Applied Mathematical Sciences, Vol. 19, 2025, no. 6, 237 - 248
HIKARI Ltd, www.m-hikari.com
https://doi.org/10.12988/ams.2025.919250

An Edge Computing Approach to EOQ Optimization for Deteriorating Items with Nonlinear Demand and Weibull Deterioration

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Abstract

In this paper deals with perishable commodities or products that are prone to obsolescence face a significant difficulty in effectively managing their inventory of deteriorating materials. When considering complex real-world circumstances, like nonlinear demand patterns and the deterioration of things over time, traditional Economic Order Quantity (EOQ) models frequently fail. To properly represent the time-varying degradation of goods, this paper suggests an improved EOQ model that includes Weibull deterioration and nonlinear demand, represented as a cubic function. By combining variables including real-time demand variations, item condition, and environmental elements that affect deterioration, edge computing facilitates quicker decision-making. We explain how this integrated method ensures optimal stock availability while minimizing overall inventory expenses, including holding, ordering, and deterioration costs.

Keywords: Edge computing; Cubic demand; Salvage value; Three-factor Weibull distribution

1. Introduction

In essence, decreasing obsolescence and depreciation expenses is at the heart of this research paper. Industrial stocks inventory can be connected with two elements, these are; holding and obsolescence costs reminding the former of what should be maintained with the potential of depreciation. Indeed, that highlighting the fact that both items are linked, it is crucial to value conceived Revenue streams forecasting and demand planning beforehand. EOQ, as a matter of fact, is hardly ever a solution in itself since EOQ consists of changeable elements which expand and shrink together. Most importantly, there is a strong correlation among non-linear demand, an interaction with a product and obsolescence/deterioration factors making it crucial to represent an item as a cubic function. Therefore, this particular paper is dedicated to triangulating how considering Weibull deterioration and a non-linear demand function in an EOQ improves the overall performance of a CP that is considering a multi-dimensional approach focusing on cutting obsolescence as a Capital-intensive race.

Inventory control is a crucial element of advanced material flow chains, primarily for businesses handling perishable or degradable goods, including foodstuffs, medicine, and chemicals. Conventional inventory theories, including the Economic Order Quantity (EOQ), have been extensively used in managing procurement strategies with an aim of minimizing total acquisition costs, carrying costs, ordering costs and stock out costs. Nevertheless, these models tend to make the demand rate a constant and do not consider the time variable, which depicts a major disadvantage whenever there is fluctuating demand and goods are perishable.

A degrading item with an instantaneous supply, quadratic time-varying demand, and shortages was introduced by Ghosh and Chaudhuri [2004]. When supplier credits are linked to order quantity size for deteriorating items with time-varying demand and deterioration rates, Chang [2004] created an EOQ model with deteriorating items under inflation. Balkhi and Alamri [2007] Learning and forgetting's effects on the ideal production lot size for degrading items with fluctuating demand and rates of degradation over time. ideal selling price and lot size with a variable rate of deterioration and exponential partial backlog, according to Dye et al. [2007]. An inventory model for degrading items with time-varying holding costs and price-dependent demand was created by Ajanta Roy [2008]. ideal selling price and lot size with a variable rate of deterioration and exponential partial backlog, according to Dye et al. [2007]. The EOQ inventory model for Weibull distributed deteriorating items under ramp-type demand and shortages was examined by Biswaranjan-Mandal [2010]. An EOQ model was developed by Sahoo et al. [2010] for time-varying holding costs and price-dependent demand rates. An inventory model for ramp-type demand and time-dependent decaying items with salvage value and shortages is discovered by Mishra and Singh [2011]. An inventory model for deteriorating items with a time-varying deterioration rate and exponentially declining demand was recently established by Aliyu & Sani [2018]. Later, Sahoo, Paul, and Kumar [2020] designed Two-Warehouse EOQ Model for deteriorating goods with demand rate is Exponentially Decreasing, Limited Suspension in Price and Salvage Value. Next, Sahoo, Paul, and Kalam [2020] developed an EOQ model for deteriorating items with cubic demand, variable declination, and discriminatory backlogging. Following that, Sahoo and Paul [2021] tracked an EOQ model for the cubic rate of deteriorating products, encouraging the maintenance of Weibull requisition and the absence of scarcity. Next, using a three-parameter Weibull Distribution Deterioration Rate, Scarcity, and Salvage Value, the researchers Paul, Sahoo, and Sarangi [2022] created an optimal policy for a model whose demand rate is a parabolic function of time. Additionally, Sahoo, Paul, and Sahoo [2021] created an EOQ model in which the salvage value, time, and shortages permitted are three parameters of the Weibull Distribution function of demand as a cubic function of time with deterioration rate.

Edge computing as a way of working with data closer to where they are produced (from sensors or other devices) decreases response time while also improving the quality of decision making, as it enables near real-time status of inventory, demand, and deterioration. Such filtering of COs provides a decentralized approach to managing inventories in more efficient and responsive ways, especially for issues with deteriorating items or nonlinear demand (Bai et al., 2018).

To this end, this paper presents an original EOQ optimization model that considers nonlinear demand and Weibull deterioration for deteriorating items using edge computing for real-time decisions. The objective is to create a model by which the quantity of orders can change with deterioration rate and fluctuations in demand to economize costs and resources. The subsequent sections provide a review of the literature on EOQ optimization for deteriorating items, demand nonlinearities, and Weibull deterioration, as well as the ability of edge computing to support optimization in such applications. A sensitivity analysis of the optimal solution is provided to illustrate the model. The main objective of this model is to find an optimal order quantity, minimizing the total inventory time.

2. Notations and assumptions

In framing the proposed model, the following notations and assumptions are listed:

2.1 Notations

- $D(t)$: Cubic demand function.
- θ: Three parameter Weibull deterioration rate.
- HC: Linear function of holding cost, $H(t) = p + qt;\ \ p > 0, q\ > 0$.
- C_1: Cost per item.
- DC: Deteriorating cost of each order.
- SC: Per order's ordering price.

- SV: Salvage value of each item per unit of time.
- $I(t)$: The level of inventories at the time.
- Q:The optimum level of inventory in the period [0, T]
- T: The time boundary of each cycle.
- TC: The total inventory variable cost of the presented model.

2.2 Assumptions

- Present model deliberates only for a single product.
- Time-dependent cubic demand function, i.e.$D(t) = a + bt + ct^2 + dt^3, a \geq 0, b \neq 0, c \neq 0, d \neq 0$.
  where $'a'$ is represents the baseline demand when t = 0.
  $'b'$ is the slope of the demand function at t = 0,
  $'c'$ represents the curvature of the demand function,
  and d is the non-linear variations in demand, such as inflection points where the curvature changes from convex to concave.
- Rate of deterioration $\theta = \gamma\lambda(t-\mu)^{\lambda-1}, \gamma > 0, \lambda > 1$.
  Where $'\gamma'$ parameter scales the entire deterioration rate,$'\lambda'$ is the parameter that determines the rate of change of the deterioration rate with respect to t, $and\ \mu$ shifts the deterioration rate curve along the t-axis.
- Fixed length of time is considered.
- Considered a linear function of time as holding cost.
- Considered ηC_1 as salvage value, where $0 \leq \eta \leq 1$ and η is the deteriorated units in the period [0, T].

3. Formulation of Mathematical Model and Analysis

Suppose $I(t)$ is the level of inventory at the variable time t. Using the above assumptions and notations, we have formulated the differential equation in the interval of time [0, T], that are represented below: $\frac{dI(t)}{dt} + \theta I(t) = -D(t), 0 \leq t \leq T$

$$\Rightarrow \frac{dI(t)}{dt} + \gamma\lambda(t-\mu)^{\lambda-1} I(t) = -(a + bt + ct^2 + dt^3), 0 \leq t \leq T \tag{1}$$

Inputting condition *I(T)= 0* in equation (1), we obtain:

$$I(t) = \left\{\begin{matrix} a(T-t) + \frac{b}{2}(T^2 - t^2) \\ +\frac{c}{3}(T^3 - t^3) + \frac{d}{4}(T^4 - t^4) \end{matrix}\right\} + \gamma \left\{\begin{matrix} (a + b\mu + c\mu^2 + d\mu^3)\left(\frac{(T-\mu)^{(\lambda+1)}}{\lambda+1}\right) \\ +(b + 2c\mu + 3d\mu^2)\left(\frac{(T-\mu)^{\lambda+2}}{\lambda+2}\right) \\ +(c + 3d\mu)\left(\frac{(T-\mu)^{\lambda+3}}{\lambda+3}\right) + d\left(\frac{(T-\mu)^{\lambda+4}}{\lambda+4}\right) \end{matrix}\right\} e^{-\gamma(t-\mu)^{\lambda}}$$

$$-\gamma \left\{\begin{matrix} (a + b\mu + c\mu^2 + d\mu^3)\left(\frac{(t-\mu)^{(\lambda+1)}}{\lambda+1}\right) + (b + 2c\mu + 3d\mu^2)\left(\frac{(t-\mu)^{\lambda+2}}{\lambda+2}\right) \\ +(c + 3d\mu)\left(\frac{(t-\mu)^{\lambda+3}}{\lambda+3}\right) + d\left(\frac{(t-\mu)^{\lambda+4}}{\lambda+4}\right) \end{matrix}\right\} e^{-\gamma(t-\mu)^{\lambda}} \tag{2}$$

Next, we have to input the condition I (0) = Q in equation (2), then it reduces to the form,

$$Q= aT+\frac{bT^2}{2}+\frac{cT^3}{3}+\frac{dT^4}{4}+\gamma\left\{\begin{matrix}(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(T-\mu)^{(\lambda+1)}}{\lambda+1}\right)\\ +(b+2c\mu+3d\mu^2)\left(\frac{(T-\mu)^{\lambda+2}}{\lambda+2}\right)\\ +(c+3d\mu)\left(\frac{(T-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(T-\mu)^{\lambda+4}}{\lambda+4}\right)\end{matrix}\right\}e^{-\gamma(t-\mu)^{\lambda}}$$
$$-\gamma\left\{\begin{matrix}(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(-\mu)^{(\lambda+1)}}{\lambda+1}\right)+(b+2c\mu+3d\mu^2)\left(\frac{(-\mu)^{\lambda+2}}{\lambda+2}\right)\\ +(c+3d\mu)\left(\frac{(-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(-\mu)^{\lambda+4}}{\lambda+4}\right)\end{matrix}\right\}e^{-\gamma(t-\mu)^{\lambda}}. \quad (3)$$

Different components of TC are represented below:

(i) Calculating the cost of holding the items in the period [0, T] is represented as,

$$HC=\frac{1}{T}\int_0^T H(t)\,I(t)dt=\left(p+\frac{qT}{2}\right)\left[\begin{matrix}\gamma\left\{\begin{matrix}(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(T-\mu)^{(\lambda+1)}}{\lambda+1}\right)\\ +(b+2c\mu+3d\mu^2)\left(\frac{(T-\mu)^{\lambda+2}}{\lambda+2}\right)\\ +(c+3d\mu)\left(\frac{(T-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(T-\mu)^{\lambda+4}}{\lambda+4}\right)\end{matrix}\right\}e^{-\gamma(-\mu)^{\lambda}}\\ -\gamma\left\{\begin{matrix}(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(t-\mu)^{(\lambda+1)}}{\lambda+1}\right)\\ +(b+2c\mu+3d\mu^2)\left(\frac{(t-\mu)^{\lambda+2}}{\lambda+2}\right)\\ +(c+3d\mu)\left(\frac{(t-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(t-\mu)^{\lambda+4}}{\lambda+4}\right)\end{matrix}\right\}e^{-\gamma(-\mu)^{\lambda}}\end{matrix}\right]. \quad (4)$$

(ii) The quantity of deteriorated units (K) within the period [0, T] is represented as

$$K=Q-\int_0^T D(t)\text{dt}$$
$$=\left[\begin{matrix}\gamma\left\{\begin{matrix}(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(T-\mu)^{(\lambda+1)}}{\lambda+1}\right)+(b+2c\mu+3d\mu^2)\left(\frac{(T-\mu)^{\lambda+2}}{\lambda+2}\right)\\ +(c+3d\mu)\left(\frac{(T-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(T-\mu)^{\lambda+4}}{\lambda+4}\right)\end{matrix}\right\}e^{-\gamma(-\mu)^{\lambda}}\\ -\gamma\left\{\begin{matrix}(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(t-\mu)^{(\lambda+1)}}{\lambda+1}\right)+(b+2c\mu+3d\mu^2)\left(\frac{(t-\mu)^{\lambda+2}}{\lambda+2}\right)\\ +(c+3d\mu)\left(\frac{(t-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(t-\mu)^{\lambda+4}}{\lambda+4}\right)\end{matrix}\right\}e^{-\gamma(-\mu)^{\lambda}}\end{matrix}\right]. \quad (5)$$

(iii) The deteriorated cost (DC) in the period [0, T] is represented as

$$DC=\frac{\text{the unit cost of item}}{T}K=\frac{c_1}{T}\left[Q-\int_0^T D(t)dt\right]$$
$$=\frac{c_1}{T}\left[\begin{matrix}\gamma\left\{\begin{matrix}(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(T-\mu)^{(\lambda+1)}}{\lambda+1}\right)+(b+2c\mu+3d\mu^2)\left(\frac{(T-\mu)^{\lambda+2}}{\lambda+2}\right)\\ +(c+3d\mu)\left(\frac{(T-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(T-\mu)^{\lambda+4}}{\lambda+4}\right)\end{matrix}\right\}e^{-\gamma(-\mu)^{\lambda}}\\ -\gamma\left\{\begin{matrix}(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(t-\mu)^{(\lambda+1)}}{\lambda+1}\right)+(b+2c\mu+3d\mu^2)\left(\frac{(t-\mu)^{\lambda+2}}{\lambda+2}\right)\\ +(c+3d\mu)\left(\frac{(t-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(t-\mu)^{\lambda+4}}{\lambda+4}\right)\end{matrix}\right\}e^{-\gamma(-\mu)^{\lambda}}\end{matrix}\right]. \quad (6)$$

(iv) The cost of ordering items in the period [0, T] is represented as $SC=\frac{A}{T}$ (7)

(v) Salvage value (SV) in the period of [0, T] is represented as

$$SV = \frac{\eta C_1}{T}[Q\text{-}\int_0^T D(t)dt]$$

$$=\frac{\eta c_1}{T}\left[\begin{array}{l}\gamma\left\{\begin{array}{c}(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(T-\mu)^{(\lambda+1)}}{\lambda+1}\right)+(b+2c\mu+3d\mu^2)\left(\frac{(T-\mu)^{\lambda+2}}{\lambda+2}\right)\\ +(c+3d\mu)\left(\frac{(T-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(T-\mu)^{\lambda+4}}{\lambda+4}\right)\end{array}\right\}e^{-\gamma(-\mu)^{\lambda}}\\ -\gamma\left\{\begin{array}{c}(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(t-\mu)^{(\lambda+1)}}{\lambda+1}\right)+(b+2c\mu+3d\mu^2)\left(\frac{(t-\mu)^{\lambda+2}}{\lambda+2}\right)\\ +(c+3d\mu)\left(\frac{(t-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(t-\mu)^{\lambda+4}}{\lambda+4}\right)\end{array}\right\}e^{-\gamma(-\mu)^{\lambda}}\end{array}\right]. \quad (8)$$

$$Total\ inventory\ variable\ cost(TC) = \frac{1}{T}(Ordering\ cost\ +\ holding\ cost\ +\ deterioration\ cost\ +\ setup\ cost - salvage\ value\ ) = \frac{1}{T}(SC + HC + DC + SV)$$

$$= \frac{A}{T} + \left[\left(p+\frac{qT}{2}\right)\left(\begin{array}{c}aT+\frac{bT^2}{2}\\ +\frac{cT^3}{3}+\frac{dT^4}{4}\end{array}\right)\right]e^{-\propto(-\mu)^{\lambda}} + \left(\begin{array}{c}p+\frac{qT}{2}\\ +\frac{c_1}{T}+\frac{\eta c_1}{T}\end{array}\right)$$

$$\left[\begin{array}{l}\gamma\left\{(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(T-\mu)^{(\lambda+1)}}{\lambda+1}\right)+(b+2c\mu+3d\mu^2)\left(\frac{(T-\mu)^{\lambda+2}}{\lambda+2}\right)+(c+3d\mu)\left(\frac{(T-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(T-\mu)^{\lambda+4}}{\lambda+4}\right)\right\}e^{-\gamma(-\mu)^{\lambda}}\\ -\gamma\left\{(a+b\mu+c\mu^2+d\mu^3)\left(\frac{(t-\mu)^{(\lambda+1)}}{\lambda+1}\right)+(b+2c\mu+3d\mu^2)\left(\frac{(t-\mu)^{\lambda+2}}{\lambda+2}\right)+(c+3d\mu)\left(\frac{(t-\mu)^{\lambda+3}}{\lambda+3}\right)+d\left(\frac{(t-\mu)^{\lambda+4}}{\lambda+4}\right)\right\}e^{-\gamma(-\mu)^{\lambda}}\end{array}\right]. \quad (9)$$

For minimization of TC, must satisfy the conditions; $\frac{\partial(TC)}{\partial T} = 0$ and $\frac{\partial^2(TC)}{\partial T^2} > 0$ and for all T > 0.

$$\frac{\partial(TC)}{\partial T} = \frac{-A}{T^2} + \left\{p(a+bT+cT^2+dT^3) + q\left(aT + \frac{3}{4}bT^2 + \frac{2}{3}cT^3 + \frac{5}{8}dT^4\right)\right\}e^{-\gamma(-\mu)^{\lambda}}$$

$$+\gamma\left[\begin{array}{l}a\left\{p(T-\mu)^{\lambda}+\left(\frac{q}{2}+\frac{-1}{T^2}(\eta c_1+c_1)\right)\left(\frac{(T-\mu)^{\lambda+1}}{\lambda+1}\right)\right\}+\left(\frac{q}{2}T+\frac{1}{T}(\eta c_1+c_1)\right)(T-\mu)^{\lambda}+\left(\frac{1}{T^2}(\eta c_1+c_1)-\frac{q}{2}\right)\left(\frac{(-\mu)^{\lambda+1}}{\lambda+1}\right)\\ +b\left\{\begin{array}{c}\left(p+\frac{qT}{2}+\frac{(\eta c_1+c_1)}{T}\right)(T-\mu)^{\lambda+1}+\left(p+\frac{qT}{2}+\frac{(\eta c_1+c_1)}{T}\right)\mu(T-\mu)^{\lambda}\left(\frac{q}{2}-\frac{\eta c_1+c_1}{T^2}\right)\left(\mu\left(\frac{(T-\mu)^{\lambda+1}}{\lambda+1}\right)+\left(\frac{(T-\mu)^{\lambda+2}}{\lambda+2}\right)\right)\\ +\left(-\frac{q}{2}+\frac{\eta c_1+c_1}{T^2}\right)\left(\left(\frac{(-\mu)^{\lambda+2}}{\lambda+2}\right)+\mu\left(\frac{(-\mu)^{\lambda+1}}{\lambda+1}\right)\right)\end{array}\right\}\\ +c\left\{\begin{array}{c}\left(p+\frac{qT}{2}+\frac{(\eta c_1+c_1)}{T}\right)\left((T-\mu)^{\lambda+2}+2\mu(T-\mu)^{\lambda+1}+\mu^2(T-\mu)^{\lambda}\right)+\left(\frac{q}{2}-\frac{(\eta c_1+c_1)}{T^2}\right)\left(\frac{(T-\mu)^{\lambda+3}}{\lambda+3}\right)+2\mu\left(\frac{(T-\mu)^{\lambda+2}}{\lambda+2}\right)\\ +\mu^2\left(\frac{(T-\mu)^{\lambda+1}}{\lambda+1}\right)+\left(-\frac{q}{2}+\frac{(\eta c_1+c_1)}{T^2}\right)\left(\frac{(-\mu)^{\lambda+3}}{\lambda+3}+2\mu\left(\frac{(-\mu)^{\lambda+2}}{\lambda+2}\right)+\left(\frac{(-\mu)^{\lambda+1}}{\lambda+1}\right)\right)\end{array}\right\}\\ +d\left\{\begin{array}{c}\left(p+\frac{qT}{2}+\frac{c_1+\eta c_1}{T}\right)\left((T-\mu)^{\lambda+3}+3\mu(T-\mu)^{\lambda+2}+3\mu^2(T-\mu)^{\lambda+1}+\mu^3(T-\mu)^{\lambda}\right)\\ \left(\frac{q}{2}-\frac{c_1+\eta c_1}{T^2}\right)\left(\left(\frac{(T-\mu)^{\lambda+4}}{\lambda+4}\right)+3\mu\left(\frac{(T-\mu)^{\lambda+3}}{\lambda+3}\right)+3\mu^2\left(\frac{(T-\mu)^{\lambda+2}}{\lambda+2}\right)+\mu^3\left(\frac{(T-\mu)^{\lambda+1}}{\lambda+1}\right)\right)\\ +\left(-\frac{q}{2}+\frac{c_1+\eta c_1}{T^2}\right)\left(\left(\frac{(-\mu)^{\lambda+4}}{\lambda+4}\right)+3\mu\left(\frac{(-\mu)^{\lambda+3}}{\lambda+3}\right)+3\mu^2\left(\frac{(-\mu)^{\lambda+2}}{\lambda+2}\right)+\mu^3\left(\frac{(-\mu)^{\lambda+1}}{\lambda+1}\right)\right)\end{array}\right\}\end{array}\right]e^{-\gamma(-\mu)^{\lambda}}. \quad (10)$$

Since equation (10) is in nonlinear form, it is difficult to solve it by using an analytical process. So, we have solved it using a computational process. The following example, represented below, was solved by using Mathematica 12.0.

4. Numerical Example

To illustrate the Model development through a numerical example related to the aforementioned parameters is presented here. Let us considered the value of A= 500, a= 20, b= 15, c= 10, d= 5, $\gamma = 0.5, \lambda = 0.6, \mu = 0.7, p = 0.2, q = 0.4, \eta = 0.1, c_1$=5. Substituting the above parameter values in equations (10), (3), and (9) and simplifying them, we obtain T =0.45791, Q =326.14625, and TC^*=572.56231.
Given data contains the following parameters;

Table

parameters	% change	value	T	TC	Q
a	50	30	0.26141	487.2351	305.17292
	25	25	0.32912	501.8732	312.45271
	0	20	0.45791	572.56231	326.14625
	-25	15	0.58932	683.1432	418.274
	-50	10	0.65213	781.2359	537.629
b	50	22.5	0.51301	583.21563	318.54624
	25	18.75	0.47152	578.53624	323.48913
	0	15	0.45791	572.56231	326.14625
	-25	11.25	0.39213	564.23924	329.14382
	-50	7.5	0.34634	558.15625	334.52314
c	50	22.5	0.51243	583.21563	318.54624
	25	18.75	0.47132	578.53624	323.48913
	0	15	0.45791	572.56231	326.14625
	-25	11.25	0.39214	564.23923	329.14382
	-50	7.5	0.34633	558.15622	334.52314
d	50	7.5	0.53254	628.6381	478.56122
	25	6.5	0.48262	596.9204	439.28534
	0	5	0.45791	572.56231	326.14625
	-25	3.75	0.23153	516.5413	280.21663
	-50	2.5	0.19561	483.9472	253.20214
γ	50	0.75	0.29354	753.19523	392.52541
	25	0.625	0.38513	685.23582	356.20543
	0	0.5	0.45791	572.56231	326.14625
	-25	0.375	0.52162	492.25614	308.06782
	-50	0.250	0.59234	413.79991	283.57181
λ	50	0.9	0.83913	729.50423	281.16044
	25	0.75	0.63014	657.11921	258.04613
	0	0.6	0.45791	572.56231	326.14625
	-25	0.45	0.25472	487.62182	359.05482
	-50	0.3	0.10283	413.82131	378.05712
μ	50	1.05	0.42163	619.13472	312.28591
	25	0.875	0.44294	592.66174	318.92023
	0	0.7	0.45791	572.56231	326.14625
	-25	0.525	0.45963	546.62853	331.62854
	-50	0.35	0.46314	532.80334	336.86282
p	50	0.3	0.25614	752.13463	392.19624
	25	0.25	0.36921	682.92172	379.23152
	0	0.2	0.45791	572.56231	326.14625
	-25	0.15	0.58913	478.23691	313.42913
	-50	0.1	0.63272	413.28914	216.13822
q	50	0.6	0.23163	448.23164	412.36913
	25	0.5	0.32592	483.16924	368.58932
	0	0.4	0.45791	572.56231	326.14625
	-25	0.3	0.56913	593.21673	308.17231
	-50	0.2	0.62344	621.62152	289.79134
η	50	0.15	0.46233	515.23183	305.43873
	25	0.125	0.45924	538.21562	314.30762
	0	0.1	0.45791	572.56231	326.14625
	-25	0.075	0.45322	589.72853	338.95671
	-50	0.05	0.45023	603.73681	346.95843
C_1	50	7.5	0.20814	620.17934	289.25291
	25	6.25	0.32793	592.98534	312.75804
	0	5	0.45791	572.56231	326.14625
	-25	3.75	0.57532	546.25153	338.21623
	-50	2.5	0.68041	531.19661	346.06391

Sensitivity analysis

In this section we have discussed sensitivity analysis of the system parameters $a, b, c, d, \gamma, \lambda, \mu, c_1, p, q$ on the total optimal inventory cost. The sensitivity analysis is also carried out to examine the effect of change of every parameters value from +50% to -50%, and considering single factor at the time of computing and hold the outstanding parameters are not unaffected. A sensitivity analysis gauges how the changes of input parameters influence the results of a model, in this case the Economic Order Quantity (EOQ) and Total Cost (TC). From the data given, we can analyze the effects of different parameters on EOQ (Q) and Total Cost (TC).

Discussion of Results

The Discussion is based on the numerical example and the results are shown in the table.

1. Demand Parameters (a, b, c, d):
   - As the coefficients a, b, c, d increase, both EOQ, Q and Total Cost, TC tend to increase. The higher demand is associated with an increase in order quantities and high inventory costs.
   - A negative value of demand coefficients indicates a reduction in the EOQ and TC, with decreases in demand implying less frequent ordering and lower inventory holding costs.
2. Deterioration Parameters (γ, η):
   - The total cost increases as the shape parameter γ increases with the Weibull distribution. This shows that more inventory is wasted, and the holding costs rise as deterioration increases.
   - An increased scale parameter λ, as it increases the rate of deterioration, also tends to increase total costs. It is because higher-order quantities are required in anticipation of faster deterioration.
3. Other Parameters (p, q, C_1):
   - The changes of p and q impact the deterioration rate and the cost structure, showing a moderate change in both the EOQ and TC.
   - The C_1 parameter (presumably a fixed cost or initial cost) has a similar effect, where lowering it lowers both EOQ and TC, indicating that lower fixed or initial costs result in less required inventory and less waste.
4. Overall Trends:
   - EOQ tends to increase as parameters affecting deterioration and demand (such as α, β, a, and d) increase.
   - As such, TC increases with increases in parameters that increase demand and deterioration rates, such as a, α, β, and C_1. On the other hand, reducing those parameters decreases total cost, because the deterioration rate reduces, the number of orders declines, and the requirements on holding inventory decrease.

Review of EOQ Optimization in Inventory Control with the Edge Computing Technique

Edge Computing is an approach to handling data and computing closer to the source, thereby minimizing Cloud Computing. Applying Edge Computing to the optimization of EOQ for declining products, where the demand function is nonlinear, could yield considerable benefits in delivering real-time data analysis, flexibility, and cost-effectiveness.

Table, which highlights how a change in the parameter

Calculating this using the edge computing approach mentioned above, the calculation is as follows:

Current Parameters: a=25, T= 0.3291, TC=501.873, Q=312.4527

To calculate the sensitivity of TC for change in a from 30 to 25

$$STC = \frac{501.873-487.235}{25-30} \times \frac{30}{487.235} \approx -1.80$$

This means that if there is a -1% in the mentioned measures, there would be a + 1% in the cumulative incidence percent that can be represented by the following formula Similarly, we can determine the sensitivity for Q by applying the same method

$$SQ = \frac{312.4527 - 305.1729}{25 - 30} \times \frac{30}{305.1729} \approx -0.45$$

Therefore, for every 1% decrease in a, the optimal order Quantity Q increases by approximately 0.45%. The rate of Deterioration of Local Temperature Data causes an increase to 30. The Edge device immediately recalculates the Economic Order quantity and the Total cost. If the system is sensitive enough to detect that the deterioration rate, which is represented by the Weibull factors, has risen, the edge computing device can instantly perform a sensitivity analysis of how the rate rise impacts the EOQ.Given the sensitivity of the EOQ model to changes in a, the edge computing system can recalculate:

- New Total Cost (TC): At the edge device, the appropriate TC is then derived, taking into account the new deterioration rate.
- New Order Quantity (Q): By recalculate the EOQ in real-time, the overall order quantity returns to the best value.

Benefits of Edge Computing in EOQ Model Improvement:

Reduced Latency: Edge computing means that decisions about what to do with the inventory are made on the spot, reducing time spent interacting with a main server for data.

- Real-Time Adjustments: Local processing enables instantaneous adjustments to EOQ and Total Cost (TC) depending on the changes in demand or the other factors.
- Minimized Costs: By constant supervision of inventory and subsequent instant adjustment of inventory levels, edge computing reduces overstocking and under stocking, in result minimize holding costs and ordering costs.

5. Conclusion & future work

This paper has demonstrated that the integration of Edge Computing to EOQ (Economic Order Quantity) model with nonlinear demand for deteriorating inventory items provides a strategic benefit in real-time data processing decision-making and cost. Finally, edge computing optimizes EOQ models for the increased flexibility, flexibility, and accuracy they can provide in echoing the market's dynamic and environmental characteristics. This system does not only enhance the process of doing business by cutting down on many areas like overstocking, perishable foods, and potential customer sales thus makes the process more cost effective and environmentally friendly. As for the future work, it could be used of machine learning and block chain, and the use of multi–echelon supply chain networks, to handle uncertainty involve the use of robust optimization models. Such improvements will help establish more effective decision-making organizations where decisions made are real time and incur less wastage of resources, and of course help guarantee efficient business operations as the business world becomes more volatile.

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Received: June 9, 2025; Published: September 12, 2025