquad \text{--- (1)}$$

By solving above differential equation using boundary condition at t = 0, Q(t) = S ,We get ,

$$Q(t)=-\frac{(a-bp)}{\theta}+\left(\frac{S\theta+(a-bp)}{\theta}\right)e^{-\theta t}\,;\;0\le t\le t_1 \qquad \text{--- (2)}$$

By using boundary condition at t = t_1 , $Q(t_1)$ = 0 , we get

$$t_1=\frac{1}{\theta}\log\left\{1+\frac{S\theta}{(a-bp)}\right\} \qquad \text{--- (3)}$$

The differential equation describing the state of inventory in the interval (t_1 , T) is given by ,

$$\frac{d}{dt}Q(t)=-(a-bp)\,;\;t_1\le t\le T \qquad \text{--- (4)}$$

By integrating both sides and solving using condition at t = t_1 , $Q(t_1)$ = 0 , we get ,

$$Q(t)=-(a-bp)t+(a-bp)t_1\,;\;t_1\le t\le T \qquad \text{--- (5)}$$

By using condition at t = T ,Q(t) = $-S_1$, we get ,

$$S_1=(a-bp)T-(a-bp)\frac{1}{\theta}\log\left(1+\frac{S\theta}{(a-bp)}\right) \qquad \text{---(6)}$$

Total deteriorating units during the time interval (0 , T) are

$$S_d=\int_0^{t_1}\theta Q(t)dt\,; \qquad 0\le t\le t_1$$

$$S_d=\theta\int_0^{t_1}\left[-\frac{(a-bp)}{\theta}+\left(\frac{S\theta+(a-bp)}{\theta}\right)e^{-\theta t}\right]dt$$

By solving above integral, we get ,

$$S_d=-(a-bp)t_1-\left[\frac{S\theta+(a-bp)}{\theta}\left(e^{-\theta t_1}-1\right)\right]$$

Therefore the deteriorating cost is given by , $C_D=C_dS_d$

$$\therefore C_D=C_d\theta\left[-\frac{(a-bp)t_1}{\theta}-\left(\frac{S\theta+(a-bp)}{\theta^2}\right)\left(e^{-\theta t_1}-1\right)\right] \qquad \text{-- (7)}$$

Holding cost over the time period (0 , T) is given by ,

$$C_H=C_1\int_0^{t_1}Q(t)dt$$

By solving above integral using equation (2) , we get

$$C_H=C_1\left[-\frac{(a-bp)t_1}{\theta}-\left(\frac{S\theta+(a-bp)}{\theta^2}\right)e^{-\theta t_1}-1\right] \qquad \text{--- (8)}$$

Shortage cost is given by

$$C_S=C_2\left[-\int_{t_1}^{T}Q(t)dt\right]$$

By solving above integral by using equation (5) , we get

$$C_S=C_2\left[\frac{(a-bp)}{2}\;T-t_1{}^{2}\right] \qquad \text{---- (9)}$$

Then the total inventory cost is given by ,

$$TIC = C_H + C_D + C_S$$

$$TIC=\;C_1+C_d\theta\;\int_0^{t_1}Q(t)dt+C_S$$

$$TIC=\;C_1+C_d\theta\left[-\frac{(a-bp)t_1}{\theta}-\left(\frac{S\theta+(a-bp)}{\theta^2}\right)e^{-\theta t_1}-1\right] \qquad \text{--- (10)}$$

$$+C_2\left[\frac{(a-bp)}{2}\;T-t_1{}^{2}\right]$$

The above equation can be simplified using series form of logarithmic term and ignoring second and higher terms. The total inventory cost becomes,

$$TIC= C_1+Cd\theta \frac{S^2}{(a-bp)}+C_2\left[\frac{(a-bp)}{2}\left(T-\frac{S}{(a-bp)}\right)^2\right]$$

---(11)

to obtain optimum order quantity differentiating TIC partially w.r.t. S and equating to 0

$$\frac{dTIC}{dS}=\frac{2\ C_1+C_d\theta}{a-bp}S+\frac{C_2}{a-bp}S-C_2T=0 \text{ ---(12)}$$

The optimum order level is given by,

$$S^o=\frac{(a-bp)\ \ C2T}{2\ \ C_1+C_d\theta\ \ +C_2} \quad \text{---(13)}$$

VI. Numerical Example

Input : a=100, b=0.5, P=40, C_1=5, C_2=20, C_d=40, T=1 , θ =0.05,

Output :

S=47.06, t_1=0.58, S_1=33.62, TIC=716.96.

Sensitivity analysis for change in deterioration rate

θ	**S**	**t_1**	**S_1**	**TIC**
0.01	51.94805	0.647251	28.21988	644.8305
0.02	50.63291	0.628939	29.68487	665.4062
0.03	49.38272	0.611638	31.06896	684.164
0.04	48.19277	0.595266	32.3787	701.2919
0.05	47.05882	0.579751	33.61994	716.955
0.06	45.97701	0.565026	34.79793	731.2987
0.07	44.94382	0.551032	35.9174	744.4515
0.08	43.95604	0.537717	36.98261	756.527
0.09	43.01075	0.525032	37.99744	767.6263
0.1	42.10526	0.512933	38.96536	777.8393

VII. Concluding Remark:

Proposed inventory model is illustrated for the fixed values of inventory parameters. Parametric study of changes in values of deterioration rate is also presented in sensitivity analysis. In sensitivity analysis table, it is observed that as deterioration rate increases, the values of TIC and shortage level are also increased whereas initial stock level and stock out time are decreased. It is also observed that, for the constant increase rate of θ, increase rate of TIC decreases proportionally. Hence a scientific control on deterioration of onion is very essential to control on inventory cost which automatically optimizes the profit. Total control on deterioration is impossible, so decision maker can select any suitable case in parametric study and try to control on deterioration rate up to that level for optimum result.

REFERENCES

[1] Bhunia A.K. and Maiti M., *An inventory model for decaying items with selling price, frequency of advertisement and linearly time dependent demand with shortages*, IAPQR Transactions, 22,11 – 49,1997.
[2] Chang, H. J. and Dye, C.Y., *An EOQ model for deteriorating items with time varying demand and partial backlogging*, Journal of the Operational Research Society, 50 1176 – 1182,1999.
[3] Cohen, M. A., *Joint pricing and ordering policy for exponentially decaying inventory with known demand*. Naval Res. Logistics quarterly, vol. 24, 257 – 268,1977.
[4] Datta, T. K. and Pal, A. K., *Deterministic inventory model for deteriorating items with inventory level dependent demand rate and shortages*, OPSEARCH, vol. 27(4), 213 – 223,1990.
[5] Giri B.C., Pal S., Goswami A. and Chudhuri K.S., *An inventory model for deteriorating items with stock-dependent demand rate*, European journal of Operational Research, 95, 604 – 610,1996.
[6] Hariga, M., *An EOQ model for deteriorating items with shortages and time-varying demand* , Journal of the Operational Research Society, 46, 398 – 404,1995.
[7] Teng, J. T., Yang, H. L. and Ouyang, L.Y., *On an EOQ model for deteriorating items with time varying demand and partial backlogging*, Journal of the Operational Research Society, 54, 432 – 436,2003.
[8] Wee Hui-Ming, *A replenishment policy for items with a price dependent demand and a varying rate of deterioration*, Production Planning and Control, vol. 8 (5), 494 – 499,1997.
[9] Wu, K.S. and Ouyang, L.Y., *A replenishment policy for deteriorating items with ramp type demand rate*, Proc. Natl. Sci. Counc. ROC (A), vol. 24 (4), 279 – 286,2000.