Inventory Model for Two-Storage System with Learning Effects and Carbon Emissions Under Preservation Technology

Dr. Pushpendra Kumar[1]; Vikash Ranwa[2]

[1]Department of Mathematics Shri Khushal Das University, Hanumangarh, Rajasthan
[2]Department of Mathematics Shri Khushal Das University, Hanumangarh, Rajasthan

[1]Orcid ID: 0000-0002-4055-0424

Publication Date: 2026/05/13

Abstract: This paper presents a carbon emissions-based inventory model that represents the impact of learning on ordering, deterioration, and storage costs in both owned and rented warehouses. The demand for perishable items is rising at an exponential rate. Perishable commodities have a high rate of deterioration and must be properly kept because their quality deteriorates quickly. When preservation technology is used, a lot of carbon units are released since the generator burns fuel and electricity, both of which are bad for the environment. To lower these emissions, governments impose additional carbon taxes. The term "green packaging cost" refers to the cost of using appropriate packaging strategies to preserve the product quality, safety, and environmental compatibility of green deteriorating items. When stock levels in a two-storage system for perishable items hit zero, the proposed model aims to minimize the total inventory cost per unit time during the cycle. It accomplishes this by specifically taking preservation and carbon emission costs into consideration. The model has been authenticated with a numerical example. As a result, the model has real-world applications and potential future study avenues.

Keywords: *Learning Effect, Preservation Technology, Deterioration, Owned Warehouse, Rented Warehouse, Carbon Emissions, Exponential Demand.*

How to Cite: Dr. Pushpendra Kumar; Vikash Ranwa (2026) Inventory Model for Two-Storage System with Learning Effects and Carbon Emissions Under Preservation Technology. *International Journal of Innovative Science and Research Technology*, 11(4), 4369-4376. https://doi.org/10.38124/ijisrt/26apr2522

I. INTRODUCTION

These days, the combustion of gasoline and diesel, as well as the movement of goods and other associated activities, contribute significantly to carbon emissions. These pollutants have a detrimental effect on the ecosystem and aid in the ozone layer's thinning. A recent example of this occurrence is Delhi NCR, where the government imposes double parking fees to reduce carbon emissions when GRAP stages 3 and 4 take effect. Because they must hold goods for prompt sales, online retailers like Flipkart, Amazon, and Myntra rely entirely on owned and rented warehouses. Customers occasionally place orders for goods from online retailers like Flipkart, Amazon, Myntra, and others. It is depending on the availability of the items, the product may or may not be delivered, or it may arrive very late since the requested product is not available.

For instance, India announced emission targets for significant industries in 2025 under the Greenhouse gases Emission Intensity Target Rules, 2025 and launched the Carbon Credit Trading Scheme (CCTS) in 2023–2024. These regulations require companies to cut back on greenhouse gas emissions from transportation, logistics, storage, and preservation technologies. They will have to pay fines or purchase carbon credits if they don't cut carbon emissions, which raises additional costs. The consumption of these energy sources results in significant of carbon emissions, which contribute to environmental pollution and climate change. Fruits, vegetables, dairy products, medications, and seasonal goods are examples of perishable goods that quickly deteriorate if improperly stored. When these products are not properly kept, their quality rapidly deteriorates, resulting in large financial losses and increasing waste from the disposal of ruined commodities. Retailers and internet vendors are investing more in preservation technology such chemical treatments, refrigeration systems, cold storage facilities, and controlled-atmosphere packaging in order to solve this problem.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2522

The concept of two-warehouse inventory systems for handling storage constraints was first proposed by early scholars like Pakkala and Acharya, according to a review of the literature. Subsequent research expanded this agenda by including elements like trade credit policies, shortages, time-dependent demand, and stock-dependent demand. Preservation technology has started to be used in more recent studies as a way to regulate how quickly perishable goods deteriorate. The role of carbon emissions in inventory models has also been studied by researchers like Kumar and Rana, who have incorporated environmental policies like carbon taxes and cap-and-trade rules. The learning effect, which shows how companies' operational efficiency improves as they acquire expertise with ordering, handling, and storage tasks, has also been included in certain research.

This process of learning has the potential to save operating costs and enhance system performance over time. Despite these developments, the majority of current models only take into account a small number of variables. Few studies take into account learning effects, fuzzy cost parameters, preservation technologies, exponential demand patterns, carbon emission considerations, and a two-warehouse inventory system all at once. As a result, another thorough model that incorporates these elements into a cohesive framework is still required. By investigating the combined effects of carbon emissions, learning effects, preservation technology, and a two-warehouse system for perishable goods, the suggested model seeks to close this gap. By combining these elements, the study aims to provide a more practical and realistic approach to inventory management while taking environmental sustainability and economic efficiency into account.

The present paper addresses this gap by creating a carbon emissions-based inventory model for perishable goods under preservation technology in a two-warehouse setting (owned and rented warehouses). The model incorporates the learning effect on ordering cost, storage costs (differentiated for rented and owned warehouses), and deterioration cost. Customer demand follows an exponential growth pattern over time. Preservation technology is used to decrease the high deterioration rate, but it generates carbon emissions through electricity or fuel usage, leading to additional carbon taxation costs imposed by regulatory authorities. The objective is to minimize the full relevant inventory cost per unit time by determining the optimal cycle length when inventory reaches zero, while accounting for ordering cost, holding costs in both warehouses, deterioration cost, preservation investment and carbon emission cost.

However, through the development of large-scale retail businesses, particularly in e-commerce and perishable goods sectors, a single warehouse is regularly insufficient to meet the storage requirements. To overcome this limitation, researchers introduced the concept of a two-warehouse inventory system. In this inventory system, products are stored in two different facilities: an owned warehouse (OW) and other a rented warehouse (RW). The owned warehouse usually has limited storage capacity but offers the lower holding costs, whereas the rented warehouse provides the additional storage space at a higher cost. This arrangement allows the retailers to efficiently manage the excess inventory when the demand is high or when dealing with items that deteriorate over time.

As a result, the two-warehouse inventory system has become an effective approach for addressing the storage limitations and improving the inventory management for perishable products. [1] Pakkala and Acharya (1992) discussed about the two-warehouse model for items that deteriorate or spoil. They assumed a replenishment rate with shortages also. This work became the base for later studies on inventory management for items that deteriorate or spoil. [2] Lee and Hsu (2009) created a two-warehouse production strategy for goods that spoil or deteriorate over time. They concentrated on inventory and production choices for spoiled or deteriorating goods. [3] Sheikh and Patel (2017) studied on the two-warehouse model for the deteriorating items with different deterioration rates, time-dependent demand, and shortages. [4] Malik et al. (2017) worked on two-warehouse model with quadratic demand for optimal ordering and also checked stock-dependent demand with maximum lifetime strategy. [5] Mandal and Giri (2017) considered a mathematical system under imperfect production in which stock-dependent demand and quantity discounts in supply chain with two-warehouses are discussed. [6] Mandal (2020) created a structural comparative analysis of an inventory management system for deteriorating items with ramp type and quadratic demand. [7] Dhivya Lakshmi & Pandian (2021) provides a production inventory model with an exponential rate of deterioration, an exponential rate of demand, and shortages; the production rate is a function of the demand rate. The cycle length, production lengths, shortfall, and overall inventory cost each cycle are all optimized. [8] Ahmad et al. (2023) created an inventory model for the deteriorating items under the preservation technology to reduce the rate of product spoilage. [9] Kumar et al. (2023) made ordering policies using preservation technology and cost effective focusing on sustainable environment. [10] Rana et al. (2023) developed a sustainable production inventory model that makes use of preservation technologies; however, it does not take carbon emission regulations into account. Developed a sustainable production inventory model that makes use of preservation technologies; however, it does not take carbon emission regulations into account. [11] Ahmed et al. (2025) investigated the role of technological investment in two-warehouse management systems to improve the storage efficiency and reduce the product wastage. [12] Limi (2025) suggested an advanced inventory model that integrated price-dependent demand, carbon emissions considerations, preservation technology, and a hybrid payment system inside a two-warehouse framework. [13] Biswas (2025) discussed the use of preservation technology while also assuming the environmental factors such as carbon emissions. These studies additionally analyze the financial facts, including payment policies and the deterioration behavior of products over the time.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2522

- *Research Gap in Two Warehouses Inventory Models for Deteriorating Items*

Their studies examined how the operational learning influences the ordering decisions, product handling, and payment structures. Although some researchers have assumed the learning effect in deteriorating inventory management systems and two-warehouse models, its integration with the preservation technology and environmental regulations such as carbon emission policies remains limited.

- *Research Gap Identifie*

Table 1 Research Gap Identified

S. No.	Author(s) and Year	Model of the Study	Key Features assumed	Research Gap Identified
1	Pakkala & Acharya (1992)	Deterministic two-warehouse inventory model	Deteriorating items, finite replenishment rate	Does not consider sustainability, learning effect, or preservation technology
2	Lee & Hsu (2009)	Two-warehouse production inventory model	Time-dependent demand, deterioration	Environmental impacts such as carbon emissions not considered
3	Sheikh & Patel (2017)	Two-warehouse model with shortages	Different deterioration rates, time dependent demand	Environmental policies and preservation technology not incorporated
4	Malik et al. (2017)	Two-warehouse inventory model	Quadratic demand pattern	Sustainability and carbon emission effects not incorporated
5	Mandal & Giri (2017)	Integrated two-warehouse inventory model	Imperfect production, stock-dependent demand	Carbon emissions and preservation investment ignored
6	Mandal (2020)	Inventory system with ramp type and quadratic demand	Structural comparison of demand patterns	Carbon emission and preservation technology not included
7	Dhivya Lakshmi & Pandian (2021)	Production inventory model	Exponential demand, declining deterioration	Carbon emission and preservation technology not integrated
8	Ahmad et al. (2023)	Green inventory model with preservation technology	Carbon emissions, deterioration, preservation technology	Learning effect and two-warehouse system not considered simultaneously
9	Kumar et al. (2023)	Fuzzy inventory model with sustainable transportation	Sustainability considerations, fuzzy modelling	Two-warehouse structure and preservation technology not analysed
10	Rana et al. (2023)	Sustainable production-inventory model	Fuel pricing, preservation technology	Two-warehouse system and learning effect not included
11	Ahmed et al. (2025)	Two-warehouse inventory model with green technology investment	Deteriorating items, selling price, carbon emissions	Learning effect and fuzzy environment not incorporated
12.	Limi (2025)	Two-warehouse model with preservation technology	Carbon emission, hybrid payment scheme	Learning effects and fuzzy parameters not studied
13.	Biswas (2025)	Two-warehouse inventory model with preservation investment	Carbon emission, preservation technology	Demand pattern and learning effects not analysed

But even after all these advancements, there is still a big research gap: very few studies put together the learning effect on ordering, storage (different for both warehouses), and deterioration costs; preservation technology investment; with carbon emission taxations in a two-warehouse model for perishable items with exponentially increasing demand. Most models take only some parts (like preservation + carbon without learning, or learning + trade credit without two-warehouse sustainability). Our present study fills this gap by making a full two warehouses inventory system with carbon emissions-based model that includes the learning across many costs, preservation technology to control high deterioration rate, and carbon taxation, while optimizing total inventory cost under exponential demand in a real two-warehouse setup.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2522

II. MODEL'S NOTATIONS AND ASSUMPTIONS

➢ *Model's Notations*

Table 2 Model with Notation and Description

Notation	Description
$D(t) = e^{rt}$	Customer's demand rate at any time
T_{cc}	The taxation for the carbon emissions
F_{bc}	The average of the carbon emissions from the burning of the fuel (ton CO2 per liter)
C_b	Average of burning of fuel consumption when no fuel (liter per kilometer)
$E(t)$	The stock level at any time in the rented warehouse (RW)
$F(t)$	The stock level at any time in the Owned warehouse (OW)
OW	Owned warehouse for the retailer
RW	Rented warehouse for the retailer
W	The capacity of owned warehouse (OW) for the retailer
l	Learning factor
y	Preservation cost for unit item in RW and OW
a	The rate of deterioration in RW
b	The rate of deterioration for in OW
$C = C_o + \frac{C_1}{n^l}$	The Ordering cost for the retailer, where $C_o, C_1;$ the fixed and variable ordering cost
$D_c = D_o + \frac{D_1}{n^l}$	The cost per unit item for deterioration in RW/OW; where D_o and D_1 are Fixed and variable ordering cost
$h_r = h_{r1} + \frac{h_{r2}}{n^l}$	The cost per unit item for storage of items in RW; where h_{r1} and h_{r2} are Fixed and variable storage cost in RW
$h_o = h_{o1} + \frac{h_{o2}}{n^l}$	The cost per unit item for storage of items in OW; where h_{o1} and h_{o2} are Fixed and variable storage cost in OW
$Z(t_0)$	The total inventory cost for the system

➢ *Model's Assumptions*

- In this system of the developed model, the taxation policy is considered. The exchange policy of perishable items is not permitted.
- The repair of the items is not allowed. It is considered that carbon emissions come from the burning of the fuel.
- It is also assumed, the deteriorating cost, ordering cost and storage also follow the effect of learning.
- The customer's demand rate is assuming the exponentially increasing function of the time, and it can be defined by $D(t)= e^{rt}, \quad r > 0.$
- The buyer's storage cost in RW is more than OW (assumed). Firstly, the perishable items have preferred in OW and after that in RW (assumed).
- Green packaging cost represents its expenditure which is required to preserve the quality of environmentally friendly deteriorating items through the appropriate packaging. It comprises the cost of packaging materials as well as the labor elaborate in the packaging process, and it varies allowing to the number of parcels handled.

III. MODEL FORMULATION

The model frame has been presented in the Fig. 4. Initially, we discuss the working of the planned model firstly in RW, the stock level of the inventory in the RW is $E(t)$ which it will be zero at $t = t_0$ and the demand of the items fulfills firstly from the rented warehouse and after that the demand of the product fulfills from the owned warehouse. The stock range in the interval $(0,\ t_0)$ is $F_1(t)$ at any time t and the stock level in the interval $(t_0,\ t_1)$ is $F_1(t)$. Let W is the initial stock of the perishable items in an owned warehouse.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2522

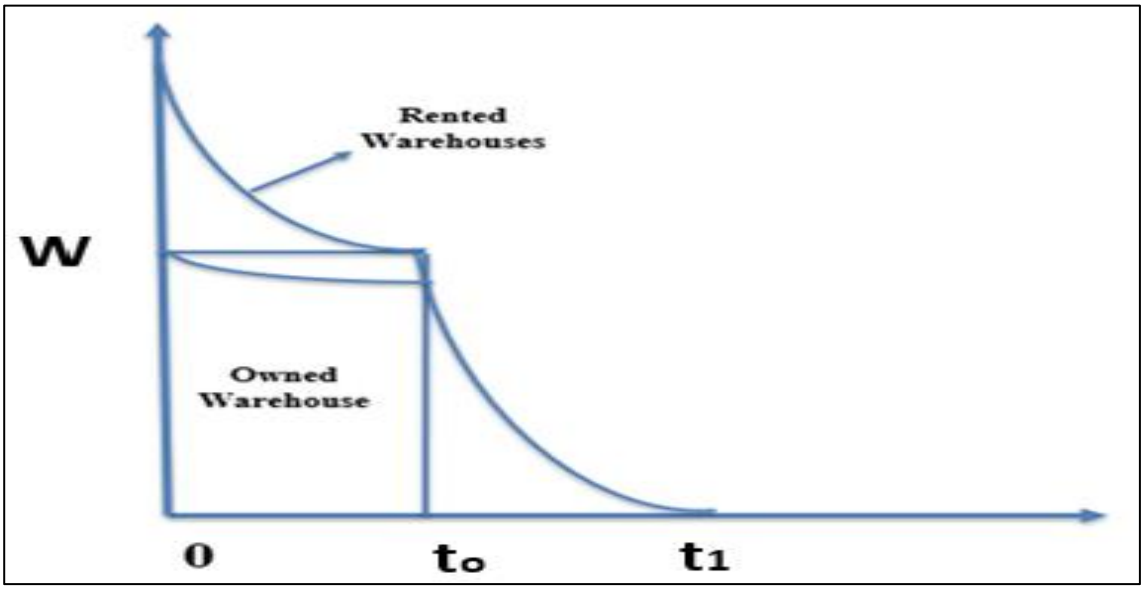


Fig 1 Graphical Representation of Two-Warehouses

The model frame has been presented in the Fig. 4. Initially, we discuss the working of the planned model firstly in RW, the stock level of the inventory in the RW is $E(t)$ which it will be zero at $t = t_0$ and the demand of the items fulfills firstly from the rented warehouse and after that the demand of the product fulfills from the owned warehouse. The stock range in the interval $(0, t_0)$ is $F_1(t)$ at any time t and the stock level in the interval (t_0, t_1) is $F_1(t)$. Let W is the initial stock of the perishable items in an owned warehouse.

The inventory level $E(t)$ at time t is decreases because of two reasons: customers buy the items (demand) and some items deteriorate (spoil) naturally. So, the rate of change of inventory in RW follows this differential equation for time 0 to t_0:

$$\frac{dE(t)}{dt} + aE(t) = -e^{rt}, \quad 0 \le t \le t_0 \qquad ...(1)$$

$$\frac{dF_1(t)}{dt} + bF_1(t) = 0, \quad 0 \le t \le t_0 \qquad ...(2)$$

$$\frac{dF_2(t)}{dt} + bF_2(t) = -e^{rt}, \quad t_0 \le t \le t_1 \qquad ...(3)$$

With the boundary conditions $E(t_0) = 0, F_1(0) = W, F_2(t_1) = 0$ respectively.

The Solution of the equation (1), (2) and (3) are

$$E(t) = \frac{1}{(r+a)}\left(e^{rt_0} . e^{a(t_0 - t)} - e^{rt}\right) \qquad (4)$$

$$F_1(t) = We^{-bt} \qquad (5)$$

$$F_2(t) = \frac{1}{(r+b)}\left(e^{rt_1} . e^{b(t_1 - t)} - e^{rt}\right) \qquad (6)$$

Due to continuity of $F(t)$ at t=t_0, it follows from the above system of equations (5) and (6), we get

$$W = \frac{1}{(r+b)}\left(e^{(r+b)t_1} - e^{(r+b)t_0}\right) \qquad (7)$$

- *The Total Cost Per Unit Time*

The total relevant cost per unit time $Z(t_0)$ is calculated by adding all important costs and dividing by cycle length t_1:

$$Z(t_0) = \frac{1}{t_1}\left(O_c + G_{pc} + PV_c + EC_c + HC_r + HC_o + DC_r + DC_o\right)$$
(8)

The total cost from the equation (8) contains following cost component which is given below

Ordering cost (O_c) is:

$$O_c = C_o + \frac{C_1}{n^l} \qquad (9)$$

The Green packaging cost is

$$G_{pc} = (M_c + L_c)N_p \qquad (10)$$

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2522

The preservation cost for the time period (t_0) is

$$PV_c = y.t_0 \tag{11}$$

The total carbon emission cost

$$EC_c = C_b.F_{bc}.T_{cc} \tag{12}$$

The inventory holding cost in RW is

$$HC_r = h_r\left[\int_0^{t_0} E(t)dt\right] = \left(h_{r_1} + \frac{h_{r_2}}{n^l}\right)\left[\int_0^{t_0} E(t)dt\right] \tag{13}$$

The inventory holding cost in OW is

$$HC_o = h_o\left[\int_0^{t_0} F_1(t)dt + \int_{t_0}^{t_1} F_2(t)dt\right] = \left(h_{0_1} + \frac{ho_2}{n^l}\right)\left[\int_0^{t_0} F_1(t)dt + \int_{t_0}^{t_1} F_2(t)dt\right] \tag{14}$$

The inventory cost due to deterioration in RW is

$$DC_r = D_c\left[\int_0^{t_0} \alpha\, E_1(t)dt\right] \quad = \left(D_0 + \frac{D_1}{n^l}\right)\alpha \int_0^{t_0} E_1(t)dt \tag{15}$$

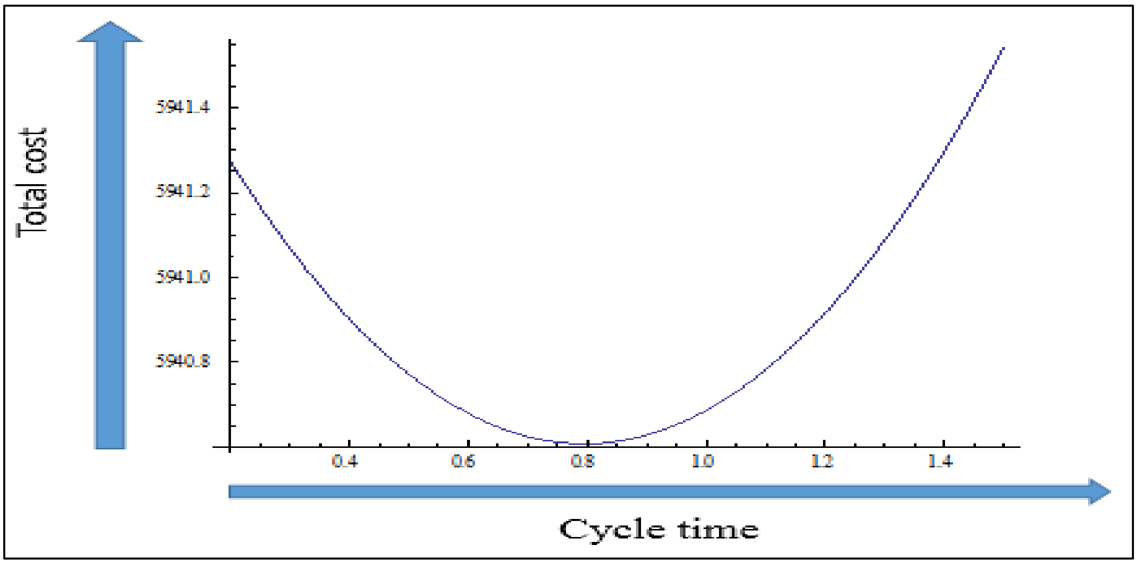
The inventory cost due to deterioration in OW is

$$DC_o = D_c\left[\int_0^{t_0} \beta\, F_1(t)dt + \int_{t_0}^{t_1} \beta\, F_2(t)dt\right]$$

$$= \left(D_0 + \frac{D_1}{n^l}\right)\beta\left[\int_0^{t_0} F_1(t)dt + \int_{t_0}^{t_1} F_2(t)dt\right] \tag{16}$$

$$Z(t_o) = \frac{1}{t_1}\left[O_c + G_{pc} + PV_C + EC_c + HC_r + HC_o + DC_r + DC_o\right] \tag{17}$$

Using optimality test the total inventory cost $Z(t_0*)$ is minimum and when $\frac{d^2Z(t_0)}{dt_0^2} > 0$, then t_0 is minimum value and it represents t_0*. In our model, the total cost function $Z(t_0)$ shows convex behavior (it first decreases then increases), which means there is only one minimum point. This convexity is shown in Fig. 5. Because of this convex shape, we are sure that t_0, we find from first derivative = 0 is the global minimum. No need to check the other points.



ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/26apr2522

Fig 2 Convexity of Total Inventory Cost

IV. NUMERICAL ILLUSTRATIONS

We use all values are, in dollars and years. The total cost function has exponential terms and integrals which made it hard to calculate. The values of inventory parameters and decision variables are C_o=300$ per order; C_1=90$ per order; hr_1=0.55 $ per unit item; hr_2=0.040$ per unit item; h_{o1}=0.35 $ per unit; h_{02}=0.025 $ per unit; n=12; l=0.21; D_0=0.50 $ per unit item; N_p=1; M_c= 3 $ packing/parcel; L_c= 2 $ / parcel; D_1=0.030$ per unit item; α=0.050; β=0.060; r=0.2; t_1=1.30 year; Ψ=0.5 per unit item; C_b=0.23; T_{cc}=$68 per ton CO2; $F_{bc}=2.4\times10^{-4}$ ton CO2; the optimum cycle length is t_0^*=0.7867; $Z\left(t_0^*\right)$= 5938.67.

This example shows that with learning effect (l = 0.21), the total cost becomes lower than compared to no learning (higher cost if l = 0). Preservation technology helps in reducing deterioration loss, but carbon tax adds the extra cost. The optimal cycle is about 0.86 per year (around 10-11 months), which is reasonable for perishable items with exponential demand growth.

Table 3 Sensitivity Analysis of the number of shipments with length of cycle, and total inventory cost

Shipments	**length of cycle** $\left(t_0^*\right)$	**Total Inventory cost** $Z\left(t_0^*\right)$
1	0.7867	6457.45
2	0.7867	6375.87
3	0.7867	6189.96
4	0.7867	6109.09
5	0.7867	5996.93
6	0.7867	5987.74
7	0.7867	5967.56
12	0.7867	**5938.67**

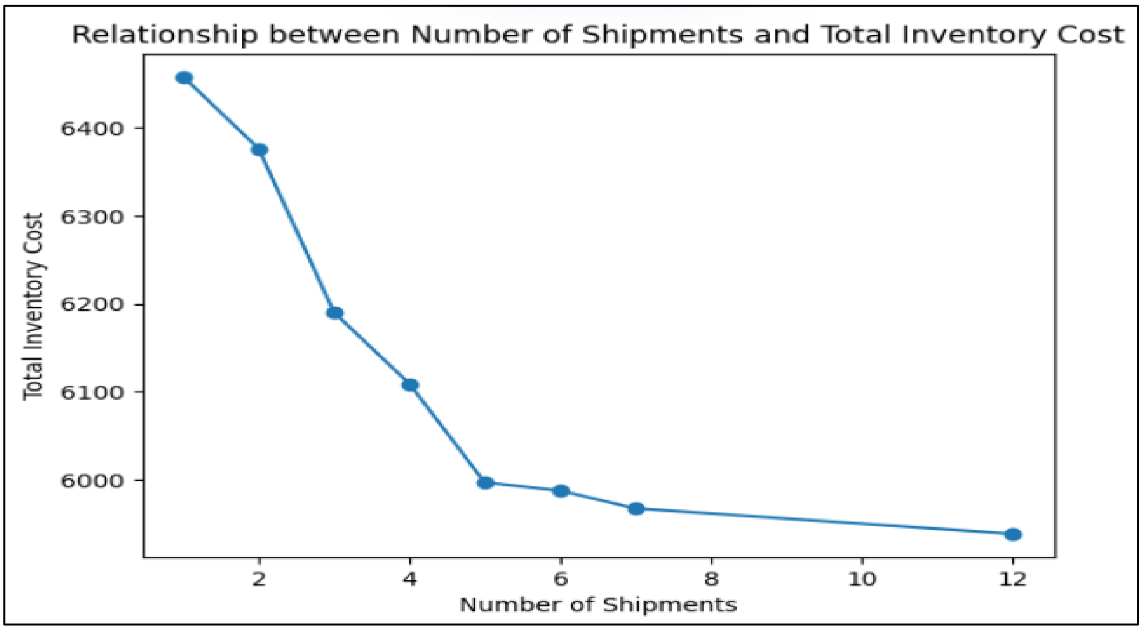


Fig 3 Graphical Representation of Number of Shipments Via Total Inventory Cost

V. CONCLUSION

In this paper, we created an inventory model based on carbon emissions that takes into account the learning effect on ordering, deterioration, and storage costs in owned and rented warehouses using preservation technologies. The model takes into account perishable goods that are frequently utilized in commercial transactions, particularly in online shopping and fresh goods retail, as well as the exponentially rising demand rate. The findings unequivocally demonstrate that ideal cycle duration and total inventory cost are positively and significantly impacted by shipping, preservation costs, carbon tax rates, and deterioration rates. Green packaging typically refers to the use of environmentally friendly materials that reduce the impact on the environment while preserving the integrity of the product, such as recyclable, biodegradable, or reusable packaging components. The usefulness and practicality of the suggested inventory model are illustrated with numerical examples. Sensitivity analysis also aids in showing how important factors affect the best choices. The inventory model can be expanded in subsequent studies by adding other elements like trade credit regulations and unpredictable or stochastic situations. These additions would improve the inventory models' realism and support for making decisions in the face of ambiguity.

REFERENCES

[1]. Pakkala, T. P., & Acharya, K. K. (1992). A deterministic inventory model for deteriorating items with two warehouses and finite replenishment rate. *European Journal of Operational Research, 57*(1), 71–76. https://doi.org/10.1016/0377-2217(92)90342-5.

[2]. Lee, C. C., & Hsu, S. L. (2009). A two-warehouse production model for deteriorating inventory items with time dependent demands. *European Journal of Operational Research*, *194*(3), 700–710. https://doi.org/10.1016/j.ejor.2007.12.036.

[3]. Malik, A. K., Kumar, S., & Kumar, S. (2017). Two warehouses inventory model with stock-dependent demand and maximum life time. *International Journal of Physical Sciences, 29*, 309–318.

[4]. Sheikh, S. R., & Patel, R. (2017). Two-warehouse inventory model with different deterioration rated under time dependent demand and shortages. *Global Journal of Pure and Applied Mathematics, 13*(8), 3951–3960.

[5]. Mandal, P., & Giri, B. C. (2017). A two-warehouse integrated inventory model with imperfect production process under stock dependent demand quantity discount offer. *International Journal of System Science: Operations & Logistics, 4*(4), 1–12.

[6]. Biswaranjan, Mandal. (2020). An inventory management system for deteriorating items with ramp type and quadratic demand: A structural comparative study. *International Journal on Soft Computing, 11*(1/2/3/4), 1–8. https://airccse.org/journal/ijsc/ijsc.html.

[7]. Dhivya Lakshmi, M., & Pandian, P. (2021). Production inventory model with exponential demand rate and exponentially declining deterioration. *Italian Journal of Pure and Applied Mathematics*, *45*, 59–71.

[8]. Ahmad, N., Sangal, I., Sharma, K., Jayaswal, M. K., Kumar, S., Pal, S. K., & Alam, K. (2023). A green realistic inventory model with preservation technology for deteriorating items under carbon emission. *Materials Today: Proceedings*. Advance online publication.

[9]. Kumar, P., Yadav, V., Naik, P. J., Malik, A. K., & Alaria, S. K. (2023). Analysis of fuzzy inventory model with sustainable transportation. *AIP Conference Proceedings*, *2782*(1), Article 020001. AIP Publishing.

[10]. Rana, R. S., Kumar, D., & Prasad, K. (2023). Sustainable production-inventory system for perishables under dynamic fuel pricing and preservation technology investment. *Environmental Science and Pollution Research, 30*(39), 90121–90147.

[11]. Ahmed, A., Kummari, K., & Shukla, R. (2025). A two-warehouse inventory model for green technology investment: Deteriorating items with selling price and carbon emissions. *European Journal of Pure and Applied Mathematics, 18*(2), Article 5847. https://doi.org/10.29020/nybg.ejpam.v18i2.5847.

[12]. Limi, A. (2025). Two-warehouse inventory model for non-instantaneously deteriorating items incorporating preservation technology, carbon emissions and hybrid payment schemes. *Yugoslav Journal of Operations Research*. Advance online publication. https://doi.org/10.2298/YJOR240715029L.

[13]. Biswas, N. (2025). A two-warehouse inventory model of deteriorating products with preservation technology investment and carbon emission. *International Journal of Advanced Operations Management*. Advance online publication. https://doi.org/10.1504/IJAOM.2025.148397.