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A NEW INVENTORY MODEL WITH MULTIPLE WAREHOUSES

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ABSTRACT

Own warehouse bears lower holding cost then rented warehouse but bears higher deterioration than rented one. If variety of products to be stored in warehouse at a time then management have to hire more rented warehouses of different storage facilities as per their requirement. Present problem is based on demand of items and availability of warehouses at different locations. This paper presents integrated inventory model to optimize the total expenditure. Also we examine which warehouse set-up is economical at different locations. The goal of this model is to examine EOQ and EOL under these environments of the inventory problem when there are many locations with mixture of these categories of warehouses.

Key Words: *Inventory, Owned Warehouse, Rented Warehouse, Shortage, Deterioration, Optimal Time, Economic Order Level, Economic Order Quantity.*

AMS Classification: 90 B 05, 90 B 30, 90 B 50.

1. INTRODUCTION

A solution of the model based inventory problem serves two ways. First is that off seasonal goods are available throughout the time interval and second that quality be retained considerably in due course of time. Warehouses are of two types one is low rented but high deterioration and other is high rented but lower deterioration. For example air-conditioned warehouse bears higher holding cost with low deterioration and non air-conditioned rented warehouses bears lower holding cost with higher deterioration rate. One can suppose to hire two warehouses; one with low and other on high rent as per requirement. In all, the business schedule assumed to be with three warehouses as one own-warehouse *(OW)* and two rented warehouses RW_1 and RW_2 respectively. The RW_2 bears high rent but low deterioration rate while RW_1 is with low rent with high deterioration. The goal of this model is to examine EOQ and EOL under these environments of the inventory problem when there are many locations with mixture of these categories of warehouses.

Certainly it needs to findout EOQ and EOL with respect to optimal time for ordering at each of locations. Further, this is the way many companies manage their multiple warehouses. However, company wishes to central ordering policy with multiple warehouses. When there is more than one warehouse, any new possibilities or problems arise in term of optimal inventory policies for each of warehouses. Deterioration items refer to the items that become decayed, damage, devaluates etc. Deterioration items categorized by two ways, the first category refers to the items that become decayed, damage, evaporative like meat, vegetables, medicine and other category refers to the items that lose part or total value through time because of new technology or the introduction of alternatives, like computer, mobile, fashion apparels.

Most of the researchers ignored the deterioration factor but in real life, it in not possible. We considered this phenomenal in different in different warehouses. We classify the location based on a parameter's' depending on population density, resources, business level etc like:

0% to m% Village level location : (i = 1); [$0 \le s \le m$]
m% to n% City level location : (i = 2); [$m \le s \le n$]
n% to 100% Micro City level location : (i = 3); [$n \le s \le 100$]

The values of constant m and n are predefined as per population's records of government or as per past experience of model builder, company manager etc. fig. 1, and fig. 2, depicts the warehouse categorization based on locations.

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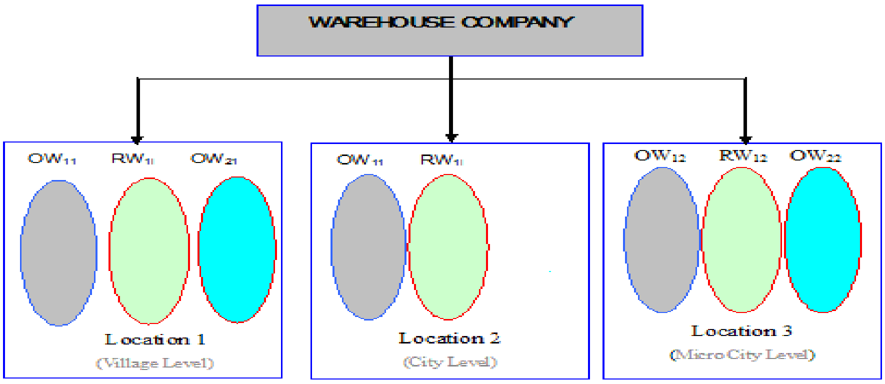

Fig. 1: (Location Variation)

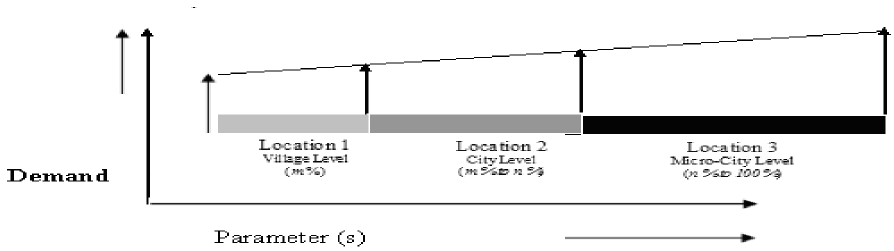

Fig. 2: (Parameter Variation)

In warehousing problem two-stage facility concept introduced by Sarma (1980) and Berkherouf (1997) advised to hire rented warehouse along with own warehouse and determine optimal cost, shortages and EOL in different warehouses for deteriorating items. Optimum policy for two warehouses has been studied due to Pakkala and Achary (1992) finite replenishment policy. Nagoor and Margatham (2007) revisited same idea and presented an inventory model with two warehouses. AL-Majed (2002) applied a recent developed technique in motion control to solve the demand variation problem in an inventory system where items deteriorate at unknown constant rate. He results any production policy based on linear control theory used in conjunction with the demand observer will be robust to changes in the demand and uncertainty in the deterioration rate also, showed the technique works for any moderately varying demand and for finite or infinite planning horizons.

Shukla and Khedlekar (2010) introduced three component demand rates (TCDR) in which two constant and after a maturation of stock a linear trend in demand suggested that related to marketing strategy and customer's responses. Sana and Choudhary (2003) considered time dependent demand and determine money value under inflation for warehouses enterprisers. Sana and Chaudhuri (2003) presented decision making policy with time-dependent demand, inflation and money value for ware-house enterprises. Text of Donald (2003) is consisting recent developments in inventory system and new issues for future researchers. Federgrum and Heching (1999) had shown that the inventory levels after ordering and price charge are strategic substitutes. They analyzed simultaneous price and inventory in an incapacitated system with stochastic demand for single item periodic model with time dependent parameters, findings depend upon inventory and pricing decisions. Some useful contributions are due to Shukla *et al*. (2009, 2010a, 2010b, 2010c) and Khedlekar and Shukla (2013).

In view of above contributions, Nagoor & Magatham (2007) and earlier attempt by Sharma (1980), Khedlekar (2012) and Shukla *et al*. (2009) a motivation is derived to use multiple warehouses with different rate of demand for different geographical locations and examine the impact of multiple storage facility over different locations with different rates of demand. Consider a district, a tehasil and a village each with three or more warehouses, and demand rate depends on locations. This effort presents the effect of location variations over the inventory model parameters with the consideration of multiple warehouses.

2. NOTATIONS AND ASSUMPTIONS

The model is proposed with following assumptions:

- Demand of items is deterministic and the rate of demand varies over Locations over time span which is $R_i = Q_i/T$, consumption rate at i^{th} location,
- Total schedule time T is fixed,
- Replenishment rate is infinite.
- Order quantity is Q_i. The variables x_i, y_i and z_i denote the quantities stored in OW_i, RW_{1i} and RW_{2i} warehouses respectively, the x_i preferred first, followed by y_i and z_i in respective order at i^{th} location,

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- The symbols a_i, b_i and c_i are deterioration in quantities stored in OW_i, RW_{1i} and RW_{2i} respectively at i^{th} location,
- A_{1i}, A_{2i} and A_{3i} represent the holding costs of goods stored in OW_i, RW_{1i} and RW_{2i} respectively at i^{th} location ($Q_i = x_i + y_i + z_i$),
- Capacity of OW_i, RW_{1i} and RW_{2i} are not limited but comparing holding costs and deteriorations are differ at i^{th} location, management find out optimal level of stocks at these warehouses as average cost optimum,
- B_i is the shortage cost per unit time at i^{th} location.

3. THE INVENTORY MODEL

The lot size $Q_i + S_i$ enters the system where S is shortage of previous cycle (if any), and Q_i is inventory for period T. Out of Q_i quantity the x_i units kept in OW_i, y_i kept in RW_{1i} and z in RW_{2i} simultaneously. First of all, the goods z_i in RW_{2i} is to be consumed and cleared in time t_2. Thereafter, the clearance and consumption of quantity y_i in RW_{1i} would be in time from t_2 to t_1. Next to start the consumptions of quantity x_i in OW_i, from time t_1 to t_0. Deteriorated items are disposed when the inventory level reaches zero. Due to the deteriorations c_i, b_i, a_i in RW_{2i}, RW_{1i} and OW_i respectively the shortage developed is ($a_ix_i+b_iy_i+c_iz_i$) until the end of period T. The aim is to obtain the optimum inventory level x_i^0 for the OW_i and y_i^0 for RW_{1i} such as the total average incurred cost is minimized over varying locations.

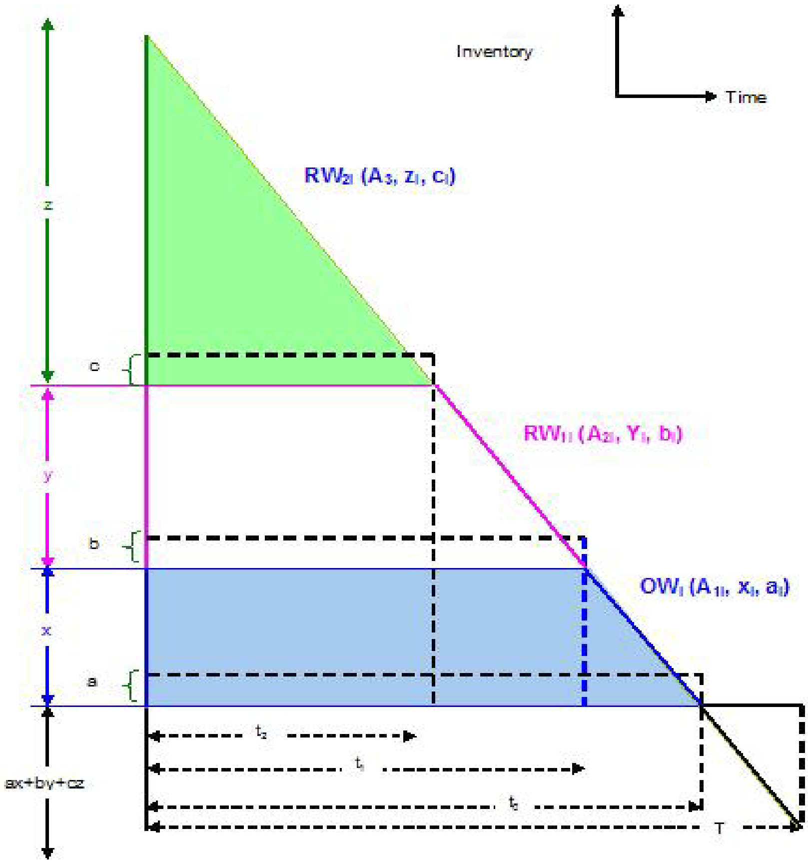

Fig. 3: (Three-warehouses Set-up)

As per assumption for demand

$$\frac{(1-c_i)z_i}{t_2} = \frac{(1-b_i)y_i}{t_1-t_2} = \frac{(1-a_i)x_i}{t_0-t_1} = \frac{a_ix_i+b_iy_i+c_iz_i}{T-t_0} = \frac{Q_i}{T} = R_i \tag{1}$$

Average holding cost of warehouse $RW_{2i} = \frac{1}{T}\left\{z_it_2c_i + \frac{1-c_i}{2}z_it_2\right\}A_{3i}$ (2)

Average holding cost of warehouse of RW_{1i} is $= \frac{1}{T}\left\{y_it_2 + \frac{1-b_i}{2}(t_1-t_2)y_i + by_i(t_1-t_2)\right\}A_{2i}$ (3)

Average holding cost of warehouse of OW_i is $= \frac{1}{T}\left\{xt_1 + \frac{1-a}{2}(t_0-t_1)x + ax(t_0-t_1)\right\}A_{1_i}$ (4)

Average shortage cost over time $T = \frac{1}{2T}(a_i x_i + b_i y_i + c_i z_i)(T - t_0)B_i$ (5)

Thus, the total average cost TC_i incurred in this schedule is

$$TC_i = \frac{1}{T}\left[\left\{z_i t_2 c_i + \frac{1-c_i}{2} z_i t_2\right\}A_{3i} + \left\{y_i t_2 + \frac{1-b_i}{2} y_i (t_1 - t_2) + b_i y_i (t_1 - t_2)\right\}A_{2i}\right] + \frac{1}{T}\left[\left\{x_i t_1 + \frac{1-a_i}{2}(t_0 - t_1)x_i + a_i x_i (t_0 - t_1)\right\}A_{1i}\right]$$
$$+ \frac{1}{T}\left[+\frac{1}{2}(a_i x_i + b_i y_i + c_i z_i)(T - t_0)B\right] \tag{6}$$

$$TC_i = \frac{1}{T}\left[\left\{\frac{1+c_i}{2} z_i t_2\right\}A_{3i} + \left\{y_i t_2 + \frac{1+b_i}{2} y_i (t_1 - t_2)\right\}A_{2i}\right] + \frac{1}{T}\left[\left\{x_i t_2 + x_i (t_1 - t_2) + \frac{1+a_i}{2} x_i (t_0 - t_1)\right\}A_{1i}\right]$$
$$+ \frac{1}{T}\left[\frac{1}{2}(a_i x_i + b_i y_i + c_i z_i)(T - t_o)B\right] \tag{7}$$

$$TC_i = \frac{1}{T}\left[\left\{\frac{1+c_i}{2} z_i t_2\right\}A_{3i} + \left\{y_i t_2 + \frac{1+b_i}{2} y_i (t_1 - t_2)\right\}A_{2i}\right] + \frac{1}{T}\left[\left\{x_i t_2 + x_i (t_1 - t_2) + \frac{1+a_i}{2} x_i (t_0 - t_1)\right\}A_{1i}\right]$$
$$+ \frac{1}{T}\left[\frac{1}{2}(a_i x_i + b_i y_i + c_i z_i)(T - t_o)B\right] \tag{8}$$

In light of fig. 3 using $z_i = Q_i - x_i - y_i$ and after replacing the proportional value of t_2, $(t_1 - t_2)$, $(t_0 - t_1)$ & $(T - t_0)$ from equation (1) we get.

$$TC_i = \frac{1}{Q_i}\left[(Q_i - x_i - y_i)^2 \frac{(1-c_i^2)}{2} A_{3i} + \left\{(Q_i - x_i - y_i) y_i (1 - c_i) + \frac{1-b_i^2}{2} y_i^2\right\}A_{2i}\right] + \frac{1}{Q_i}\left[\left\{x_i y_i (1 - b_i) + (Q_i - x_i - y_i) x_i (1 - c_i) + \frac{x_i^2}{2}(1 - a_i^2)\right\}A_{1i}\right]$$
$$+ \frac{1}{Q_i}\left[\frac{1}{2}\{a_i x_i + b_i y_i + c_i (Q_i - x_i - y_i)\}^2 B_i\right] \tag{9}$$

On differentiating TC_i with respect to quantities x_i and y_i, we have

$$\frac{\partial TC_i}{\partial x_i} = \frac{1}{Q_i}\left[-(Q_i - x_i - y_i)(1 - c_i^2)A_{3i} - y_i (1 - c_i) A_{2i}\right] + \frac{1}{Q_i}\left[\left\{y_i (1 - b_i) + (1 - c_i)(Q_i - 2x_i - y_i) + x_i (1 - a_i^2)\right\}A_{1i}\right]$$
$$+ \frac{1}{Q_i}\left[\{a_i x_i + b_i y_i + c_i (Q_i - x_i - y_i)\}(a_i - c_i) B_i\right] = 0 \tag{10}$$

$$\frac{\partial TC_i}{\partial y_i} = \frac{1}{Q_i}\left[-(Q_i - x_i - y_i)(1 - c_i^2)A_{3i} + \left\{(Q_i - x_i - 2y_i)(1 - c_i) + y_i (1 - b_i^2)\right\}A_{2i}\right] + \frac{1}{Q_i}\left[\left\{x_i (1 - b_i) - x_i (1 - c_i)\right\}A_{1i} + \{a_i x_i + b_i y_i + c_i (Q_i - x_i - y_i)\}(b_i - c_i) B_i\right] = 0 \tag{11}$$

Above two equations can be re-arranging in the following forms

$$f_{1i}\, x_i + f_{2i}\, y_i = f_{3i} \quad \text{and} \quad f_{2i}\, x_i + f_{4i}\, y_i = f_{5i} \tag{12}$$

where

$f_{1i} = \left[(1 - c_i^2)A_{3i} - (1 - 2c_i + a_i^2)A_{1i} + (a_i - c_i)^2 B_i\right]$

$f_{2i} = \left[(1 - c_i^2)A_{3i} - (1 - c_i)A_{2i} + (c_i - b_i)A_{1i} + (b_i - c_i)(a_i - c_i)B_i\right]$

$f_{3i} = \left[c_i Q_i (c_i - a_i)B + Q_i (1 - c_i^2)A_{3i} - Q_i (1 - c_i)A_{1i}\right]$

$f_{4i} = \left[(1 - c_i^2)A_{3i} - (1 - 2c_i + b_i^2)A_{2i} + (b_i - c_i)^2 B_i\right]$

$f_{5i} = \left[c_i Q_i (c_i - b_i)B + Q_i (1 - c_i^2)A_{3i} - Q_i (1 - c_i)A_{2i}\right]$

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On solving equations (12), we get optimum solutions $x^o{}_i$ and $y^o{}_i$ as

$$x^o{}_i = \frac{f_{3i} f_{4_i} - f_{2i} f_{5i}}{f_{1i} f_{4i} - f_{2i}{}^2}, \quad y^o{}_i = \frac{f_{3i}\ f_{2i} - f_{1i} f_{5i}}{f_{2i}{}^2 - f_{1i} f_{4i}} \text{ and } z_i^o = Q_i - x_i^o - y_i^o \tag{13}$$

Clearly

$$r_i = \frac{\partial^2 TC_i}{\partial x_i{}^2} = \frac{1}{Q_i}\left[(1-c_i{}^2)A_{3i} - (1-2c_i + a_i{}^2)A_{1i} + (a_i - c_i)^2 B_i\right] \tag{14}$$

$$s_i = \frac{\partial^2 TC_i}{\partial x_i \partial y_i} = \frac{1}{Q_i}\left[(1-c^2)A_{3i} - (1-c_i)A_{2i} + (c_i - b_i)A_{1i} + (b_i - c_i)(a_i - c_i)B_i\right] \tag{15}$$

$$t_i = \frac{\partial^2 TC_i}{\partial y_i{}^2} = \frac{1}{Q_i}\left[(1-c_i{}^2)A_{3i} - (1-2c_i + b_i{}^2)A_{2i} + (b_i - c_i)^2 B_i\right] \tag{16}$$

For each value of A_{1i}, A_{2i}, A_{3i}, B such that $A_{1i} < A_{2i} < A_{3i} < B$ and a_i, b_i and c_i are probabilities of deterioration lies between 0 and 1 at i[th] location,.we get,

$$r_i t_i - s_i{}^2 > 0 \tag{17}$$

$$\text{and } r_i = \frac{\partial^2 TC_i}{\partial x_i{}^2} = \frac{1}{Q_i}\left[(1-c_i{}^2)A_{3i} - (1-2c_i + a_i{}^2)A_{1i} + (a_i - c_i)^2 B_i\right] > 0 \tag{18}$$

Using (17) to (18), one can observe that cost TC_i is minimum for value x_i^o, y_i^o at i[th] location as in (9) and

$z_i^o = (Q_i - x_i^o - y_i^o)$.

4. TWO WAREHOUSES

The inventory model with two warehouses is a particular case of the proposed model if we consider $z_1 = 0$ and $x_1 + y_1 = Q_i$, $t_2 = 0$, $A_{31} = 0$. The fig. 4 shows the diagram of inventory model.

As per uniform demand $\frac{(1-b_i)y_i}{t_1} = \frac{(1-a_i)x_i}{t_1 - t_0} = \frac{a_i x_i + b_i y_i}{T - t_0} = \frac{Q_i}{T}$

$$TC_i = \frac{1}{Q_i}\left[\frac{1}{2}(1-b_i{}^2)y_i{}^2 A_{2i} + \left\{(1-b_i)x_i y_i + \frac{1}{2}(1-a_i)^2 x_i{}^2 + a_i(1-a_i)x_i{}^2\right\}A_{1i}\right] + \frac{1}{Q_i}\left[\frac{1}{2}(a_i x_i + b_i y_i)^2 B_i\right] \tag{19}$$

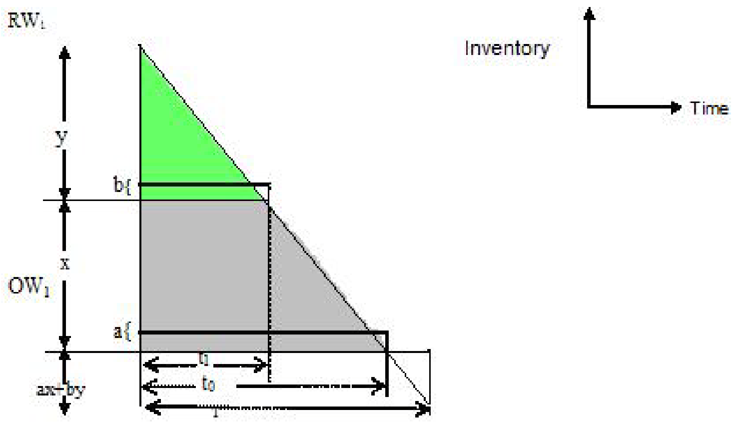

Fig. 4: (Two Warehouses Set-up)

On substituting $y_i = Q_i - x_i$

and solution of $\frac{dTC_i}{dx_i} = 0$, provides optimum value $x_i^* = \left[\frac{(1-b_i^2)A_{2i} - (1-b_i)A_{1i} - b_i(a_i - b_i)B}{(1-b_i^2)A_{2i} - (1-2b_i + a_i^2)A_{1i} + (a_i - b_i)^2 B}\right]Q_i$ and $y_i{}^* = (Q_i - x_i{}^*)$ (20)

We Define $\Delta_i = [TC_i\ (x_i^{\ *}, y_i^{\ *}) - TC_i\ (x_i^{\ 0}, y_i^{\ 0}, z_i^{\ 0})]$ and If $\Delta_i > 0$, then there shall be a gain due to average total cost in the proposed inventory strategy.

5.1. Numerical Example and Comparison
The demand of an item is uniform over time as 5000 units per month. Order size is constant for a year and shortages are backlogged. The firm has enough storage facility in the form of an own warehouse and two rented warehouses. Holding costs of these storage capacities are \$1.0, \$1.2 and \$1.5 per unit time respectively. Deteriorations are 0.30, 0.20 and 0.10 as in accordance and shortage is at the rate \$ 2.0 per unit time. The optimal EOL is required.

Time T = 1 year, Q_1 = total annual demand = 5000 x 12 = 60000 units in a year further, A_{11}= \$1.0, A_{21} = \$1.2, A_{31} = \$1.5, a_1 = 0.3, b_1 = 0.2, c_1 =0.1, B = \$2.0. Then using (13), the optimum inventory allocation is x_i^0= 38265 units, y_i^0 = 19917 units z_i^0 =1818 units, and average cost TC_i = \$30888.9 at x_i^o, y_i^o and z_i^o.

5.2. For Two Warehouses
To compare ($x_i^0\ y_i^0$) with x_i^* we consider the same example with only two warehouses. A_{3i} = 0 then we get x_i^* = 42353 units, y_i^* = 17647 units, and average cost TC_i = \$31324.6 over (x_i^*, y_i^*).

Clearly Δ_i = \$ [31324.6-30888.9] = \$435.7 which is positive in the undertaken numerical example.

6. SIMULATION
To illustration for decision making to inventory management we examine in which condition three warehouses set-up beneficiary and in which two warehouses set-up.

6.1. Data Set for First Location
We list the data set in table 1, for holding costs A_{11}, A_{21}, A_{31} for ware houses OW_1, RW_{11} and RW_{21} respectively and B_1 is shortage cost such that $A_{11} < A_{21} < A_{31} < B_1$ and $a_1 > b_1 > c_1$ are probabilities of deterioration lies between 0 and 1. Optimal EOL in three warehouse set-up and two warehouse set-up are computed and comparing them computation is given in table 1.

TABLE 1: Analysis for I Location

Data	a_1	b_1	c_1	A_{11}	A_{21}	A_{31}	$x_1 0$	$y_1 0$	$z_1 0$	x_1*	y_1*	TC_2	TC_3	Δ_1
1	0.3	0.2	0.195	10	12	13.5	35373	15837	8789	38838	21162	309012	359984	-50971
2	0.3	0.2	0.110	10	12	13.5	37667	18714	3619	38838	21162	309012	280456	28556
3	0.3	0.2	0.100	10	12	13.5	37981	19302	2717	38838	21162	309012	273488	35524
4	0.3	0.2	0.095	10	12	13.5	38144	19625	2232	38838	21162	309012	270654	38358
5	0.3	0.2	0.090	10	12	13.5	38309	19969	1722	38838	21162	309012	268371	40640
6	0.3	0.2	0.085	10	12	13.5	38479	20337	1184	38838	21162	309012	266749	42263
7	0.3	0.2	0.080	10	12	13.5	38654	20729	617	38838	211623	309012.	265910	43102
8	0.3	0.2	0.075	10	12	13.5	38833	21149	18.87	38838	21162	309012	266002	43010

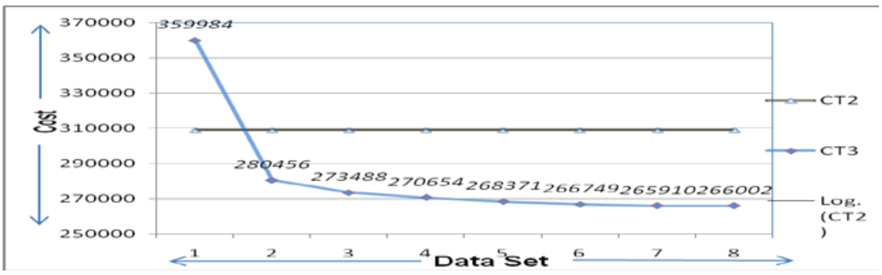

Fig. 5: (Simulation for first location)

In this location three warehouse set up is beneficiary for data sets 2, 3, 4, 5 and 6 (as fig. 5) and data set 1, is beneficiary for two warehouse set-ups.

6.2. Data Set for Second Location
At this location deterioration of second rented warehouse decreases and due to this holding cost increases corresponding, optimal policy given in table 2.

TABLE 2: Analysis for II Location

a_2	b_2	c_2	A_{12}	A_{22}	A_{32}	x_2^0	y_2^0	z_2^0	x_2*	y_2*	TC_2	TC_3	Δ_2
0.3	0.2	0.195	10	12	13.5	35374	15837	8789	38838	21161	309012	359984	-50971
0.3	0.2	0.19	10	12	14.0	35827	16454	7718	38838	21161	309012	340442	-31430
0.3	0.2	0.15	10	12	14.5	36997	17844	5158	38838	21161	309012	299460	9551
0.3	0.2	0.1	10	12	15.0	38265	19917	1818	38838	21161	309012	269198	39813
0.3	0.2	0.09	10	12	15.5	38526	20458	1016	38838	21161	309012	266597	42415
0.3	0.2	0.08	10	12	16.0	38742	20936	322	38838	21161	309012	265854	43158
0.3	0.2	0.077	10	12	16.5	38802	21075	123	38838	21161	309012	265918	43095
0.3	0.2	0.075	10	12	16.6	38836	21156	8.70	38838	21161	309012	266012	43000

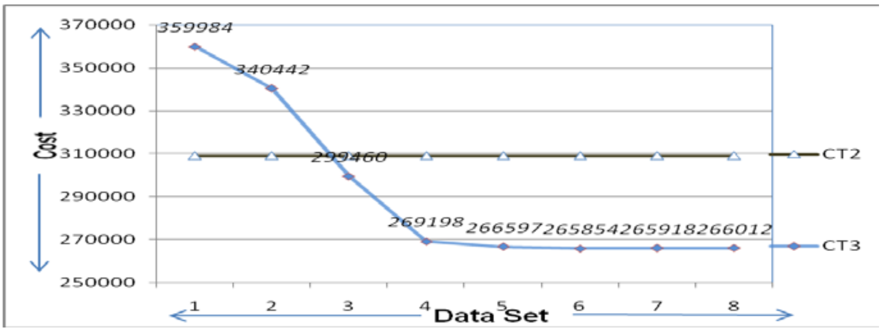

Fig. 6: (Simulation for second location)

At this location three warehouses set-up out perform to two warehouse set-up (as fig. 6).

6.3. Data Set for Third Location

Following dataset at location is based on the theory that if deteriorations decrease by α (parameter) then holding cost increase by α %. Values of data set are given below in table 3.7.3. $\alpha_3 = 0.01$, $a_3 = 0.3$, $b_3 = 0.2 - \alpha$, $c_3 = 0.1 - \alpha$, $A_{13} = 10$, $A_{23} = 12 + (12)(\alpha)$, $A_{33} = 15 + (15)(\alpha)$, $B_3 = 30$.

TABLE 3: Analysis for III Location

α	a_3	b_3	c_3	A_{13}	A_{23}	A_{33}	x_3^0	y_3^0	z_3^0	x_3*	y_3*	TC_2	TC_3	Δ_3
0.01	0.3	0.2	0.1	10	12.00	15.00	33009	20038	695	34979	25020	333629	339890	-6261
0.01	0.3	0.19	0.09	10	13.20	16.50	38341	16637	5021	39476	20523	338302	336555	1746
0.01	0.3	0.18	0.08	10	14.52	18.15	42262	14083	3655	42924	17075	341881	335749	6131
0.01	0.3	0.17	0.07	10	15.97	19.96	45245	12099	2655	45630	14369	344685	336107	8577
0.01	0.3	0.16	0.06	10	17.56	21.96	47574	10524	1902	47792	12207	346924	337023	9901
0.01	0.3	0.15	0.05	10	19.32	24.15	49429	9247	1322	49548	10451	348739	338227	10512
0.01	0.3	0.14	0.04	10	21.25	26.57	50933	8200	866	50992	9008	350230	339617	10612
0.01	0.3	0.13	0.03	10	23.38	29.23	52167	7333	499	5219	7808	351467	341185	10281

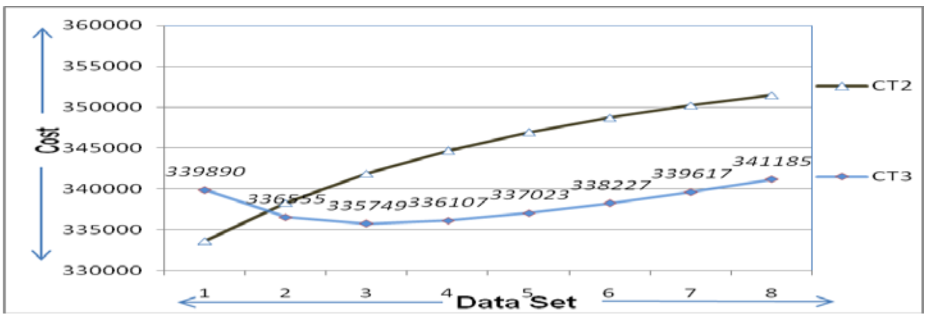

Fig. 7: (Simulation for third location)

The theoretical result reflects in out put which again reveals three warehouses set-up out perform to two warehouse set-up (fig. 7).

6.4. Data Set for Fourth Location

We apply the same theory that if deteriorations decrease by γ (parameter) then holding cost increase by γ % in RW_{14} and RW_{24}. Values of data set are given below in table 3.7.4 as per assumption $a_4 = 0.35,\ b_4 = 0.25 - \gamma,\ c_4 = 0.15 - \gamma,\ A_{14} = 11,$ $A_{24} = 12 + (12)\gamma,\ A_{34} = 14 + (14)(\gamma)$ and $B = 30$.

TABLE 4: Analysis for IV Location

γ	a_4	b_4	c_4	A_{14}	A_{24}	A_{34}	$x_4 0$	$y_4 0$	x_4^*	TC_2	TC_3	Δ_4
0.01	0.35	0.25	0.15	11	12	14	23450	23185	28708	361453	496691	-135237
0.015	0.35	0.24	0.135	11	13.2	15.4	31274	18946	34395	368491	451518	-83027
0.02	0.35	0.225	0.115	11	14.52	16.94	3686	16026	38647	373774	420586	-46812
0.025	0.35	0.205	0.09	11	15.97	18.634	41040	13956	41987	377939	396779	-18841
0.03	0.35	0.18	0.06	11	17.57	20.497	44304	12562	44698	381329	377128	4201.0
0.035	0.35	0.15	0.025	11	19.33	22.547	46874	11917	46947	384146	362519	21625

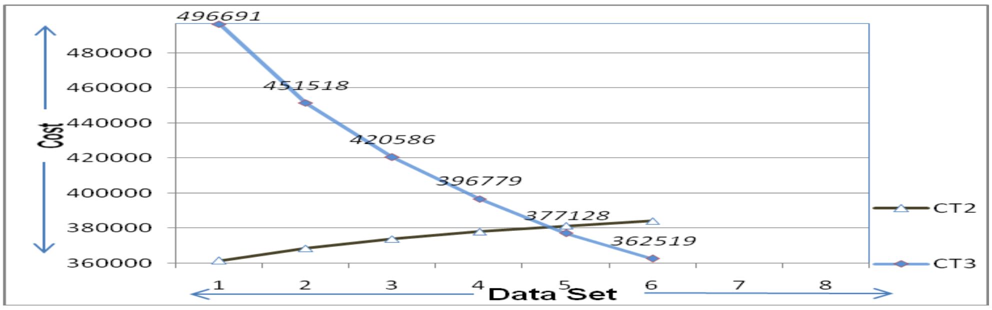

Fig. 8: (Simulation for fourth location)

In this case two warehouse set-up is beneficiary than warehouse set-up also three warehouse set-up will be beneficiary after the data set *n=5* (as fig. 8).

6.5. Data Set for Fifth Location

We apply the same theory that if deteriorations decrease by β (parameter) then holding cost increase by β % in OW_5, RW_{15} and RW_{25}. Values of data set are given below in table 5.

TABLE 5: Analysis for V Location

β	a_5	b_5 =ß.a	c_5 =.5ß.a_5	A_{15} =50ß.a_5	A_{25} =60ß.a_5	A_{35} =70ß.a_5	x_5^0	y_5^0	z_5^0	x_5^*	TC_2	TC_3	Δ_5
0.4	0.45	0.18	0.09	9.0	10.8	12.6	21524	25919	125556	23732	315790	376898	-61108
0.4	0.43	0.172	0.086	8.6	10.32	12.04	21962	25780	12257	24076	301146	346476	-45329
0.4	0.42	0.168	0.084	8.4	10.08	11.76	22194	25705	12100	24261	293825	331913	-38088
0.4	0.41	0.164	0.082	8.2	9.84	11.48	22435	25627	11938	24454	286505	317783	-31278
0.4	0.39	0.156	0.078	7.8	9.36	10.92	22945	25458	11596	24867	271871	290823	-18951
0.4	0.35	0.14	0.07	7.0	8.40	9.8	24098	25062	10840	25817	242651	242044	607.18
0.4	0.32	0.128	0.064	6.4	7.68	8.96	25095	24699	10205	26656	220800	209831	10968
0.4	0.29	0.116	0.058	5.8	6.96	8.12	26230	24261	9508	27628	199028	181164	17864

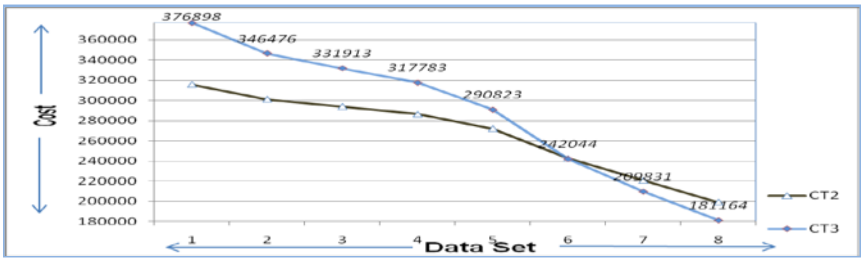

Fig. 9: (Simulation for fifth location)

Three warehouse setup beneficiary after n = 5 (as fig. 9).

7. CONCLUSION

A decision making result illustrated for different locations for three warehouse set-up. If $\Delta_i > 0$, one can conclude that proposed strategy is cost effective over the earlier one over all five different locations. The rented warehouse RW_{1i} and RW_{2i} has a significant role in reducing the total average costs in storing the items. Although, the rent is high for RW_{2i} but lower deterioration rate provides, benefit in terms of keeping the lower cost and it is found that in so many cases three warehouses set-up out perform to two warehouses set-up. Location variations have strong impact over optimum strategy. One can extend the model by considering linear demand and variable deterioration at different locations.

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REFERENCES

1. AL-Majed, M.I. (2002). Continuous-time optimal control of deteriorating inventory/production system using a demand observer, ***Journal King Saud University***, 15(1), 81-94.
2. Berkherouf, L. (1997). A deterministic order level inventory model for deteriorating items with two storage facilities. ***International Journal of the Production Economics***, 48, 167-175.
3. Donald, W. (2003), Inventory Control and Management, ***John Wiley & Sons Ltd. England***.
4. Federgruen, A. and Heching A. (1999). Combined pricing and inventory control under uncertainty. *Operations Research*, 47(3), 454-475.
5. Khedlekar, U.K., and Shukla, D. (2013), Dynamic inventory model with logarithmic demand, ***Opsearch***, 50(1), 1-13.
6. Khedlekar, U.K. (2012). A disruption production model with exponential demand. ***International Journal of Industrial Engineering Computations,*** 3(4), 607-616.
7. Nagoor, G.A. and Margatham, M. (2007). Inventory model with two warehouses. ***Proceeding of the International Conferences on Mathematics and Computer Sci***ence, 520-521.
8. Pakkala, T.P.M. and Achary, K.K. (1992). A deterministic inventory model for deteriorating items with two warehouses and finite replenishment rate. ***European Journal of Operational Research***, 57, 71-76.
9. Sana, S. and Chaudhuri, K.S. (2003). An EOQ model with time-dependent demand, inflation and money value for ware-house enterprises. ***Advanced Modeling and Operations***, 5(2), 116-128.
10. Shah, V.R., Sreehari, M. (1996). An inventory model for a system with multiple storage facilities and conditional credit facility, ***Opsearch***, 33(2), 96-106.
11. Sharma, K.V.S. (1980). A deterministic order level inventory model for deteriorating items with two storage facilities. ***European Journal of Operations Research***, 29, 70-73.
12. Shukla, D., and Khedlekar, U.K. (2010a). An order level inventory model with three-component demand rate (TCDR) for newly launched deteriorating item, ***International Journal of Operations research***, 7(2) 61-70.
13. Shukla, D., Chandel, R.P.S., Khedlekar, U.K., and Agrawal, R.K. (2010b). Multi-items inventory model with time varying holding cost and variable deterioration, ***Canadian Journal on Computing in Mathematics, Natural Sciences, Engineering & Medicine***, 1(8), 223-227.
14. Shukla, D., Khedlekar, U.K., and Bhupendra, (2009). An inventory model with three warehouses, ***Indian Journal of Mathematics and Mathematical Science***, 5(1), 39-46.
15. Shukla, D., Khedlekar, U.K., Chandel, R.P.S., and Bhagwat, S. (2010c). Simulation of inventory policy for product with price and time dependent demand for deteriorating item, ***International Journal of Modeling, Simulation, and Scientific Computing***, 3(1), 1-30.

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