An Economic Inventory Model Comparing Stock Dependent and Fixed Demand for Random Machine Breakdown, Repair Time and Deterioration

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Abstract: In this article, effect of random machine breakdown along with random repair time for a manufacture unit exposed to exponentially decreasing rate due to machine breakdown. Production is taken as directly proportional to demand and greater than demand. The model is proposed for demand as stock dependent and also for fixed demand. The unit is also producing deteriorating items. Comparison of expected lost sale cost has been made by considering demand as stock dependent and then as fixed. Using uniform probability density function expected manufacturing time is estimated. The work is done to compare both the demands and then come to a decision for the manufacture system to optimize the expected overall cost with respect to time, subjected to random machine breakdown. To summarize the model a numerical example is also discussed.

Keywords: Inventory; Economic Production Quantity; Optimization; stochastic repair time

1. Introduction

Conventional economic production quantity (EPQ) model considers the manufacturing units as reliable. This concept, however, doesn't succeed for some real systems. In actual, even the advanced and the latest developed assembling frameworks go through the situation of startling crisis, for example, machine breakdown, work strike and so on, and the time taken in solving the issue depends on type of the issue. By and large, the assembling framework is considered as flexible and to work in accordance with the demand. The assembling might stop at any subjective time and this period is moreover considered to be random. The purpose for this study is to choose the normal ideal manufacturing run time with the ultimate objective of decreasing the general expenses per unit time.

Subsequently, a significant research point lately has been the investigation of mechanism support and production control with regards to erratic breakdowns. In the same direction, Valentin Pando *et al.*[1] proposed the optimal model for return on stock administration cost. The demand rate depends both on the selling cost and the stock-level. The choice factors are the selling value, the stock level and the reorder point.

Pousoltan *et al.*[2] proposed the EPQ Model by considering stochastic machine breakdown and fix moment with random deterioration items and they studied the entire expense examination for various production time. Such imperfect things will influence accessible stock levels, making deficiencies and requiring changes to the repetition of orders.

Jawla *et al.*[3] proposed EPQ model to inspect the protection innovation sway with machine failure by accepting multivariate demand charge through fresh and fuzzy circumstance. Model is created for multi-things through faulty quality by thinking about the circumstance of arbitrary machine failure. Demand rate is thought to be multivariate.

Fang and Yeh[4] proposed EPQ model with random demand by considering inconsistent item life cycle. The unfulfilled client request happens on the current dissemination framework in the organization.

The lead time for item conveyance to clients is long because of the long stages in the dispersion organization. The significant delays for buyers lead to significant expenses[5].

An organization that incorporates these three things in direction can turn into an upper hand in the market[6]. The proposed dispersion conspire causes extra item conveyance areas through expanding item conveyance distances. Therefore, this concentrate likewise proposes a Vehicle Routing Problem (VRP) model to decide the dispersion course for transportation oil items to their merchants with least travel cost. With its effect lessening carrying price, VRP can be measured as a device to decrease ecological degradation[7].

A later metaheuristic usage was utilizing elephant crowd optimization[8]. Ozturk managed random machine breakdown with two cases during creation along with following creation to enhance the normal expense, disposing of the imperfect items, and others are offered at economical costs[9].

Lyong *et al.* proposed the EPQ model along with random apparatus breakdown, random fix point with deterioration to improve the creation price. This paper tends to the circumstance where a transitory (deteriorated) item is made and consumed at the same time, the interest of this item is steady throughout the moment, machine also features arbitrary disappointment and an opportunity to fix this machine is too unsure[10].

Singh *et al.* proposed the EPQ Model with random machine break and random fix period. Request is inventory dependent and for the time of sale it relies upon decrease on selling price. Manufacture rate is a interest component along with unwavering creation quality production is assumed to be exponentially diminishing capacity of moment. Fix moment is assessed utilizing continuous distribution[11].

Wang *et al.* fostered an EOQ model to advance the capacity with inadequate quality stuff, and choice factors rely on time interval. They concentrated on an issue of parcel size with occasional investigated, irregular yield, because of disturbances breakdown in assembling[12]. An unnatural weather change causes genuine effect towards the climate together with the increment of ocean levels and worldwide temperature because of the occurrence of ozone harming substances (GHG) in the air[13].

In the interim, Shahriari *et al.*[14] expressed that air contamination and petroleum expenditure can be decreased as the shipping use is limited. Throughout the long term, carbon dioxide (CO_2) is known as the principal supporter of ozone depleting substance, in which refrigerants is one of the reasons for carbon emission[15].Widyadana[16] formulated an EPQ model by considering random machine failure and irregular fix period. They analyzed that irregular fix model gives the recovered expense when contrasted with foreordained fix time.

Sana [17] proposed a model to assess the pace and steadiness of item to amplify benefit. They advanced the benefit for defective creation by thinking about consistency and assembling rate. They consider variable item unwavering quality component, inconsistent unit creation cost with dynamic creation rate for time-fluctuating interest. Chakraborty *et al.*[18] thought about an EPQ with machine failure in addition to deterioration. They thought about precautionary and remedial support, all the while. They introduced an EPQ model to cover a defective creation framework impacted by deterioration along with machine breakdowns and fixes. The model was planned involving inconsistent likelihood circulations for an opportunity to machine collapse, remedial and preventive fix period. They observed that the recommended model had the option to fundamentally decrease the stock expense and infer the optimal creation amount.

Hou and Lin [19] researched the machine collapse impacts on a manufacture model where the stock control NR representation is applied to an item specifically dependent upon remarkable rot.

Giri *et al.*[20] examined a creation stock examination for a flawed creation framework which is dependent upon random machine disappointment, without any than two disappointments happening in a cycle. They considered the AR policy following the underlying disappointment in incomplete delay purchasing, however the NR strategy in case of a second disappointment during a time of deficiency. Exploratory and computational examination on mechanical properties of supported added substance fabricated part conducted by Maurya and Rastogi[21].

Beemsterboer *et al*. investigated the work shop control issue, they inspected the impact of part size adaptability yet they didn't think about cost and time subordinate interest. They proposed the EPQ model through random machine failure, stochastic fix period and disintegration to upgrade the creation cost The current review takes on a half and half MTO-MTS creation framework stretching out past examination to cost and lead time subordinate irregular demand[22].

Li *et al*. considered for irregular interest and remanufacturing respects improve the model. They have thought of, the two viewpoints are consolidated together in a solitary way to deal with tackle single machine, single item EPQ issue. There are thought to be two states: 1) in-charge and 2) crazy state[23].

Luong *et al.* proposed the EPQ representation with random machine breakdown, random fix time and weakening to enhance creation cost. Their work intended to the circumstance where a short-lived (decayed) item is fabricated and consumed all the while, the interest of this item is steady throughout the time, machine that produces the item likewise face irregular disappointment and an opportunity to fix this machine is likewise uncertain[24].

Modak fostered a 2-level single-channel inventory network under cost and conveyance time touchy added substance stochastic interest for realized circulation capability of the irregular factors.. Here cost and loading choices for both the retail and the internet based channels, conveyance lead season of online channel is likewise expected as a choice variable[25].

Taleizadeh fostered a stock reproduction for single-machine creation of various things, doing precautionary upkeep with fractional delay purchasing and administration level limitations. They investigated two opportunities for the finest timing of precautionary support: when the stock level is positive and when it is negative[26].

2. Assumptions

- Production rate is demand function

$$K = rD(q), r > 1$$

- The demand ability of the object is attention to be dependent on stock

$$D(q) = (\alpha + \beta q)$$

3. Model illustration:

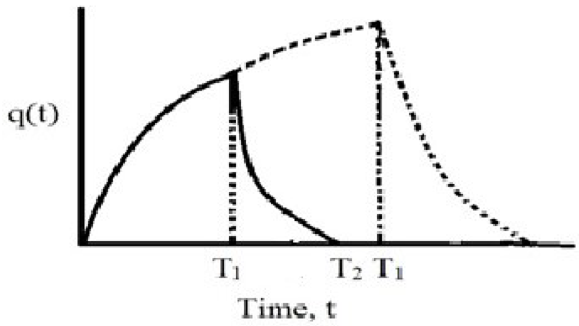

Fig.1: Formulation of mathematical model

In this projected model, as displayed, a system is modeled in which assembling measure is thought to be adaptable and producing is finished by the interest rate. The consistency of the creation is thought to be a dramatically diminishing capacity of time because of machine breakdown, therefore likelihood thickness work for machine breakdown is accepted as:

$$f(T_l) = ke^{-kT_l} \qquad (1)$$

At time $t = 0$, the production cycle stars with zero inventories, through time span $0 \leq t \leq T_1$ inventory increases. In case of random machine breakdown, manufacturing process may stop prior to time T_1. During the machine breakdown, production halts at $t = T_l$result in decrease in inventory and it reaches to zero at $t = T_2$. As repair time is random, loss sale may probably occur.

$$\frac{dq}{dt} + \theta q = (p-1)(\alpha + \beta q) \qquad (2)$$
$$q(0) = 0 \qquad 0 \leq t \leq T_1$$

$$\frac{dq}{dt} + \theta q = -(\alpha + \beta q) \qquad (3)$$
$$q(T_1^-) = q(T_1^+)$$
$$T_1 \leq t \leq T_2$$

Solving (2) and (3)

$$q(t) = \frac{(p-1)\alpha}{\theta-(l-1)\beta}\left(1 - e^{((p-1)\beta-\theta)t}\right))$$

$$q(t) = \frac{\alpha}{\beta+\theta}\left(e^{(T_2-t)(\beta+\theta)} - 1\right) \qquad (4)$$

$$T_2 = \frac{p\beta T_1}{\beta+\theta} \qquad (5)$$

If machine breakdown happen at time T_l in that case total Inventory is

$$E(I) = \frac{(p-1)\alpha}{\theta-(p-1)\beta}(T_1 - \left(\frac{e^{(p-1)\beta-\theta)T_1} - 1}{(p-1)\beta-\theta)}\right) + \frac{\alpha}{\beta+\theta}\left(-T_2 + T_1 + \frac{e^{(T_2-T_1)(\beta+\theta)} - 1}{\beta+\theta}\right) \quad , \; T_1 > T_l$$

$$E(I) = \frac{(p-1)\alpha}{\theta-(p-1)\beta}(T_l - \left(\frac{e^{(p-1)\beta-\theta)T_1} - 1}{(p-1)\beta-\theta)}\right) + \frac{\alpha}{\beta+\theta}\left(-T_2 + T_l + \frac{e^{(T_2-T_l)(\beta+\theta)} - 1}{\beta+\theta}\right) \quad , \; T_l > T_1$$

Since probability density function of machine breakdown is.

$$f(T_{l)}) = ke^{-kT_l} \, , \qquad T_l > 0 \, ,$$

Probable inventory $E\left(\frac{I}{T_l}\right)$ is calculated as

$$E\left(\frac{I}{T_l}\right) = \frac{(p-1)\alpha}{\theta-(p-1)\beta}\left(\frac{1-e^{-kT_1}}{k} - \frac{e^{((p-1)\beta-\theta-k)T_1}}{(p-1)\beta-\theta-k} + \frac{k}{((p-1)\beta-\theta-k)((p-1)\beta-\theta)} + \frac{2e^{-kT_1-1}}{(p-1)\beta-\theta}\right) + \frac{\alpha}{\beta+\theta}\left(\left(1-\frac{p\beta}{\beta+\theta}\right)\left(\frac{1-e^{-kT_1}}{k}\right) + \left(\frac{e^{((p-1)\beta-\theta-k)T_1}}{\beta+\theta}\right)\left(\frac{(p-1)\beta-\theta}{(p-1)\beta-\theta-k}\right) - \frac{k}{((p-1)\beta-\theta-k)(\beta+\theta)} - \frac{2e^{-kT_1}-1}{\beta+\theta}\right)$$

probable carrying cost

$$= h\Big(\frac{(p-1)\alpha}{\theta-(p-1)\beta}\left(\frac{1-e^{-kT_1}}{k} - \frac{e^{((p-1)\beta-\theta-k)T_1}}{(p-1)\beta-\theta-k} + \frac{k}{((p-1)\beta-\theta-k)((p-1)\beta-\theta)} + \frac{2e^{-kT_1-1}}{(p-1)\beta-\theta}\right) + \frac{\alpha}{\beta+\theta}\left(\left(1-\frac{p\beta}{\beta+\theta}\right)\left(\frac{1-e^{-kT_1}}{k}\right) + \left(\frac{e^{((p-1)\beta-\theta-k)T_1}}{\beta+\theta}\right)\left(\frac{(p-1)\beta-\theta}{(p-1)\beta-\theta-k}\right) - \frac{k}{((p-1)\beta-\theta-k)(\beta+\theta)} - \frac{2e^{-kT_1}-1}{\beta+\theta}\right)$$

probable deteioration cost

$$= \theta\mu\Big(\frac{(p-1)\alpha}{\theta-(p-1)\beta}\left(\frac{1-e^{-kT_1}}{k} - \frac{e^{((p-1)\beta-\theta-k)T_1}}{(p-1)\beta-\theta-k} + \frac{k}{((p-1)\beta-\theta-k)((p-1)\beta-\theta)} + \frac{2e^{-kT_1-1}}{(p-1)\beta-\theta}\right) + \frac{\alpha}{\beta+\theta}\left(\left(1-\frac{p\beta}{\beta+\theta}\right)\left(\frac{1-e^{-kT_1}}{k}\right) + \left(\frac{e^{((p-1)\beta-\theta-k)T_1}}{\beta+\theta}\right)\left(\frac{(p-1)\beta-\theta}{(p-1)\beta-\theta-k}\right) - \frac{k}{((p-1)\beta-\theta-k)(\beta+\theta)} - \frac{2e^{-kT_1}-1}{\beta+\theta}\right)$$

If time of repair exceeds T_2, lost sale takes place.
For the repair period, the pdf is considered as

$$\Gamma(t) = \frac{1}{b}, \quad 0 \le t \le b$$
$$= 0 \qquad \text{or else}$$

Probable loss sale cost

$$=\frac{S\alpha}{b}\int_{T_l=0}^{T_1}\int_{t=T_2}^{b}(t-T_2)ke^{-kT_l}dt\, dT_l$$

Probable loss sale cost

$$= \frac{S\alpha k}{2b}\left(\frac{\left(b-\frac{p\beta T_1}{\beta+\theta}\right)^2 e^{-kT_1}}{-k} + \frac{b^2}{k} + \frac{2p\beta}{\beta+\theta}\left(\left(b-\frac{p\beta T_1}{\beta+\theta}\right)\frac{e^{-kT_1}}{k^2} - \frac{b}{k^2}\right) - \frac{4l^2\beta^2}{(\beta+\theta)^2}\left(\frac{e^{-kT_1-1}}{k^3}\right)\right)$$

Probable overall cost $E(OC) = S + E(H) + E(LS) + E(DC)$

The probable manufacture time is probable manufacture up time, non-manufacture period and probable repair time later than, $t = T_2$,

Probable production time:

$$E(T) = \int_{T_l=0}^{T_1} T_2 ke^{-kT_l}dT_l + \int_{T_l=T_1}^{\infty} T_2\, ke^{-kT_l}dT_l + \int_{T_l=0}^{T_1}\int_{t=T_2}^{\infty}(t-T_2)\Gamma(t)\, ke^{-kT_l}dT_l$$

$$= \frac{p\beta}{(\beta+\theta)}(1-e^{-kT_1}) + \frac{k}{2b}\left(\frac{\left(b-\frac{p\beta T_1}{\beta+\theta}\right)^2 e^{-kT_1}}{-k} + \frac{b^2}{k} + \frac{2p\beta}{\beta+\theta}\left(\left(b-\frac{p\beta T_1}{\beta+\theta}\right)\frac{e^{-kT_1}}{k^2} - \frac{b}{k^2}\right) - \frac{4p^2\beta^2}{(\beta+\theta)^2}\left(\frac{e^{-kT_1-1}}{k^3}\right)\right)$$

Now,

$$\frac{dE(T)}{dT_1} = (\frac{p\beta}{\beta+\theta} + \frac{k}{2b}((c-\frac{p\beta T_1}{\beta+\theta})^2 + \frac{2p\beta^2}{(\beta+\theta)^2k^2})e^{-kT_1}$$

$$\frac{d^2E(T)}{dT_1^2} = (\frac{k}{2b}\left(\frac{-2p\beta\left(b-\frac{p\beta T_1}{\beta+\theta}\right)}{\beta+\theta}\right) - k\left(b-\frac{p\beta T_1}{\beta+\theta}\right)^2 - \frac{2p^2\beta^2}{(\beta+\theta)^2k}) - \frac{p\beta k}{\beta+\theta})e^{-kT_1}$$

Expected overall Average Cost, *E(OAC)*= $\frac{E(OC)}{E(T)}$

4. Optimal solution method:

The essential condition for *E(OAC)* to be smallest is:

$$\frac{d(OAC)}{dT_1} = 0\,, \frac{d^2(OAC)}{dT_1^2} > 0.$$

Examine the behavior of *E(T)* between the times $0 \le T_2 \le c$

$$\frac{dE(T)}{dT_1} = (\frac{p\beta}{\beta+\theta} + \frac{k}{2c}((c-\frac{p\beta T_1}{\beta+\theta})^2 + \frac{2p^2\beta^2}{(\beta+\theta)^2k^2})e^{-kT_1}$$

$$\frac{d^2E(T)}{dT_1^2} = (\frac{k}{2c}\left(\frac{-2l\beta\left(c-\frac{p\beta T_1}{\beta+\theta}\right)}{\beta+\theta}\right) - k\left(c-\frac{p\beta T_1}{\beta+\theta}\right)^2 - \frac{2p\beta^2}{(\beta+\theta)^2k}) - \frac{p\beta k}{\beta+\theta})e^{-kT_1}$$

$$\frac{d^2E(T)}{dT_1^2} < 0 \; if \; c - \frac{p\beta T_1}{\beta+\theta} > 0$$

If $c - T_2 > 0$, if $T_2 < c$ or $0 \le T_1 \le c$, therefore *E(T)* is concave when $0 \le T_1 \le c$

To prove $\frac{d^2E(TAC)}{dT_1^2} > 0 \; if \; \frac{d^2E(TC)}{dT_1^2} > 0 \quad where \quad 0 \le T_1 \le c$

$$\frac{d^2E(TAC)}{dT_1^2} = \frac{d^2(\frac{E(TC)}{E(T)}}{dT_1^2} = \frac{E(T)\frac{d^2E(TC)}{dT_1^2} - E(T)\frac{d^2E(T)}{dT_1^2}}{(E(T))^2}$$

Now$(T) > 0, E(TC) > 0, \frac{d^2E(T)}{dT_1^2} < 0$, in the period $0 \le T_1 \le c$,

As a result, in the period$0 \le T_1 \le c$,$\frac{d^2E(TAC)}{dT_1^2} > 0$ if $\frac{d^2E(TC)}{dT_1^2} > 0$

$$\frac{dE(TC)}{dT_1} = (h+\theta)(\frac{(r-1)\alpha}{\theta-(r-1)\beta}\Big(e^{-kT_1} - e^{((r-1)\beta-\theta-k)T_1} - \frac{2ke^{-kT_1}}{(p-1)\beta-\theta}\Big) + \frac{\alpha}{\beta+\theta}\Big(\Big(\frac{-r\beta}{\beta+\theta}+1\Big)e^{-kT_1} + \frac{((r-1)\beta-\theta)}{\beta+\theta}e^{((p-1)\beta-\theta-k)T_1} + \frac{2ke^{-kT_1}}{\beta+\theta})\Big) + \frac{S\alpha k}{2c}\Big(\Big(c-\frac{l\beta T_1}{\beta+\theta}\Big)^2 + \frac{2r^2\beta^2}{(\beta+\theta)^2k^2}\Big)e^{-kT_1}$$

$$\frac{d^2E(TC)}{dT_1^2} = (h+\theta)(\frac{(r-1)\alpha}{\theta-(r-1)\beta}\Big(-ke^{-kT_1} - ((r-1)\beta-\theta-k)e^{((r-1)\beta-\theta-k)T_1} + \frac{2k^2e^{-kT_1}}{(r-1)\beta-\theta}\Big) + \frac{\alpha}{\beta+\theta}\Big(-k\Big(\frac{-r\beta}{\beta+\theta}+1\Big)e^{-kT_1} + \frac{(r-1)\beta-\theta-k)^2}{\beta+\theta}e^{((r-1)\beta-\theta-k)T_1} - \frac{2k^2e^{-kT_1}}{\beta+\theta})\Big) + \frac{S\alpha k}{2b}\Big(-2\frac{r\beta}{\beta+\theta}\Big(b-\frac{r\beta T_1}{\beta+\theta}\Big)\Big)e^{-kT_1} - \frac{S\alpha k^2}{2b}\Big(\Big(b-\frac{r\beta T_1}{\beta+\theta}\Big)^2 + \frac{2r^2\beta^2}{(\beta+\theta)^2k^2}\Big)e^{-kT_1}$$

$$\frac{d^2E(TC)}{dT_1^2} = \frac{S\alpha k}{2b}\Big(-2\frac{p\beta}{\beta+\theta}\Big(b-\frac{p\beta T_1}{\beta+\theta}\Big)\Big)e^{-kT_1} - k\frac{dE(TC)}{dT_1}$$

$$\frac{d^2E(TC)}{dT_1^2} > 0 \qquad if \qquad \frac{S\alpha k}{2b}\Big(-2\frac{p\beta}{\beta+\theta}\Big(b-\frac{r\beta T_1}{\beta+\theta}\Big)\Big)e^{-kT_1} > 0$$

As a result, in the period$0 \le T_1 \le c$,$\frac{d^2E(TAC)}{dT_1^2} > 0$

Also, as θ tend to 0 and k tends to zero $\frac{dE(TC)}{dT_1}$ converted to the manufacture run time known in predictable EPQ model.

5. Sensitivity analysis with numerical illustration

In this division, numerical outcomes are considered by taking into consideration variety of parameter to demonstrate the probable production period *E(T)*, and probable overall average cost *E(OAC)*. Estimations are done using mathematical tool *WolframMathmatica7*. Assortments of parametric values taken are as follows:

β = 0.2, S = 200, k = 0.2,α = 20, S = 30 , c = 5 , , r = 2 , θ=0.1,μ=1

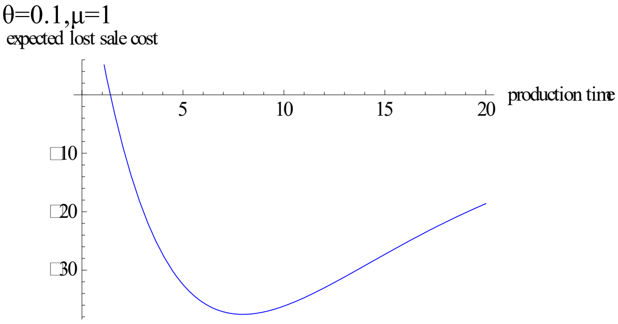

Fig.2: Effect of production time on loss sale cost

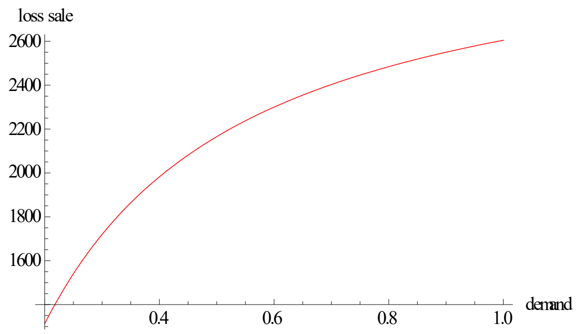

Fig.3: Effect of demand on loss sale

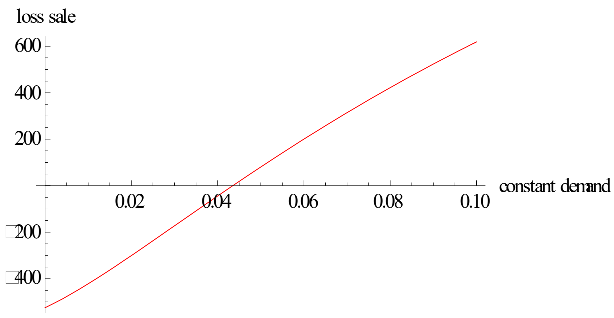

Fig.4: Effect of constant demand on loss sale

Table 1. Outcome of carrying cost on optimum value of E(T), E(LS) and E(OAC)

H	0.1	0.2	0.3	0.4
T_1	1.47414	2.67765	3.8146	5.36132
E(T)	2.40115	4.24588	6.14701	9.07641
E(LS)	434.723	978.21	1799.68	3455.3
E(H)	3286.41	5205.16	6382.93	6993.54
E(TC)	3921.133	6383.37	8382.61	10648.84
E(TAC)	1633.0229	1503.4198	1363.6890	1173.2436

Table 1 and Fig. 2 show the outcome of holding price on optimum rate of probable manufacture period *E(T), E(LS)* and *E(TAC)*. It can be observed from Table1 and Fig.1 that as holding cost increases production uptime also increases which increases the inventory. As demand depends upon the inventory, expected total average cost also decreases.

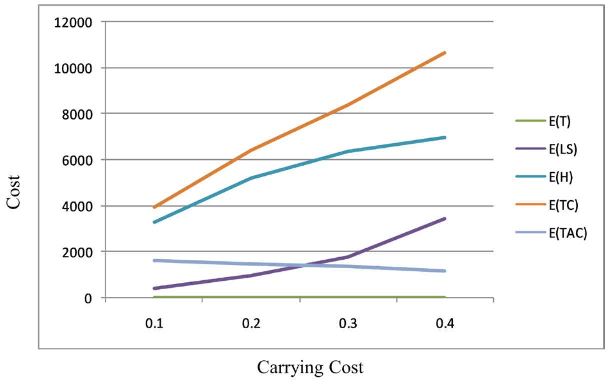

Fig.5: Outcome of carrying price on E(T), E(LS) and E(TAC)

Table 2. Effect of deterioration rate on optimum value of expected manufacture time E(T), E(Q) and E(TAC)

Θ	0.1	0.2	0.3	0.4
T_1	1.47414	2.67765	3.8146	5.36132
E(T)	2.40115	4.24588	6.14701	9.07641
E(LS)	434.723	978.21	1799.68	3455.3
E(H)	3286.41	5205.16	6382.93	6993.54
E(TC)	3921.133	6383.37	8382.61	10648.84
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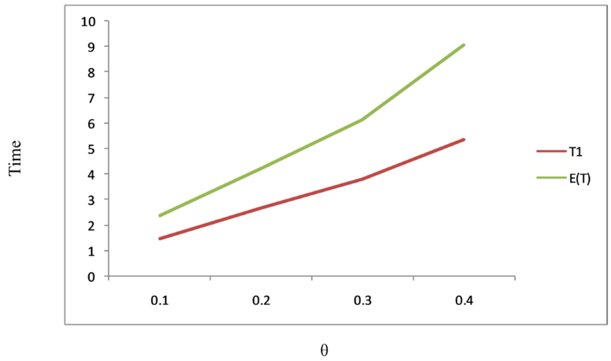

Fig. 6: Variation of T1 and (T) with **Θ**

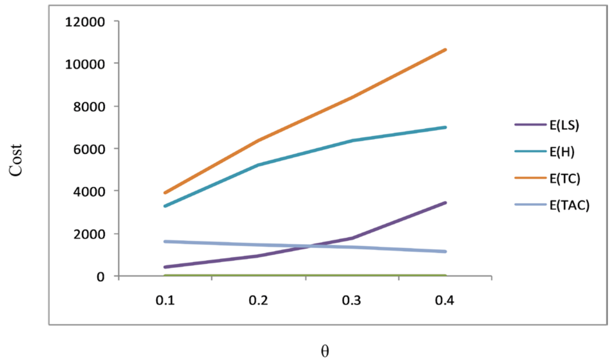

Fig.7: Variation of E(LS), E(H), E(TC) and E(TAC) with **Θ**

Table 1 and Figs. 3 & 4 show the effect of deterioration rate on optimum value of expected manufacture time E(T), E(LS) and E(TAC). It can be observed that when the deterioration rate increases with increase in production uptime, and with increase in production uptime inventory increases which reduce the total expected average cost.

5.1 Comparison of expected loss sale:

A comparison of expected loss sale cost is made with keeping demand as fixed and then stock dependent. Table 3 and Fig. 5 show the variation of loss sale in both the cases. In case of fixed demand expected production time is less as compared to stock dependent demand as a result expected loss sale is also less.

Table 3. Comparison of fixed demand and stock dependent demand

h	Constant demand	Stock dependent demand
0.1	534.994	434.723
0.2	420.337	978.21
0.3	440.707	1799.68
0.4	411.133	3455.30

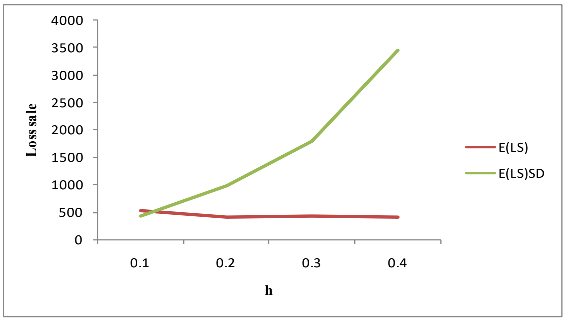

Fig.8: Loss sale comparison of fixed demand and stock dependent demand

6. Conclusion:

During stochastic machine breakdown and the random repair time, proposed model suggests that if stock quality and quantity satisfy the demand then even for high holding cost and for high deterioration rate total average cost will reduce. In case of fixed demand, as demand does not depend upon the stock there is no need to run the machine for a long time.

Nomenclature

q(t)	existing inventory level of items
D(q)	constitute demand rate
S	is the set-up price
h	carrying price per unit object
θ	Deterioration rate
T_1	represents production halts time
T_1	represents machine breakdown time
T_2	represents inventory deficiency time which give rise to loss sales
E(T)	expected manufacture phase
E(H)	expected carrying cost in manufacture phase
E(OC)	expected overall cost
E(OAC)	expected overall average cost per unit phase

Greek symbols

β	the shape factor and is utilized to work out of affectability of interest to fluctuate the degree of accessible stock.
α	deterministic factor
µ	deterioration cost

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