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A TWO – ECHELON INVENTORY MODEL FOR DETERIORATING ITEMS WITH RAMP – TYPE DEMANDS AND VARIABLE HOLDING COSTS

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SUMMARY

It presents a dynamic model of inventory management of the deteriorating items with time-sensitive demand and variable holding costs. The model is used to solve the problem in industries where demand is seasonal or because of other external conditions, like weather or market conditions. A two-tier inventory model is implemented as a way of minimizing the overall costs through holding costs, production costs, and losses of deteriorating items. Demand rate is exponential as well as linear in terms of the rate of deterioration. The model can be used to address a wide range of real-life conditions, such as shortages, irregular deterioration rates, and production constraints. Mathematical equations are given to model the inventory levels, and they are solved via differential equations. The model is used by providing numerical illustrations of how the model is applied to the optimization of inventory and the minimization of costs under different conditions. The statistical analysis and sensitivity analysis are carried out to see how various parameters, including deterioration rate, production time, and setup costs, among others, affect the overall system performance. The findings show that the deterioration rates, setup, and production time are increasing to result in increased total costs and reduced optimal levels of inventory and cycle times. Findings are useful in industries with perishable products since proper inventory management is important. It is possible to include more realistic assumptions in the model, like the presence of many products and non-linear deterioration rates. This study will add value to inventory management techniques and develop partnerships among supply chain partners in order to overcome inventory degradation and quality loss.

Key words: *inventory management, deteriorating items, time-dependent demand, variable holding costs, sensitivity analysis, supply chain optimization, perishable goods.*

INTRODUCTION

In the dynamic landscape of modern business activities, inventory management has become a crucial aspect for maintaining competitiveness and meeting customer demands while providing excellent service. The most significant challenge in this area is the variability in customer demands over time. The most significant factor is the shortage of stock, which prevents the timely fulfillment of customer orders. This directly impacts the business, and the resulting losses cannot be compensated through any other means. Therefore, it is inappropriate to ignore the losses incurred, which result from inadequate inventory planning and affect the overall benefits that could be obtained. For any business owner, the main objective of establishing a business is to maximize profits and grow their business. Consequently, their primary focus is on inventory management. This property is based on concepts such as strict cost control, efficient resource allocation, and economical operation. In the current situation, businesses increase their storage capacities to maximize profits. This involves establishing new warehouses to store surplus seasonal products. In addition to this, retailers, such as those selling clothing, shoes, or jewelry, use low-cost warehouses that they have built or prepared themselves in suitable locations to maximize profits and minimize additional expenses such as rent and maintenance costs for warehouses. Trade credit also plays a significant role in inventory management [19].

This directly impacts businesses by allowing them to attract new customers, handle more orders, increase sales, and reduce inventory costs, ultimately leading to higher net profits. With minimal administrative costs and limited capital investment, it is possible to order a larger quantity of goods. Additionally, during the loan period taken for business promotion and expansion, interest income is also earned from sales. Every business deals with perishable goods. In some businesses, these items are perishable for a short period, while in others, they are more numerous but have a shorter shelf life [20]. Examples include fruits, medicines, soft drinks, and agricultural products. Most of these everyday items have a limited lifespan. Retailers try to sell them before their expiration date to maximize their profits. Considering the above facts, an inventory model is developed to demonstrate their utility and importance. This model reflects the shortcomings in the business, such as time-dependent decreasing demand, variable holding costs, and scheduled payment delays. Its main objective is to minimize total costs, as fluctuations and decay in actual demand are inevitable.

1. An item deterioration inventory model is developed based on the dynamic inventory model in which the demand at each point in time and the variable holding cost are known, and the overall aim of the model is to maximize inventory level and minimize costs.
2. The analysis carried out by the study conducts a sensitivity analysis as an evaluation of how important parameters, which are the deterioration rate, cycle time, and setup cost, influence inventory optimization and total costs.
3. The application of the model is illustrated using numerical examples, and future research is recommended with multi-product cases and non-linear rates of deterioration.

In the paper, the dynamic two-echelon inventory model of the items that deteriorate with time, with time-dependent demand and variable holding costs, is developed. It emphasizes the efficiency of inventory to make it cost-effective, dealing with perishable products and fluctuating demand levels. The methodology involves the use of differential equations and sensitivity analysis to evaluate the effects of the deterioration rates, cycle time, and costs on inventory and total costs. It is proposed in the conclusion to apply this model to multi-product cases and non-linear deterioration rates, as well as to apply the current forecasting and sustainability techniques.

LITERATURE REVIEW

Inventory control is an essential part of the contemporary business, particularly of perishable or degrading products. Scholars have, over the years, come up with different models to maximize inventory management, reduce expenses, and manage uncertainties in inventory, including fluctuating demand, declining prices, and storage expenses. The two-echelon supply chain inventory model developed by Barman and Das (2021) can be used to solve the problem of variable lead times and ramp-type demand of deteriorating items with the on-top credit period [1] [18]. This model puts into perspective the importance of credit policies in controlling inventory and profitability, especially in the circumstances of variable demand and slow payments. On the same note, Pervin et al. (2017) analyzed a two-echelon inventory model, where stock demand is dependent on the available stock and holding costs are variable, such that the deteriorating items are being considered in terms of demand variability and deterioration rates [2] [11].

Kaushik (2025) proposed a stock-dependent system of an inventory model of deteriorating items whose demand is of the form of a ramp. This method aims at making precise predictions of inventory requirements when the demand pattern varies [3] [12]. Karmakar and Choudhury (2014) have discussed the inventory models under ramp-type demand and partial backlogging by developing a model with time-varying holding costs under the assumption that the actual situation in life might be characterized by the fact that the holding costs vary with time [4] [13]. The research by Hasan et al. (2021) is dedicated to the Economic order quantity (EOQ) model in non-instantaneous deteriorating goods with ramp-type demand in a two-warehouse system. Through this model, trade credit policy is incorporated, and the goal is to maximize inventory and minimize the operational cost [5] [14]. In the same manner, Taghizadeh-Yazdi et al. (2020) introduced a multi-level supply chain inventory model of deteriorating items, where the demand depends on the prices and other cost elements, enhancing the decision-making at different stages of the supply chain [6] [15]. Chandra (2021) and Kaushik (2023) have also played a role in the perception of the improvement of inventory management of perishable products based on preservation technology and demand optimization, and both also highlighted the significance of integrating deterioration rates in inventory models [7] [8]. Additional important works, including Kumar et al. (2024) and Kumar et al. (2012), have also addressed the inclusion of environmental elements like carbon emissions and inflation, which determine the practicality of inventory models in the real world [9] [10]. Following such developments, Chakrabarty et al. (2018) and Kumar et al. (2022) consider the integration of financial aspects in inventory management of deteriorating products by modeling them using numerous factors, including capacity limitations, partial backordering, and trade credit [16] [17].

Generally, the literature points out the complexity of managing inventory in dynamic conditions where items are deteriorating, and demand is in the form of a ramp because the consideration of costs, including holding, production, and backordering costs, is necessary to enhance the efficien of the supply chain.

METHODOLOGY

Assumption And Notation

Assumption

1. The demand rate is $\alpha e \beta t$, where α and β are both constant, such that α > 0; β > 0.
2. Two rates of production are considered.
3. Production runs only a single product.
4. The production rate is always greater than or equal to the sum of the demand rate and the deterioration rate.
5. The rate of deterioration is a linear function of rate.
6. Shortages are not allowed.

Notations

- Pt = Initial Production Rate in Units/Unite Time
- Io1 = On - Hand Inventory Level at Time $t1$

- Io2 = On - Hand Inventory Level at Time t2
- Io = Optimal Inventory
- Pc = Production Cost / Unit Time
- Hc = Holding Cost /Unit/Year
- Sc = Setup Cost /Setup
- a + bt = Rate of Deterioration, where 0 < a; b << 1
- t = Cycle Time
- Ut = Unit Time in Period; t = 1,2,3……
- CT = Total Cost

Mathematical Formula: Let the cycle starts at time t = 0 and during the time interval [0, t1], the production rate is$P$t and the demand rate is αeβt such that Pt > αeβt and the inventory level increases at the rate Pt - αeβt. At time t1.

Suppose that Io1 is the maximum inventory level. During the time interval [t1 , t2], the production rate is MPt and demand rate is Mαeβt where ϒ is constant and M > 0 and hence, inventory level increases in this interval at the rate M[Pt − αeβt] . At time t2 production stopped and suppose that Io2 is maximum inventory at that time. Due to demand and deterioration inventory level starts to decrease and after time t inventory becomes zero.

Let It be the inventory level at any time t where 0 ≤ tO ≤ t. then the model is governing by the following differential equations

$$\frac{dI_0}{dt} + (a + bt)I_0 = P_t - \alpha e^{\beta t} \qquad 0 \le t_0 \le t_1 \tag{1}$$

$$\frac{dI_0}{dt} + (a + bt)I_0 = \Upsilon(P_t - \alpha e^{\beta t}) \qquad t_1 \le t \le t_2 \tag{2}$$

$$\frac{dI_0}{dt} + (a + bt)I_0 = -\alpha e^{\beta t} \qquad t_2 \le t \le t_0 \tag{3}$$

he boundary condition of above Differential Equation 4 ,5, 6 are given by

I (0) = 0; I(t1) = It_1; I(t2) = It_2; I(t) = 0 (4)

Using the boundary condition (3) and neglecting second and higher power of a and b are very small

then, the solution of equation (1), (2), (3) are given by respectively

$$I = \frac{\alpha}{\beta}(1 - e^{\beta t}) + P_t(T - \frac{aT^2}{2} - \frac{bT^3}{3}) - \frac{a\alpha}{\beta^2}\left(1 + \beta T - e^{\beta t}\right) + \frac{ab}{\beta}[\frac{1}{\beta^2} - \frac{T^2}{2} + \left(\frac{T}{\beta} - \frac{1}{\beta^2}\right)e^{\beta t}]; 0 \le t_0 \le t_1 \tag{5}$$

$$I = \frac{\alpha}{\beta}\left[b\left(\frac{1}{\beta} - \frac{1}{\beta^2}\right) + \frac{\alpha}{\beta} - 1\right]e^{\beta t} - \frac{\alpha e^{\beta t}}{\beta}\left(at + \frac{bt^2}{2}\right) + \frac{\alpha e^{\beta t}}{\beta}\left[1 + a\left(t - \frac{1}{b}\right) + b\left(\frac{1}{b^2} + \frac{t^2}{2} - \frac{t}{\beta}\right)e^{\beta t}\right]; \ t_2 \le t \le t_0 \tag{6}$$

RESULTS

It was done through testing the proposed two-echelon inventory model of deteriorated items whose demand is in a ramp shape and whose holding costs are variable among a set of numerical examples. The model was applied to estimate the optimum inventory quantities and reduce the total costs at different conditions. The model was solved and the results obtained were calculated using the assumptions and notations mentioned above. In this part, the findings are provided according to sensitivity analysis and the impact of various parameters on the performance of the system.

Numerical Examples

Let us consider an inventory model with the following data:

Pt= 3880; α = 582; β = 0.291; a = 0.0097; b = 0.097; ϑ = 0.388; γ = 1.94; Sc=

77.6; Pc= 38.8; Hc= 1.94; t = 5.65607; IO = 19515.43; t1 = 1.41717; t2 =

3.542828; IO1 = 4092.236; IO2 = 1142.466; CT= 30185.527; $P*$= 22269.26; $S*$ =

13.3084; $H*$ = 6504.917; $D*$ = 1397.576.

Sensitivity

1. Increasing of deterioration, cycle time t, Optimal inventory I, production time (t1, t2), maximum inventory 1 and total cost, decreases but maximum inventory 2 increases.

2. Increasing of setup cost, cycle time t, Optimal inventory I, production time (t1, t2), maximum inventory t1 and t2 total cost, remains unchanged.

3. Increasing of holding cost, cycle time t, Optimal inventory I, production time (t1, t2), maximum inventory t1 decreasing but total cost, and maximum inventory t2 increases.

4. Increasing of production cost, cycle time t, Optimal inventory I, production time (t1, t2), maximum inventory t1 and total cost, increases but maximum inventory t2 decreases.

Table 1. Variation in total cost rate and deteriorating items with inventory

a	b	t	I*o*	P∗	S∗	H∗	D∗	CT
0.0097	0.0097	5.65607	19515.43	22269.698	13.3084	6504.917	1397.516	30185.4979
0.0199	0.0097	5.596415	18956.71	22325.035	13.4539	6386.965	1197.756	29923.1905
0.0291	0.0097	5.537245	1841.42	22382.75	13.5897	6271.729	997.839	29665.8301
0.0097	0.0776	6.204411	25363.56	19913.13	12.1347	7287.319	2767.313	29979.8773
0.0097	0.0873	5.910889	22066.53	21248.335	12.7361	6857.512	2007.318	30125.8526

The relationship between other parameters in table 1 including deterioration rate (a), demand rate (b), cycle time (t), optimal inventory (I o), cost of production (P o), setup cost (S o), holding cost(H o), deterioration cost (D o), and total cost (C T) is represented in this table. These factors are factors which affect the performance of the system as demonstrated by the table. The faster the rate of deterioration and the cycle time, the higher the cost and the lower the optimum inventory. This illustrates the trade-off between cost management and inventory optimization of having a two-echelon inventory system of deteriorating items.

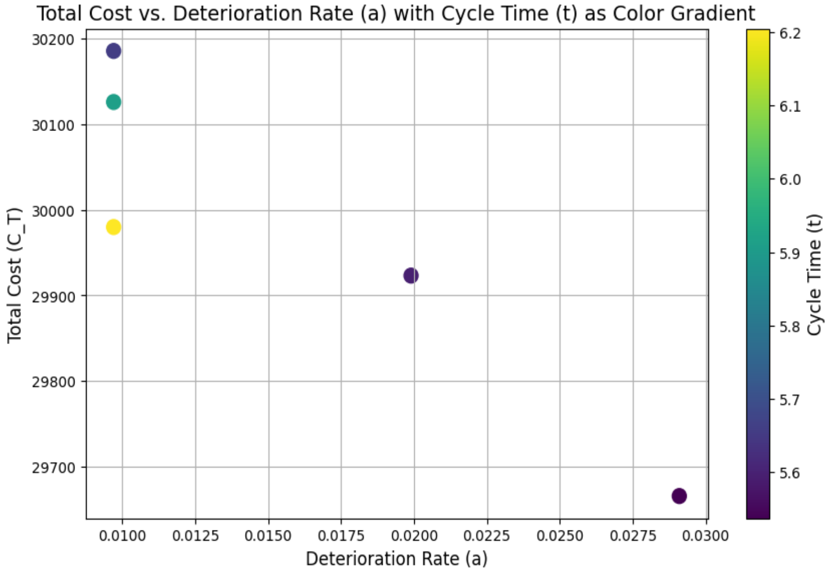

Figure 1. Variation in total cost rate and deteriorating items with inventory

In this figure 1it depicts the dependence of Total Cost (C T) on Deterioration rate (a) and Cycle Time (t) as a color gradient. The plot represents the variation in the total cost at different deterioration rates of various cycle times. The higher the deterioration rate the higher the cost, and the lower the cycle time. The color bar on the right points to the range of cycle time to make one relate the color to the correspondingly corresponding values on the graph. This graph reveals the influence of the deterioration rate and the period of cycle on the inventory cost optimization in a two-level inventory system of deteriorating products.

Table 2. Effect of demand and cost parameters on optimal values

a	b	t	Io	t1	t2	$Io1$	$Io2$	CT
0.0097	0.0097	5.65607	19515.43	22269.698	13.3084	6504.917	1397.516	30185.4979
0.0199	0.0097	5.596415	18956.71	22325.035	13.4539	6386.965	1197.756	29923.1905
0.0291	0.0097	5.537245	1841.42	22382.75	13.5897	6271.729	997.839	29665.8301
0.0097	0.0776	6.204411	25363.56	19913.13	12.1347	7287.319	2767.313	29979.8773
0.0097	0.0873	5.910889	22066.53	21248.335	12.7361	6857.512	2007.318	30125.8526
Sc	67.9	5.65607	19515.43	1.41717	3.542925	4092.333	1141.884	30182.132
	77.6	5.65607	19515.43	1.41717	3.542828	4092.236	1142.466	30185.4979
	87.3	5.65607	19515.43	1.41717	3.542828	4092.236	1142.466	185.4979
Hc	1.455	5.7133	20064.838	1.429004	3.572413	4115.904	962.337	28549.525
	1.94	5.65607	19515.43	1.41717	3.542828	4092.236	1142.466	30185.527
	2.425	5.602429	19012.291	1.4065	3.516056	4070.605	1301.74	31802.42
	33.95	5.62503	19222.878	1.410865	3.527211	4079.626	1235.78	27224.408
	38.8	5.65607	19515.43	1.417073	3.542828	4092.236	1142.466	30185.527

Pc	43.65	5.681096	19754.05	1.42202	3.555632	4102.518	1064.963	33141.796
β	0.0097	5.511346	5836.684	0.477628	1.194167	1595.068	4557.351	41841.144
	0.194	5.765874	11358.506	1.331422	3.328943	3986.021	4442.891	31391.334
	0.291	5.65607	11358.506	1.331422	3.542828	4092.236	1142.466	30185.4979
α	543.2	5.825723	19771.316	1.503694	3.75332	4341.138	605.474	31810.956
	582	5.65607	19515.43	1.417073	3.542828	4092.236	1142.466	30185.527
	620.8	5.511152	19394.083	1.341316	3.353229	3864.868	1444.039	28990.099
ϑ	0.388	5.65607	19515.43	1.417073	3.542828	4092.236	1142.466	30185.527
	0.485	5.304736	16418.608	1.538711	3.077442	4322.902	2790.496	23197.55
	0.582	5.16331	15296.9	1.733972	2.890018	4633.011	2732.587	20374.365
ϒ	1.94	5.65607	19515.43	1.417073	3.542828	4092.236	1142.466	30185.527
	2.134	5.474583	17858.185	1.309791	3.274526	3866.711	2670.992	28239.319
	2.328	5.332866	16649.856	1.2222	3.055403	3668.346	3838.872	26945.242

The table 2 shows the change in the key parameters of a two echelon inventory model that takes into account deteriorating items. It contains a rate of deterioration (a), rate of demand (b), cycle time (t), optimal inventory (I o) and production time (t1 and t2) and maximum inventory levels (I o 1 and I o 2) and total cost (C T). The table identifies the variation in deterioration rates, demand rates, and cycle times and their effect on the optimal inventory levels and their total costs. The more the deterioration rate, the lower the overall cost, and the lower the optimum inventory levels. Production and holding costs included, as well as the set-up costs, are also taken into account and present the trade-offs between these variables. This table plays a critical role in the context of the effect of various parameters on managing inventories and cost optimization of deteriorating items.

This Figure 2 demonstrates the interdependence between Total Cost (C T), Deterioration rate (a) and Demand rate (b). The color gradient is used to show the Cycle Time (t). It is depicted in the plot that the overall cost will vary with the variation in deterioration and demand rates whereby the cost varies with the cycle time. The color gradient can be used to interpret the relationship between cycle time and overall cost intuitively because these two variables interact with each other in the inventory management of deteriorating items.

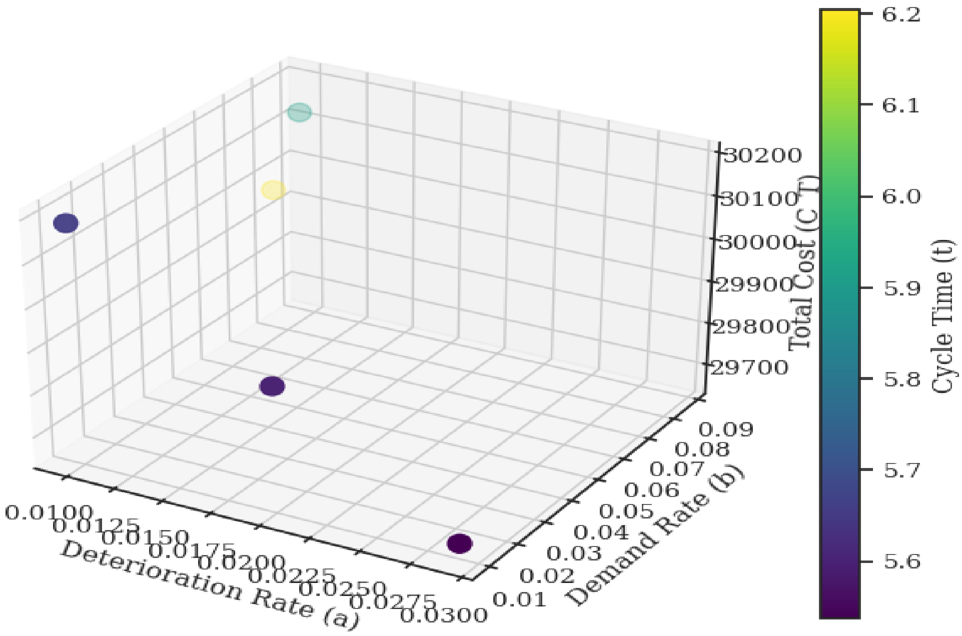

Figure 2. Effect of demand and cost parameters on optimal values

CONCLUSION

This paper introduces a dynamic two-echelon inventory system that takes a time-varying demand of deteriorating items and a time-varying holding cost. The model will reduce the total costs through optimizing inventory, production costs, holding costs and deterioration losses. The model provides an example of how variations in rate at which the parts deteriorate, cycle time and production cost affect the overall system performance through a series of numerical examples and sensitivity analysis. According to the results, the higher the deterioration rates, the less optimum inventory and the more total costs; cycle time and holding costs have the same result in influencing the balance between the inventory and costs. The model is an important instrument to industries that process perishable products because it offers insights into the efficient approaches to inventory management to minimize the loss of inventory and enhance cost-efficiency.

It is possible to extend the current model to include some more realistic assumptions, including multi-product cases, non-linear deterioration rates, and the attention to other external factors, including weather or market interference. Besides, the use of modern forecasting methods of demand and deterioration patterns may also enhance the accuracy of the model. The effect of the disruption and unpredictability of supply chain on inventory management may also be investigated in the future. Moreover, the consideration of sustainability aspects, including lessening carbon emissions or waste, might fit the model with modern supply chain optimization activities. Machine learning-based demand forecasting and inventory management also make the model more adaptive to dynamic environments, and such solutions may result in smart, real-time inventory management.

REFERENCES

[1] Barman D, Das B. Two-echelon supply chain inventory model with variable lead time and ramp-type demand for deterioration item under bi-level credit period. International Journal of Inventory Research. 2021;6(1):14-46. https://doi.org/10.1504/IJIR.2021.113816

[2] Pervin M, Roy S, Weber GE. A Two-echelon inventory model with stock-dependent demand and variable holding cost for deteriorating items. Numerical Algebra Control and Optimization. 2017;7(1). https://doi.org/10.3934/naco.2017002

[3] Kaushik J. An inventory model for deteriorating items with ramp type demand pattern: a stock-dependent approach. Cogent Business & Management. 2025 Dec 12;12(1):2442547. https://doi.org/10.1080/23311975.2024.2442547

[4] Karmakar B, Choudhury KD. Inventory models with ramp-type demand for deteriorating items with partial backlogging and time-varing holding cost. YUJOR. 2014 Jun 1;24(2):249-66.

[5] Hasan A, Kausar A, Verma M. An EOQ model for non-instantaneous deteriorating items with ramp-type demand in a two-warehouse facility. International Journal of Services Operations and Informatics. 2021;11(2-3):115-58. https://doi.org/10.1504/IJSOI.2021.117264

[6] Taghizadeh-Yazdi M, Farrokhi Z, Mohammadi-Balani A. An integrated inventory model for multi-echelon supply chains with deteriorating items: a price-dependent demand approach. Journal of Industrial and Production Engineering. 2020 Apr 2;37(2-3):87-96. https://doi.org/10.1080/21681015.2020.1733679

[7] Chandra S. Two warehouse inventory model for deteriorating items with ramp type demand and price discount on backorders. Journal of Scientific Research. 2021 May 1;13(2):455-65. https://doi.org/10.3329/jsr.v13i2.50000

[8] Kaushik J. Inventory model for perishable items for ramp type demand with an assumption of preservative technology and Weibull deterioration. International Journal of Procurement Management. 2023;18(2):238-59. https://doi.org/10.1504/IJPM.2023.133232

[9] Kumar V, Sharma A, Gupta CB. A multi-item EOQ model for deterioration items with ramp-type demand and partial backlogging under carbon emission and inflationary environment. International Journal of Operational Research. 2024;51(2):260-96. https://doi.org/10.1504/IJOR.2024.142255

[10] Kumar N, Singh SR, Kumari R. Three echelon supply chain inventory model for deteriorating items with limited storage facility and lead-time under inflation. International Journal of Services and Operations Management. 2012 Jan 1;13(1):98-118. https://doi.org/10.1504/IJSOM.2012.048277

[11] Padiyar SV, Gupta V, Rajput N. Multi-echelon supply chain inventory model for perishable items with fuzzy deterioration rate and imperfect production with two-warehouse under inflationary environment. International Journal of Business Performance and Supply Chain Modelling. 2023;14(2):144-72. https://doi.org/10.1504/IJBPSCM.2023.131678

[12] Hemmati M, Fatemi Ghomi SM, Sajadieh MS. A multi-echelon supply chain of deteriorating items with stock-and price-sensitive demand under consignment stock policy. Engineering optimization. 2023 Mar 4;55(3):476-93. https://doi.org/10.1080/0305215X.2021.2012658

[13] Nath BK, Sen N. A partially backlogged two-warehouse EOQ model with non-instantaneous deteriorating items, price and time dependent demand and preservation technology using interval number. International Journal of Mathematics in Operational Research. 2021;20(2):149-81. https://doi.org/10.1504/IJMOR.2021.118744

[14] Mahmoodi A. Pricing and inventory decisions in a manufacturer-Stackelberg supply chain with deteriorating items. Kybernetes. 2021 Jul 22;50(8):2347-66. https://doi.org/10.1108/K-03-2020-0149

[15] Shaikh AA, Panda GC, Khan MA, Mashud AH, Biswas A. An inventory model for deteriorating items with preservation facility of ramp type demand and trade credit. International Journal of Mathematics in Operational Research. 2020;17(4):514-51. https://doi.org/10.1504/IJMOR.2020.110895

[16] Chakrabarty R, Roy T, Chaudhuri KS. A two-warehouse inventory model for deteriorating items with capacity constraints and back-ordering under financial considerations. International journal of applied and Computational mathematics. 2018 Apr;4(2):58.

[17] Kumar N, Dahiya S, Kumar S. Two warehouse inventory model for deteriorating items with fixed shelf-life stock-dependent demand and partial backlogging. Journal of Mathematical and Computational Science. 2022 Feb 16;12: Article-ID.

[18] Singh MR, Yadav AS, Swami MA. A two-warehouse model for deteriorating items with holding cost under inflation and soft computing techniques. International Journal of Advanced Engineering, Management and Science. 2016;2(6):239525.

[19] Pathak K, Yadav AS, Agarwal P. Optimizing Two-Warehouse Inventory for Shelf-Life Stock with Time-Varying Bi-Quadratic Demand Under Shortages and Inflation. Mathematical Modelling of Engineering Problems. 2024 Feb 1;11(2). https://doi.org/10.18280/mmep.110216

[20] Ogbonna UU, Oladugba AV, Ezra NP. Deterministic Two-Storage Inventory Model for Deteriorating Items with Salvage Value Under Inflation. Journal of the Indian Society for Probability and Statistics. 2024 Dec;25(2):789-806. https://doi.org/10.1007/s41096-024-00206-8