AN INVENTORY MODEL WITH PARTIAL BACKORDERING, WEIBULL DISTRIBUTION DETERIORATION UNDER TWO LEVEL OF STORAGE

Kamlesh Patil[1], Dr. Arihant Jain[2]and Dr. Ritesh Yadav[3]
[1,2]Department of Mathematics, Dr. A. P. J. Abdul Kalam University, Indore
[3]Department of Physis, Dr. A. P. J. Abdul Kalam University, Indore
Corresponding Author: -kamleshpatil405@gmail.com

ABSTRACT

Inventory management is a recurring issue that managers in a variety of organizations, such as manufacturing companies, distribution networks, or retail businesses, must deal with on a daily basis in this paper, it is presumed that both warehouses' rates of degradation vary. This notion is supported by the fact that each warehouse has a varied set of preservation facilities. Thus, the holding costs are seen as distinct and linearly time-dependent. It is assumed that the demand rate is constant. Shortages are permitted in the OW and partly backlogged during the next replenishment cycle, and salvage value is connected to the deteriorating units of inventory. This model's objectives are to determine the ideal order quantity and to reduce the overall cost of inventory. Using a numerical example, the model's applicability is examined. The shape parameter of the degradation rate in RW, which affects PCC value, is not sensitive to value.

Keywords: Inventory Model, Partial, Weibull Distribution Deterioration and Warehouse
DOI Number: 10.48047/NQ.2022.20.13.NQ88501 **Neuroquantology 2022; 20(13): 4125-4133**

INTRODUCTION

An inventory of raw materials aids in the planning of efficient production runs in a manufacturing system. By maintaining an appropriate inventory of items, a shopkeeper may boost his sales and earnings. The fact that it is physically impossible or economically unwise to have things on hand exactly when demand arises is one of the primary justifications for keeping inventories of commodities. Customers often get antsy when a stockout of a product happens until the next shipment of stock comes. Because of expected variations in the pricing of goods, inventories are sometimes kept on hand. Thus, stocks are kept to prevent frequent replenishments, to maintain systematic production runs, to earn money, to arrange for flexibility in scheduling sequential facilities, etc.

No business can survive a stock-out scenario in a market when options are accessible since there are several alternatives with more characteristics. Furthermore, it is impossible to precisely predict demand using a tried-and-true technique. Although there is a significant amount of administration required, regional specialization, periodic volatility, and the mismatch between supply and demand need businesses to maintain inventories of a variety of items in order to operate properly.

The inventory has to be kept in a warehouse in a manner that both protects and preserves its physical characteristics. The corporation may own the warehouse or it may be leased. The rental warehouse (RW) is a short distance from or close to the OW. The holding cost in RW is often higher than the OW. Furthermore, until the stock level of RW is depleted, the products from RW are sent in bulk to OW to satisfy consumer demand. When an object is stored, its life is believed to be limitless in the traditional inventory models. But when it comes to the preservation of certain often used physical items like fruits, vegetables, and so forth, the impact of degradation is quite essential.

In these situations, a portion of these commodities have either been harmed or have degraded to the point that they can no longer be used to meet customer demand in the future. These units deteriorate over time continuously, and the amount of inventory on hand often reflects this. In general, two aspects of the problem—item degradation and variations in demand rate over time—have drawn researchers' increasing attention as they developed inventory models.

LITERATURE REVIEW

Srinivasa Reddy, Maram et.al. (2020). The two-warehouse inventory model for deteriorating goods is presented in this study where the rate of deterioration can be controlled using preservation technology and the demand rate exhibits a non-linear trend (i.e., quadratic form) with multiple deterioration rates under an acceptable payment delay. The system's ideal cost is estimated while accounting for shortages. The holding cost is also assumed to be a linear function of time. A numerical example is provided, and sensitivity analysis is used to evaluate the model's robustness.

Jaggi, Prof. (Dr.) Chandra et.al. (2017). Manufacturing processes can result in both ideal and subpar products. The moment they are added to inventory, the perfect objects begin to degrade. The suppliers, on the other hand, put off payment in an effort to encourage their customers to buy more goods. This study creates a two-warehouse inventory model that takes degradation, defective quality products, and one level of trade credit into account. The suggested inventory model maximizes the overall profit per unit of time by optimizing the order quantity. Finally, a sensitivity analysis is performed to demonstrate how the proposed inventory model responds to changes in parameter values and numerical examples are used to test the proposed inventory model and its solution technique.

Kumar, Kamal et.al, (2019) A key component of the research effort that links the earlier work to the present study is the examination of the literature. This essay discusses current research on the management of perishable commodities' inventories. The Ford Harris EOQ Model, which was the last significant evaluation of this issue, was published in 1913. The basic structure, modeling approach, capacity restrictions, trade credit, fuzzy parameters, with shortages and diverse demand are highlighted in the articles. We examine several publications from numerous journals that pertain to deteriorating things with certain characteristics. We provide an overview of the EGQ model of inventory.

Malik, A. et.al. (2017) To create a mathematical model for two warehouses is the goal of this paper. Due to seasonal product for keeping the raw material/products, we will assume two warehouse systems, one of which is Own Warehouse (OW) and the other is Rent Warehouse (RW). The suggested research is designed for an environment with quadratic demand, fluctuating holding costs, and no room for shortages. The result of the suggested method serves as an illustration of the ideal total inventory cost and ideal amount of inventory.

Agarwal, Ritu et.al. (2021). In a real-world setting where the lead time fluctuates over time, this research proposes an inventory model for things that degrade with time. For calculating the overall cost and order quantity in a limited planning horizon with m number of cycles, a mathematical model has been devised. Information technology and the implications of currency inflation, shortages, and lead times have all been taken into account. The total backlog and immediate degradation have their own special instances. An arbitrary log-concave function of time is the demand rate. The study has a demand function that uses the error function as an illustration. On the order amount and the overall supply chain cost for this function, the impact of several factors including degradation rate and backlogging parameter is investigated. Utilizing MATLAB software, data analysis and sensitivity analysis are performed.

AssumptionsandNotations

The following presumptions form the foundation of the mathematical model designed to solve the two-warehouse inventory problem:

Assumptions

- The demand rate is predictable and steady.
- There is no starting inventory level and a very short lead time.
- There is no end to the replenishing pace.
- Backorders and shortages are also permitted.
- The pace of deterioration differs between

the two warehouses.

- Deterioration rate follows a two parameter Weibull distribution and is time dependent.$\alpha > 0$denotescaleparameterand$\beta > 1$the shape parameter should be indicated.

Notations

This PAPER makes use of the notations below:

d Units demanded per unit of time (constant)

W CapacityofOW

α Scale parameters of the pace of OW degradation and$0 < \alpha < 1$

β the degradation rate in OW and its shape parameter$\beta > 1$

μ The RW degradation rate's scale parameter,$\alpha > \mu, 0 < \mu < 1$

η Shape parameter of the deterioration rate in RW and η>1

F Backordered portion of demand during the stock out period

C_o Cost per order for ordering

C_d Cost of deterioration per item in each of the two warehouses

$H_o = bt_1$: maintaining cost per unit per unit time in OW throughout T_1 time period; $b > 0$

$H_o = bt_2$: maintaining cost per unit per unit time in OW throughout T_2 time period;$b > 0$

$H_R = at_1$: Cost per unit every unit of time held in RW throughout T_1timeperiodwere

$$HR > Ho$$

C_s Cost of the shortage for each unit of time

L_c Cost of a shortage in terms of units, time, and lost sales

Q_o The number of orders in OW

Q_R The amount of the order in RW

Q_M Maximum ordered quantity T after the specified amount of time

T_C^I The following table gives the present value of the entire relevant inventory cost divided by the rate of deterioration:

t Deterioration o ver time,t>0

Rate of OW degradation on-the-spot

Z(t)=$\alpha\beta t^{\beta-1}$ where 0 <α< 1

Rate of immediate worsening in

RWR(t)=μ5t^{y-1} where0<μ<1

Development of Mathematical Model

Twoware house system

The inventory system of OW is shown in Figure-1. It may be broken down into three sections, as shown by T_1,T_2andT_3.A part of each replenishment is utilized to address backlog shortages, with the remaining amount being added to the system. goods are held in OW in units of W, while the remaining goods are retained in RW. In Figure-2, the inventory level in the RW inventory system has been visually shown. Due to higher holding costs than OW, the inventory in RW is delivered first in order to save inventory costs. Stock during the time period in the RW T_1 until it approaches zero, the resource depletes as a result of demand and wear. The sole cause of the inventory in OW's decline over the timeframe is degradation. Due to the combined effects of demand and degradation over time, the stock of OW decreases. T_2.Throughout the period T_3,A portion of the shortfall is on backorder for the next replenishment, and both warehouses are bare.

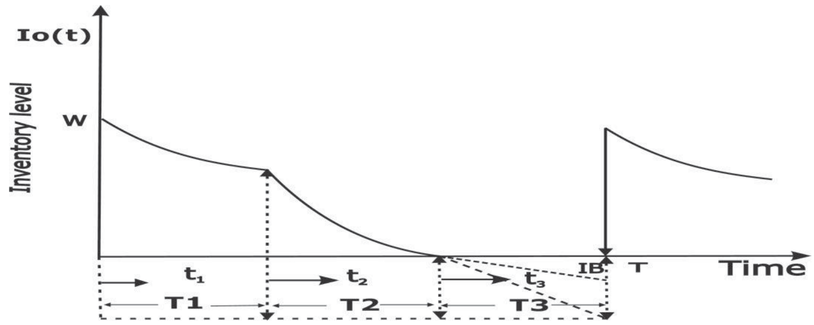


Figure-1Graphical representation for OWInventory System(InventoryLevelVs.CycleLength)

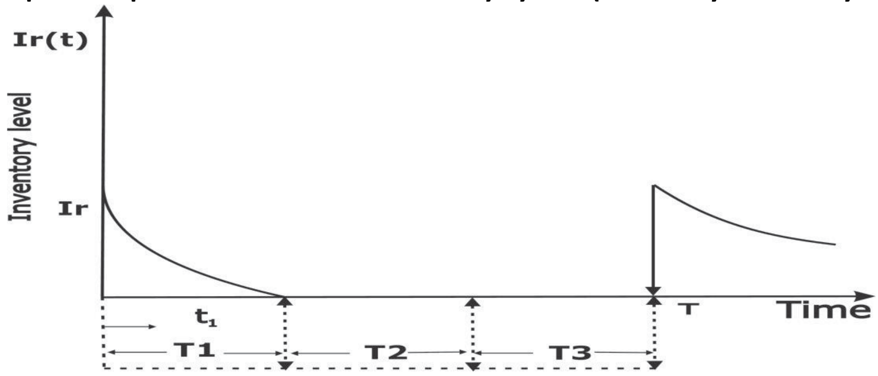


Figure-2 Graphical representation for RWInventory System (Inventory Level Vs. Cycle Length)

The products placed in RW are used to satisfy customer demand during the initial stage of the inventory cycle, which reduces the rate of change of inventory during periods of positive RW stock. $T_1$the following differential equation provides

$\frac{dI^R(t_1)}{dt_1} = -\mu\eta\, t_1^{\eta-1} I^R(t_1) - d; \qquad 0 \le \mathrm{t} \le \mathrm{T}$

the above equation's solution includes B.C. $I^R(0) = I^R$ is 4128

Where

$$I^r = d\int_O^{T_1} e^{\mu\mu^\eta} du = d\sum_{m=0}^{\infty} \frac{\mu^m T_1^{m\eta+1}}{m!\,(mn+1)}$$
$$\approx d(T_1) + \frac{\mu T_1^{n+1}}{n+1}$$

The rate of inventory change during the course of a positive stock in OW and the time period T_1+T_2+T_3 may be modeled by the differential equation below.

$$\frac{dI_1^0(t_1)}{dt_1} = -\alpha\beta t_1^{\beta-1} I_1^O(t_1); 0 \le t_1 \le T_1$$
$$\frac{dI_2^0(t_2)}{dt_2} = -\alpha\beta t_1^{\beta-1} I_2^O(t_2) - d; 0 \le t_2 \le T_2$$

Beginning at the time of stock out are shortages. T3 the differential equation may be used to describe in OW.

$$\frac{dI_3^0(t_3)}{dt_3} = -Fd; \qquad\qquad 0 \le t_3 \le T_3$$

Using boundary conditions, the aforementioned differential equation is solved. +* G (0) =W, +* G (=*) =W$ %M." N =+I G (0) and +K G (0) =0 may be provided as

$$I_2^0(t_1) = we^{-at_1^\beta} 0 \le t_1 \le T_1$$
$$I_2^0(t_1) = we^{-at_1^\beta} - d\int_0^{t_2} e^{au\beta} du)e^{-at_2^\beta}\ 0 \le t_2 \le T_2$$
$$I_3^0(t_3) = -Fdt_3 0 \le t_3 \le T_3$$

DR indicates and reports the quantity of inventory that depreciated in RW during time period T_1 as follows:

$$D^R = \int_0^{T_1} R(t) I^R(t) dt_1$$
$$\int_0^{T_1} \mu\eta\ \ t^{\eta-1}(I^r - d\int_0^{t_1} e^{\mu\mu^\eta} du)e^{-\mu t_1^\eta}\, dt_1$$

$=\mu d\ \left(T_1 + \frac{\mu T_1^{\eta+1}}{\eta+1}\right) T_1^\eta \approx \mu d T_1^{\eta+1}$

The value of depreciated objects in RW is documented and provided as

$$CD^R = C_d \mu d T_1^{\eta+1}$$

Inventory degradation throughout the time period $T_1 + T_2$ in OW is indicated by DO and is provided as

$$D^O = \int_O^{T_1} Z(t)wdt_1 + (we^{-\alpha T_1^\beta} \_ \int_0^{T_2} d\,dt_2$$

$$= \int_O^{T_1} \alpha\beta t^{\beta-1} \;\; Wdt_1 + (we^{-\alpha T_1^\beta} \_ \int_0^{T_2} d\,dt_2$$

$$= W\left(\alpha T_1^\beta + e^{-\alpha T_1^\beta}\right) - dT_2$$

CDO indicates and provides the cost of damaged things in OW as

$$CD^O = C_d\{W(\alpha T_1^\beta + e^{-\alpha T_1^\beta}) - dT_2\}$$

The term "MQ" stands for "maximum ordered quantity" and is used to indicate

$$M_Q = d\left(T_1 + \frac{\mu T_1^{\eta+1}}{\eta+1}\right) + W + Fd\frac{T_3^2}{2}$$

IHO indicates and provides the following value for the inventory holding cost in OW for the time period $T_1 + T_2$:

$$IH^O = \int_O^{T_1} H_O I_1^O(t_1)dt_1 + \int_o^{T_2} H_O\, I_2^O(t_2)dt_2$$

$$= \int_O^{T_1} bt_1\, We^{-\alpha T_1^\beta}; dt_1 + \int_o^{T_2} bt_2\,(W\,e^{-\alpha T_1^\beta} - d\int_o^{t_2} e^{au^\beta}du)\,e^{-\alpha T_2^\beta}dt_2$$

$$= \left[bW\left\{\frac{T_1^2}{2} - \frac{\alpha T_1^{\beta+2}}{\beta+2}\right\} + bW\left\{\frac{T_1^2}{2}\left(1-\alpha T_1^\beta\right) - \frac{\alpha T_1^{\beta+2}}{\beta+2}\right\} - bd\left\{\frac{T_2^3}{3} - \frac{\alpha\beta T_2^{\beta+3}}{(\beta+1)(\beta+3)}\right\}\right]$$

Single Ware-house System

The graphical depiction of one warehouse inventory system is shown in Figure-3. We calculated the inventory level throughout time periods $T_1 and\, T_2$for a single warehouse inventory system, which is represented by the differential equation below.

$$\frac{dI_1^0(t_1)}{dt_1} = -\alpha\beta_1^{\beta-1}W - d; \qquad\qquad 0 \le t_1 \le T_1$$

$$I_1^0(0) = W$$

Using boundary conditions, the aforementioned differential equation is solved.

$$dI_1^0(t_1) = W\left(1 - \alpha t_1^\beta\right) - dt_1 0 \le t_1 \le T_1$$

During the time period, there are shortages [0 T_1]. The current cost of shortages is

$$S_c = C_S\left\{\int_O^{T_2} (\,Fdt_2\right)dt_2$$

$$= \frac{C_S Fd}{2} T_2^2$$

Sales are lost during the T_2 timeframe. The cost of missing sales at OW present value is stated as

$$CL_S = L_C\{\int_O^{T_2} (\,1 - F)dt_2$$

$$= L_C(1-F)dT_2$$

Cost of depreciated units over time [0 T_1] is stated as

$$CD^R = C_d\alpha W d\; T_1^\beta$$

The most items that may be ordered per order is

$$M_Q = W + \frac{Fd}{2}T_2^2$$

Salvages value per unit time of degraded units is

$$SV = \gamma W\alpha T_1^\beta$$

Inventory holding expenses over time T_1 is

$$IH^O = \int_O^{T_1} H_O I_1^O(t_1) dt_1$$

$$= \int_O^{T_1} bt_1 \left(W\left(1 - aT_1^{\beta}\right) - dt_1\right) dt_1$$

$$= bW \left\{\frac{T_1^2}{2} - \frac{\alpha\beta T_1^{\beta+2}}{\beta+2}\right\}$$

Noting that T= T_1+T_2, The ordering cost, holding cost, shortages cost, lost sales cost, and salvage value of degraded units are added together to provide the total present value of the entire relevant cost per unit time within the cycle.

$$T_C^1(T_1T_2) = \frac{1}{T}\left[O_C + bW\left\{\frac{T_1^2}{2} - \frac{\alpha T_1^{\beta+2}}{\beta+2}\right\} + C_d \alpha W d T_1^{\beta} + C_S F d \frac{T_2^2}{2} + L_C(1-F)dT_2 - \gamma W \alpha T_1^{\beta}\right]$$

The ideal issue might be written as Minimize:

$$T_C^1(T_1T_2)$$

Subject to: $T_1 \geq 0$, $T_2 \geq 0$;

Getting rid of equation (3.33) T_1, T_2 according to the values of $\check{T}_1$, $\widetilde{T_2}$ and T* a Equation (3.32) is used to get the total minimum inventory cost using the values that were obtained.

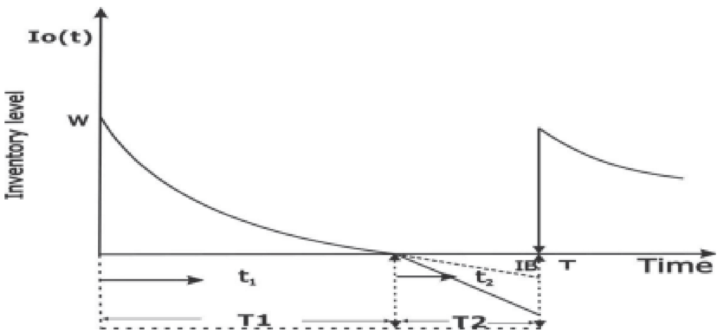


Figure-3 Graphical representation for a single warehouse Inventory System (Inventory Level Vs. Cycle Length)

Numerical results

Table-1 lists the decision variables that were derived for the models.

Table-1: Representing value of decision variables and inventory cost

Decision Variables	Value obtained for Two Ware-house model	Value obtained for One Warehouse system
$\check{T}_1$	0.4003150	0.0426341
$\check{T}_2$	3.5014900	0.0426341
$\check{T}_3$	0.0859854	-----------
T*	3.9877904	0.1668881
T_C^{I*}	1487.8800	1794.0300

Table-1 shows that the best solution is found when all the requirements and restrictions are met. The choice variables' respective optimum values in this case are 1487.88 for the minimum present value of total relevant inventory cost per unit time in an applicable unit. $\check{T}_1$, $\widetilde{T_2}$, $\widetilde{T_3}$and T* are 0.4003150, 3.5014900, 0.0859854 and 3.9877904 respectively.

When there is only one warehouse with a limited number of W units, the minimal present value of the total relevant inventory cost per unit of time in an appropriate unit is 1794.03, and the optimal time periods for positive and negative inventory levels are 0.0426341, 0.0426341, and 0.1668881 respectively. Comparing the cost incurred in two warehouse systems to the cost incurred in the corresponding

inventory, there has been an increase of $306.15. The system lacks the capacity to keep more units, and holding costs and shortage costs drive up the overall relevant inventory cost.
Ť1, Ť2, Ť3 and T* are, respectively, 6.65684, 1.78748, 0.212266, and 8.656586. Comparing the total relevant inventory cost to the partial backlogging model under the two-warehouse system, there is an increase of 634.78.
Figure-4 provides a visual illustration of the convexity of inventory cost for a two-warehouse system. There is a point when the overall relevant inventory cost is negligible, as shown in Figs. 4

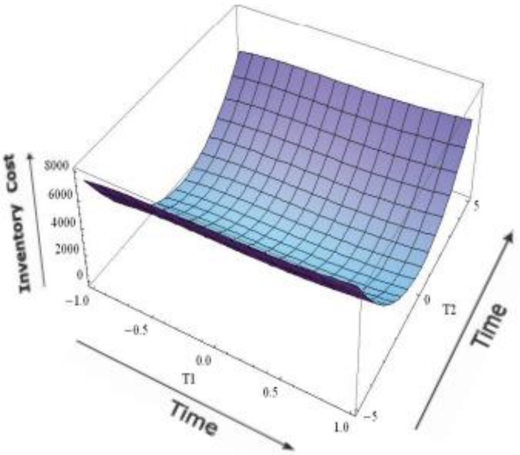


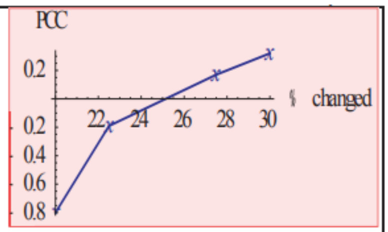
Figure-4: Graphical representation of cost function (When Ť3*= 0.0859854) depicting convexity w.r.t. T1 and T2 for Two Warehouse System

Sensitivity Analysis

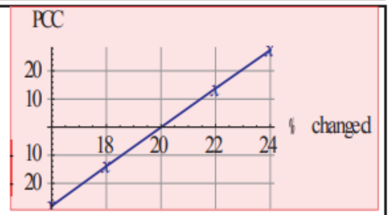
Sensitivity analysis is carried out for the numerical example in order to investigate the impact of changes in parameter values after the best solution. The best bargains of $\check{T}_1$, $\widetilde{T_2}$, $\widetilde{T_3}$ and T_C^1 are obtained when one parameter in subset S grows by 10% while all other values stay constant. Table-2 displays the sensitivity analysis's findings along with a related graphical illustration. The percentage Change in Cost (PCC) representing the change in the entire relevant inventory cost is provided by $PCC = \frac{T_C^1 - T_C^1}{T_C^1} \times 100$

Table-2: Representing Sensitivity Analysis in relation to the parameters to investigate the percentage change in cycle duration and cost function

a	Ť1*	Ť2*	Ť3*	T_C^{IC}	PCC (%)
30	0.3732	3.4991	0.0866	1492.72	0.32
27.5	0.3859	3.5002	0.0863	1490.43	0.17
22.5	0.4169	3.5029	0.0856	1485.08	-0.19
20	0.4362	3.6668	0.0853	1475.85	-0.80

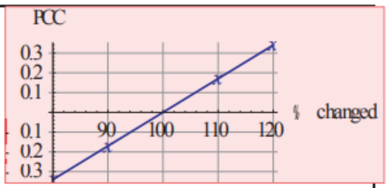


b	Ť1*	Ť2*	Ť3*	T_C^{IC}	PCC (%)
24	0.4515	3.5220	0.1370	1896.03	27.43
22	0.4268	3.5123	0.1116	1692.90	13.78
18	0.3714	3.4894	0.0607	1280.54	-13.94
16	0.3393	3.4756	0.0338	1070.75	-28.04

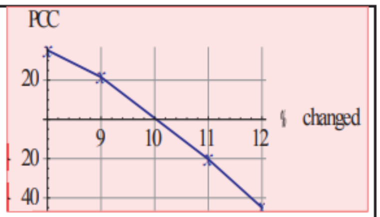


4131

C_o	$\check{T}_{1*}$	$\check{T}_{2*}$	$\check{T}_{3*}$	T_C^{IC}	PCC (%)
120	0.4008	3.5002	0.0863	1492.90	0.34
110	0.4013	3.4989	0.0866	1490.39	0.17
90	0.3998	3.5027	0.0857	1485.38	-0.17
80	0.3993	3.5040	0.0853	1482.87	-0.34



C_d	$\check{T}_{1*}$	$\check{T}_{2*}$	$\check{T}_{3*}$	T_C^{IC}	PCC (%)
12	0.2515	3.4328	0.0024	818.951	-44.96
11	0.3307	3.4653	0.0448	1185.25	-20.34
9	0.4636	3.5402	0.1262	1809.35	21.61
8	0.5224	3.5807	0.1655	2012.73	35.28



(1) The value of PCC is directly proportional to the values of the parameters W (capacity of own warehouse), Y (Salvages value incurred on deteriorating products), and b (Holding cost of inventory in OW).

(2) The Value of PCC is indirectly proportional to the values of Cd (Cost of Deterioration), d (Demand of Inventory), and α (Scale Parameter of the Deterioration Rate in OW). It is very sensitive to these values.

(3) The value of PCC is directly proportional to the values of β Cs (Cost of Shortages), Lc (Cost of Lost Sale), Co (Ordering Cost), and a (Holding Cost in RW) and is somewhat sensitive to the values of µ (The shape parameter of deterioration rate in RW) and (scale parameter of deterioration rate in OW).

(4) The value of PCC is indirectly proportional to F (Number of shortages backlogged) and is only marginally sensitive to its values.

(5) The shape parameter of the degradation rate in RW, which affects PCC value, is not sensitive to value.

CONCLUSION:

For two warehouse inventory problems with varied rates of degradation and partial backlogs, an inventory model is described in this Paper to find the best replacement cycle. The model assumes that the distributors' warehouse has a finite capacity. By minimizing the overall relevant cost of the inventory system, the optimal replenishment strategy is determined using the optimization approach. An example using numbers is provided to demonstrate the model's viability. The overall relevant cost per unit time of the inventory system is greater when just one warehouse is present than when there are two warehouses. The Weibull distribution degradation rate for things that degrade instantaneously makes use of this model since inventory costs are indirectly related to demand.

REFERENCES

1. Srinivasa Reddy, Maram & Venkateswarlu, Rangavajhala. (2020). A Two-Warehouse Inventory Model with Controllable Deterioration Rate and Time Dependent Quadratic Demand Rate.
2. Jaggi, Prof. (Dr.) Chandra & Cárdenas-Barrón, Leopoldo & Tiwari, Sunil & Shafi, Aliakbar. (2017). Two-warehouse inventory model for deteriorating items with imperfect quality under the conditions of permissible delay in payments. Scientia Iranica. 24. 390-412. 10.24200/sci.2017.4042.
3. Kumar, Kamal & Kumar, Sachin & Scholar, Research & Sigroha,. (2019). INVENTORY CONTROL POLICY WITH TWO- WAREHOUSE, VARIOUS DEMAND, SHORTAGES, TRADE CREDIT AND FUZZY ENVIRONMENT REVISITED. 19. 987-1016.
4. Malik, A. & Chakraborty, Dipak & BANSAL, KAPIL & Kumar, Satish. (2017). Inventory Model with Quadratic Demand under the Two Warehouse Management System. International Journal of Engineering and Technology. 9. 2299-2303. 10.21817/ijet/2017/v9i3/170903138.
5. Chakraborty, Dipankar & Jana, Dipak & Roy, Tapan. (2018). Two-warehouse partial backlogging inventory model with ramp type demand rate, three-parameter Weibull distribution deterioration under inflation and permissible delay in payments. Computers & Industrial Engineering. 123. 10.1016/j.cie.2018.06.022.
6. Agarwal, Ritu & Badole, Chandrakumar. (2021). Mathematical Modelling for Perishable Product

Supply Chain Under Inflation and Variable Lead Time. 10.1007/978-3-030-77169-0_11.
7. Padiyar, Surendra & Singh, S R & Punetha, Neha. (2021). Inventory system with price dependent consumption for deteriorating items with shortages under fuzzy environment. International Journal of Sustainable Agricultural Management and Informatics. 7. 218. 10.1504/IJSAMI.2021.118124.
8. Duary, Avijit & Das, Subhajit & Arif, Md & Abualnaja, Khadijah & Khan, Md & Zakarya, Mohammed & Shaikh, Ali. (2022). Advance and delay in payments with the price-discount inventory model for deteriorating items under capacity constraint and partially backlogged shortages. AEJ - Alexandria Engineering Journal. 61. 10.1016/j.aej.2021.06.070.
9. Lee, Yu-Ping & Dye, Chung-Yuan. (2012). An inventory model for deteriorating items under stock-dependent demand and controllable deterioration rate. Computers & Industrial Engineering. 63. 474–482. 10.1016/j.cie.2012.04.006.
10. Chiu, Singa & Chen, Han-Ying & Wu, Hua-Yao & Chiu, Yuan-Shyi. (2019). Mathematical modelling for a fabrication–inventory problem with scrap, an acceptable stock-out level, stochastic failures and a multi-shipment policy. Arab Journal of Basic and Applied Sciences. 26. 58-71. 10.1080/25765299.2018.1553547.
11. Pervin, Magfura & Roy, Sankar & Weber, Gerhard-Wilhelm. (2018). An integrated inventory model with variable holding cost under two levels of trade-credit policy. Numerical Algebra, Control & Optimization. 8. 169-191. 10.3934/naco.2018010.
12. Khanna, Aditi & Kishore, Aakanksha & Jaggi, Prof. (Dr.) Chandra. (2017). Strategic production modeling for defective items with imperfect inspection process, rework, and sales return under two-level trade credit. International Journal of Industrial Engineering Computations. 8. 85-118. 10.5267/j.ijiec.2016.7.001.
13. Chiu, Yuan-Shyi & Huang, Chao-Chih & Wu, Mei-Fang & Chang, Huei-Hsin. (2013). Joint determination of rotation cycle time and number of shipments for a multi-item EPQ model with random defective rate. Economic Modelling. 35. 112-117. 10.1016/j.econmod.2013.06.024.
14. Liu, Rui & Liu, Shan & Zeng, Yu-Rong & Wang, Lin. (2017). Optimization model for the new coordinated replenishment and delivery problem with multi-warehouse. The International Journal of Logistics Management. 28. 290-310. 10.1108/IJLM-11-2015-0217.
15. Chołodowicz, Ewelina & Orlowski, Przemyslaw. (2021). Development of new hybrid discrete-time perishable inventory model based on Weibull distribution with time-varying demand using system dynamics approach. Computers & Industrial Engineering. 154. 107151. 10.1016/j.cie.2021.107151.