Section A-Research paper
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Design of EOQ model for Decreasing Demand and Parabolic Holding cost carry forward with two-parameter Weibull Deterioration Rate.

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Abstract:
The aim of this work is to discuss a production and inventory model for perishable goods with an exponentially decreasing demand, Parabolic holding cost along with Deterioration rate as two-parameter Weibull functions of time. This model has been subjected to optimization using Mathematica12. Using numerical data in MATLAB software to plot the Graphs which is very much helpful to analyze the correctness of the discussed model and examine the viability of the optimized solutions. This proposed research project's contribution is to determine the minimum total inventory cost per cycle time and the corresponding order quantity. Sensitivity analysis of the optimal solution is also represented with respect to the various parameters used in the numerical examples.

Keywords: Two-parameter Weibull Deterioration, Demand, Inventory, Parabolic Holding Cost.

Introduction:

Generally, the production inventory models are designed on the basis of Assumptions. In actuality, the impact of deterioration is vital in many stock frameworks. Deterioration for all goods is not at the same rate. In our daily life, we have transect deteriorated goods like potatoes, tomatoes, vegetables, bread, mobile, high-tech products, oil, insulin, organic honey, and Some of the clinical goods like special types of Vaccines (BCG, Hep-B*, OPV series, Rota series, Penta series, DPT Booster series, IPV series, etc. for children and Covid vaccines for people above 18^{+}years), seasonal fruits and milk where the quality of the goods degrades over time due to direct spoilage or physical decay factored by covid-19 induced decrease in sell and increase in holding time. Design for this model is taken as exponential decreasing demand rate, parabolic holding cost along with two parameters Weibull function of time as its deterioration rate.

It is characterized by decay or damage in material, quality, or/and convenience, and so on are things that fall under the transient classification and the upkeep of these things should be finished with legitimate consideration. There are many different types of things with various disintegration structures and rates, decay forces are a central point in inventory management. Many researchers have created different stock models by thinking about deterioration as a significant effect. In the business world, each manufacturing firm/provider generally keeps up with the stock to offer the item to their possible client. There is an unavoidable issue, how to keep up with the stock level and how to offer the items to their potential customers? Basically, the most extreme benefit or minimum loss depends on the premise of these two conditions. What's more, there are a few different factors likewise elaborate which are given below

(I) to control the weakening rate

(II) Stock level is kept up with so that the business association will continuously fulfill the

Customer's interest.

(III) Introduce a few alluring proposals with sell more items.

First time model planned by wee [1]. based on most the actual merchandise go through decay or deterioration over the long run. The proposed model is focus on around the decaying things. The things that display the above peculiarity are food things, visual movies, drugs, synthetic substances, drugs, electronic parts, blood kept in blood donation centers, etc. Accordingly, the impact of weakening on these things can't be ignored in their stock frameworks. Thus, the creation and stock issue of falling apart things has been broadly concentrated by specialists. A portion of the specialists incorporates Ghare and Schrader [2]. who are the main specialists to determine a monetary request amount model by accepting outstanding for the deterioration items. Later the researchers, covert and Philip [3]. extended Ghare and Schrader's [2]. model by taking the Weibull distribution with two parameters for the deterioration rate. Then, the researcher Shah and Jaiswal [4]. fostered a request-level stock model for deterioration items with a steadily accelerating rate of decline. Aggarwal [5]. amended the examination in Shah and Jaiswal's model [4]. Later time, Dave and Patel [6]. checked a stock model for weakening things with time-corresponding interest when deficiencies were not allowed. Authors, for example, Hollier and Imprint [7]., Hariga and Benkherouf [8]., and Wee [9][10] all have fostered in their models by accepting interest rate will be an exponential form. A few late deals with deteriorating items incorporate crafted by Goyal and Giri [11]. in which they made sense of an excellent study on the new patterns in displaying deteriorating inventory. Likewise, the researchers Ouyang et al. [12]. introduced an Economic order quantity (EOQ) model for disintegrating items in which the race of interest capability is progressively deteriorating, with some backlog. Likewise, Shah and Pandy [13].in their review fostered an ideal requesting strategy for a time-dependent deterioration rate with related rescue esteem where postpone in installments is allowed. Another most recently developed work is He and He [14]. which extended their thought to account for the possibility that some goods might disintegrate while being stored. They developed a creation stock model for decaying things with creation interruptions. The inventory plans and ideal creation were given, so that the maker can limit the misfortune brought about by disruptions. Kumar et al. [15]. in their study, developed a deterministic inventory model for decaying things, where they viewed their interest as a quadratic capability of time, no deficiencies are permitted and how the model is affected by expansion rate was thought to be over a limited arranging skyline taking a variable holding cost. The researchers, Singh and Pattnayk [16]. also in their study introduced an EOQ model for deteriorating items with Interest that is time-dependent and quadratic and variable deterioration rate, under permissible postpone in installment. Later the analyst, Dash et al [17]. also developed a stock model for breaking down things having a period subordinate outstanding decreasing request rate and changing holding times cost as a straight capability of time. Shortages were not permitted. From the commonsense viewpoint, the majority of the substances worry about fashionable goods, better innovative substances, etc. It has been observed that the stock rate decreases as the holding-up range increases. Taking into account capacity pace as conflicting, the equivalent depends on the range of time slip by nearly further refilling. Sahoo, Paul, and Kalam [20] noticed the EOQ model for declining substances with cubic rate, variable degradation, and unbalanced stockpiling. Sahoo. C. K and Paul. K.C. [21][24]. recognized an EOQ model for cubic deterioration, substances advanced keeping Weibull demand and lacking shortage. Sahoo, C.K. K, Paul, K.C and Kumar. S [19]. studied the pair Distribution centers EOQ Stock Model of declining substances having remarkable declining requests, confined suspension in cost including rescue values. Paul. K.C, Sahoo. C.K. and Sarangi M.R. [22]. designed an Ideal Approach with an Explanatory Interest convey sent with a Three-variable Weibull distribution deterioration Rate, Shortage, and Salvage value. Next Sahoo. C.K, Paul.K.C., and Sahoo. S.S. [23]. also developed an EOQ model in form amid cubic demand carry forwarded with three parameter weibull distribution deteriorating item, exclusive of scarcity and salvage value. Later the specialists, Aliyu and Sani [18]. developed an inventory model for disintegrating items with summed up outstanding diminishing interest and straight time-varying holding cost. It was thought that the rate of deterioration was constant. Deficiencies were not permitted.

Comparison Table:

Author(s)	Deterioration	Demand Rate	Shortages	Level of Permissible Delay in Payments
Wee, H.M.	Y	-	PBO.	N
Ghare, P.N and Schrader, G.P.	Y	EDOD	P	N

Covert, R.B. and Philip, G.S	Y	CON	P	N
Shah et al.	CON.	OLI	P	N
Aggarwal, S.P.	CON.	OLI	PBO.	N
Dave et al.	Y	TVDP	N	N
Hollier et al.	Y	DMD	P	N
Hariga et al.	Y	ETVD.	P	N
Wee, H.M.	Y	DMD	Y	N
Wee, H.M.	Y	DMD	Y	N
Goyal et al.	Y	VDR	N	Y
Ouyang et al.	Y	EDOD	P	N
Shah et al.	Y	TVDP	P	Y
He et al.	CON.	CON.	N	N
Kumar et al.	Y	QDR	PBO	N
Singh et al.	Variable Deterioration.	QDR	P	Y
Dash et al.	Y	EDOD	N	N
Aliyu et al.	Y	EDOD	N	N
Sahoo, Paul & Kumar	Y	EDOD	SNA	N
Sahoo, Paul & Kalam	Y	CD	inequitable backlogging	N
Sahoo and Paul (2021)	Y	TPWD	SNA	N
Sahoo and Paul (2021)	Y	TWD	SNA	N
Sahoo, Paul& Sahoo (2021)	Y	CD	SSV	N
Paul, Sahoo and Sarangi (2022)	TWD	Parabolic Demand	SSV	N
Present Paper	Two-Parameters Weibull Distribution.	Degrading Demand.	SNA	N

SPD= Selling Price dependent, P= Partial backlogging, CON = Constant, SA= Shortages allowed, SNA= Shortages are not allowed, SSV= Scarcity and Salvage Value, SD=Stock-dependent demand, TWD= Three-Parameter Weibull Distribution, TPWD= Two parameter Weibull Distribution, PBO= partial back Ordering, AP= Advance payment, TVDP= time-varying demand pattern, ETVD= Exponentially time-varying demand, DMD=Declining Market demand, LTDD= Linearly time-dependent Demand, SASD=Selling price and stock dependent, SAAD=Selling price and frequency of advertisement dependent, EDOD=Exponential Decreasing Order Demand, PDD=price dependent Demand, VDR=Variable demand rate, SDR=Stochastic demands, PTDD=Price and time-dependent Demand, QDR= Quadratic demand rate, ILDD=Inventory level dependent Demand, OLI= order level Inventory, S=Single, CB=Complete backlogging, CD=Cubic Demand Rate, NDDR=Non-decreasing demand Rate, SAPB=shortages are allowed and partially backlogged, Y=Yes, N=No.

Research Gap and Contribution:

we might utilize a settlement ahead-of-time strategy. The providers offer a few limits on the expense of buying items at whatever point retailers got the item and furthermore, the retailers give credit offices to their prime customers. The commercial is one more significant variable to advance the matter of retailers as well as being familiar with the item. Thus, the motivation behind promotions is to animate the interest in the related items. protection Innovation idea might be utilized to control the weakening pace of the items. The main contributions of this current work are we consider a similar summed up dramatic diminishing interest and the holding cost is thought

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to be explanatory while the decay rate is thought to be two parameters Weibull function of time and shortages are not permitted.

Assumptions:

- The demand rate is an exponentially decreasing function of time.
- The deterioration rate is two-parameter Weibull function of time.
- Lead time is zero.
- Shortages. are not allowed.
- The inventory system is considered over an infinite time horizon.
- Assume that the holding cost is parabolic.

Notation:

- N_0: The fixed ordering cost per order
- I(t) : The inventory at any time t, $0 \leq t \leq T$
- D(t) : The exponential demand rate, where $\mathrm{D(t)} = \mathrm{Ke}^{\mathrm{h}-\beta \mathrm{t}}$, $\mathrm{K} > o, h > 0, \beta > 0$ all are constants.
- Deterioration rate is two parameter weibull function of time. i.e., $\alpha\beta t^{\beta-1}$,$\alpha > 0, \beta > 0$
- Holding cost is parabolic. i.e., $a + bt - ct^2$, where a$> 0, b > 0$ and $c > 0$.
- C: unit. Deterioration cost.
- T: Ordering cycle length.
- I_0 : stating stock.
- TC: The total cost per unit time.
- T*: The optimal length of the cycle.
- I: The economic order quantity
- TC: The minimum total cost per unit time.

Formulation of Mathematical Model:

The arrangement of stock at t = 0, a lot size of specific unit of things are send off into the framework. The stock level decreases progressively and partially during the interval due to the interest rate variable and will decrease over time. Shortage acknowledges during gap $[t_1, T]$ alongside each order inside shortage span in the interval $[t_1, T]$ is to some degree multiplied. Allow the stock to even out I(t) at the time [0, T] is addressed by the differential condition is

$$\frac{dI(t)}{dt} + \alpha\beta t^{\beta-1}.\mathrm{I}\,(\mathrm{t}) = -D(t),\ 0 \leq\ t\ \leq T \tag{1}$$

Where $D(t) = Ke^{h-\beta t}$

$$\Rightarrow I(t) = \frac{-Ke^{h-\beta t}}{\beta(\alpha t^{\beta-1}-1)} + C_1 e^{-\alpha t^{\beta}} \tag{2}$$

Putting $I(T) = 0$ in eqn (2), then we get

$$I(t) = \frac{Ke^{h}}{\beta}\left\{\begin{matrix}\frac{e^{-\beta T+\alpha T^{\beta}-\alpha t^{\beta}}}{\alpha T^{\beta-1}-1}\\ -\frac{e^{-\beta t}}{\alpha t^{\beta-1}-1}\end{matrix}\right\}, 0\leq\ t\ \leq T \quad (3)$$

Again, putting $I(0) = I_0$ in equation (3) when t=0, then we get

$$I(0) = I_0 = \frac{Ke^{h}}{\beta}\left\{1+\frac{e^{-\beta T+\alpha T^{\beta}}}{\alpha T^{\beta-1}-1}\right\} \quad (4)$$

During the cycle period $[0,T]$ the total demand is

$$\int_0^T D(t)\text{dt} = \int_o^T Ke^{h-\beta t}dt = \frac{Ke^{h}}{\beta}\left(1-e^{-\beta T}\right) \quad (5)$$

The total number of deterioration units is

$$y = I_0 - \int_0^T D(t)\text{dt} \qquad = \frac{Ke^{h-\beta T}}{\beta}\left(1+\frac{e^{\alpha T^{\beta}}}{\alpha T^{\beta-1}-1}\right) \quad (6)$$

In the cycle period $[0,T]$ cost of deterioration (DC) =Cy

$$= \frac{\text{CK}e^{h-\beta T}}{\beta}\left(1+\frac{e^{\alpha T^{\beta}}}{\alpha T^{\beta-1}-1}\right) \quad (7)$$

In the cycle period $[0,T]$ total Inventory holding (THC)

$$= \int_0^T (a+bt-ct^2).I(t)dt$$

$$= \int_0^T (a+bt-ct^2).\frac{Ke^{h}}{\beta}\left\{\begin{matrix}\frac{e^{-\beta T+\alpha T^{\beta}-\alpha t^{\beta}}}{\alpha T^{\beta-1}-1}\\ -\frac{e^{-\beta t}}{\alpha t^{\beta-1}-1}\end{matrix}\right\}dt$$

$$= \frac{Ke^{h-\beta T+\alpha T^{\beta}}}{\beta(\alpha T^{\beta-1}-1)}\int_0^T (a+bt-ct^2)\,e^{-\alpha t^{\beta}}dt - \frac{Ke^{h}}{\beta}\int_0^T (a+bt-ct^2)\,\frac{e^{-\beta t}}{\alpha t^{\beta-1}-1}dt$$

$$= I_1 - I_2 \quad (8)$$

$$I_1 = \frac{Ke^{h-\beta T+\alpha T^{\beta}}}{\beta(\alpha T^{\beta-1}-1)}\int_0^T (a+bt-ct^2)\,e^{-\alpha t^{\beta}}dt$$

$$= \frac{Ke^{h-\beta T+\alpha T^{\beta}}}{\beta(\alpha T^{\beta-1}-1)}\left[\begin{matrix}aT+\frac{bT^2}{2}-\frac{cT^3}{3}\\ -\alpha\left(\frac{aT^{\beta+1}}{\beta+1}+\frac{bT^{\beta+2}}{\beta+2}-\frac{cT^{\beta+3}}{\beta+3}\right)\end{matrix}\right]$$

And

$$I_2 = \frac{Ke^{h}}{\beta}\int_0^T (a+bt-ct^2)\,\frac{e^{-\beta t}}{\alpha t^{\beta-1}-1}dt$$

$$= \frac{Ke^h}{\beta}\left[\begin{array}{c} \frac{aT}{2}(\beta T-2)+\frac{bT^2}{6}(2\beta T-3) \\ -\frac{cT^3}{12}(3\beta T-4) \\ +\alpha\left\{\begin{array}{c} a\left(\frac{\beta T^{\beta+1}}{\beta+1}-\frac{T^\beta}{\beta}\right) \\ +b\left(\frac{\beta T^{\beta+2}}{\beta+2}-\frac{T^{\beta+1}}{\beta+1}\right) \\ -c\left(\frac{\beta T^{\beta+3}}{\beta+3}-\frac{T^{\beta+2}}{\beta+2}\right) \end{array}\right\} \end{array}\right]$$

Putting the value of I_1 and I_2 in equation (8), then we get

$$THC = \frac{Ke^h}{\beta}\left[\begin{array}{c} aT\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta T}{2}+1\right)+\frac{bT^2}{2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{2\beta T}{3}+1\right)-\frac{cT^3}{3}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{3\beta T}{4}+1\right) \\ +\alpha\left\{\begin{array}{c} \frac{aT^{\beta+1}}{\beta+1}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+1}{\beta T}+\beta\right)+\frac{bT^{\beta+2}}{\beta+2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+2}{(\beta+1)T}+\beta\right) \\ -\frac{cT^{\beta+3}}{\beta+3}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+3}{(\beta+2)T}+\beta\right) \end{array}\right\} \end{array}\right] \quad (9)$$

Total variable cost $=\frac{1}{T}[\text{Ordering cost(OC)} + \text{Deterioration cost(DC)} + \text{Holding cost(HC)}]$

$$= \frac{1}{T}(OC + DC + HC)$$

$$TC(T) = \frac{1}{T}(OC + DC + HC)$$

$$= \frac{1}{T}\left[\begin{array}{c} N_0+\frac{\mathrm{CK}e^{h-\beta T}}{\beta}\left(1+\frac{e^{\alpha T^\beta}}{\alpha T^{\beta-1}-1}\right) \\ +\frac{Ke^h}{\beta}\left[\begin{array}{c} aT\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta T}{2}+1\right)+\frac{bT^2}{2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{2\beta T}{3}+1\right)-\frac{cT^3}{3}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{3\beta T}{4}+1\right) \\ +\alpha\left\{\begin{array}{c} \frac{aT^{\beta+1}}{\beta+1}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+1}{\beta T}+\beta\right)+\frac{bT^{\beta+2}}{\beta+2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+2}{(\beta+1)T}+\beta\right) \\ -\frac{cT^{\beta+3}}{\beta+3}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+3}{(\beta+2)T}+\beta\right) \end{array}\right\} \end{array}\right] \end{array}\right]$$

$$= \frac{1}{T}\left[N_0+\frac{\mathrm{K}e^h}{\beta}\left[\begin{array}{c} Ce^{-\beta T}\left(1+\frac{e^{\alpha T^\beta}}{\alpha T^{\beta-1}-1}\right)+aT\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta T}{2}+1\right) \\ +\frac{bT^2}{2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{2\beta T}{3}+1\right)-\frac{cT^3}{3}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{3\beta T}{4}+1\right) \\ +\alpha\left\{\begin{array}{c} \frac{aT^{\beta+1}}{\beta+1}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+1}{\beta T}+\beta\right)+\frac{bT^{\beta+2}}{\beta+2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+2}{(\beta+1)T}+\beta\right) \\ -\frac{cT^{\beta+3}}{\beta+3}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+3}{(\beta+2)T}+\beta\right) \end{array}\right\} \end{array}\right]\right] \quad (10)$$

Our objective is Minimize the Total variable cost per unit Time.

So the Necessary and Sufficient condition for Optimization of $TC(T)$ is $\frac{dTC(T)}{dT} = 0$ and is $\frac{d^2TC(T)}{dT^2} > 0$.

For satisfy the Necessary condition, we differentiate equation (10) w.r.t 'T', then we get

$$\frac{dTC(T)}{dT} =$$

$$\frac{1}{T^2}\left[N_0 + \frac{\mathrm{K}e^h}{\beta}\left[\begin{array}{c} Ce^{-\beta T}\left(1+\frac{e^{\alpha T^\beta}}{\alpha T^{\beta-1}-1}\right) + aT\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{\beta T}{2} + 1\right) \\ + \frac{bT^2}{2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{2\beta T}{3} + 1\right) - \frac{cT^3}{3}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{3\beta T}{4} + 1\right) \\ +\alpha\left\{\begin{array}{c} \frac{\alpha T^{\beta+1}}{\beta+1}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{\beta+1}{\beta T} + \beta\right) + \frac{bT^{\beta+2}}{\beta+2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{\beta+2}{(\beta+1)T} + \beta\right) \\ - \frac{cT^{\beta+3}}{\beta+3}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{\beta+3}{(\beta+2)T} + \beta\right) \end{array}\right\} \end{array}\right]\right]$$

$$+\frac{\mathrm{K}e^h}{\beta T}\left[\begin{array}{c} \frac{Ce^{-\beta T}}{\left(\alpha T^{\beta-1}-1\right)^2}\left\{\beta e^{\alpha T^\beta}\left(\alpha T^{\beta-1}-1\right)^2 - \beta\left(\alpha T^{\beta-1}-1\right) - \alpha(\beta-1)T^{\beta-2}e^{\alpha T^\beta}\right\} \\ +a\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{\beta T}{2} + 1\right) + aT\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta\left(\alpha T^{\beta-1}-1\right)^2 - \alpha(\beta-1)T^{\beta-2}\right\}}{\left(\alpha T^{\beta-1}-1\right)^2} - \frac{\beta}{2}\right] \\ +bT\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{2\beta T}{3} + 1\right) + \frac{bT^2}{2}\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta\left(\alpha T^{\beta-1}-1\right)^2 - \alpha(\beta-1)T^{\beta-2}\right\}}{\left(\alpha T^{\beta-1}-1\right)^2} - \frac{2\beta}{3}\right] \\ -cT^2\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{3\beta T}{4} + 1\right) - \frac{cT^3}{3}\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta\left(\alpha T^{\beta-1}-1\right)^2 - \alpha(\beta-1)T^{\beta-2}\right\}}{\left(\alpha T^{\beta-1}-1\right)^2} - \frac{3\beta}{4}\right] \\ +\alpha\left[\begin{array}{c} \alpha T^\beta\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{\beta+1}{\beta T} + \beta\right) + \frac{\alpha T^{\beta+1}}{\beta+1}\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta\left(\alpha T^{\beta-1}-1\right)^2 - \alpha(\beta-1)T^{\beta-2}\right\}}{\left(\alpha T^{\beta-1}-1\right)^2} + \frac{\beta+1}{\beta T^2}\right] \\ +bT^{\beta+1}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{\beta+2}{(\beta+1)T} + \beta\right) + \frac{bT^{\beta+2}}{\beta+2}\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta\left(\alpha T^{\beta-1}-1\right)^2 - \alpha(\beta-1)T^{\beta-2}\right\}}{\left(\alpha T^{\beta-1}-1\right)^2} + \frac{\beta+2}{(\beta+1)T^2}\right] \\ -cT^{\beta+2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1} - \frac{\beta+3}{(\beta+2)T} + \beta\right) - \frac{cT^{\beta+3}}{\beta+3}\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta\left(\alpha T^{\beta-1}-1\right)^2 - \alpha(\beta-1)T^{\beta-2}\right\}}{\left(\alpha T^{\beta-1}-1\right)^2} + \frac{\beta+3}{(\beta+2)T^2}\right] \end{array}\right] \end{array}\right] \quad (11)$$

Equating Equation (11) to zero since we need to decide the cost is minimum. This is the prerequisite for obtaining an equation's roots that enhance the equation. As a result, the prerequisite for obtaining the equation's defining moments. $\frac{dTC(T)}{dT} = 0$

$$\Rightarrow \frac{1}{T^2}\left[N_0+\frac{Ke^h}{\beta}\left[\begin{array}{c} Ce^{-\beta T}\left(1+\frac{e^{\alpha T^\beta}}{\alpha T^{\beta-1}-1}\right)+aT\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta T}{2}+1\right) \\ +\frac{bT^2}{2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{2\beta T}{3}+1\right)-\frac{cT^3}{3}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{3\beta T}{4}+1\right) \\ +\alpha\left\{\begin{array}{c}\frac{aT^{\beta+1}}{\beta+1}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+1}{\beta T}+\beta\right)+\frac{bT^{\beta+2}}{\beta+2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+2}{(\beta+1)T}+\beta\right) \\ -\frac{cT^{\beta+3}}{\beta+3}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+3}{(\beta+2)T}+\beta\right)\end{array}\right\}\end{array}\right]\right]$$

$$+\frac{Ke^h}{\beta T}\left[\begin{array}{l} \frac{Ce^{-\beta T}}{(\alpha T^{\beta-1}-1)^2}\left\{\beta e^{\alpha T^\beta}(\alpha T^{\beta-1}-1)^2-\beta(\alpha T^{\beta-1}-1)-\alpha(\beta-1)T^{\beta-2}e^{\alpha T^\beta}\right\} \\ +a\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta T}{2}+1\right)+aT\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta(\alpha T^{\beta-1}-1)^2-\alpha(\beta-1)T^{\beta-2}\right\}}{(\alpha T^{\beta-1}-1)^2}-\frac{\beta}{2}\right] \\ +bT\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{2\beta T}{3}+1\right)+\frac{bT^2}{2}\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta(\alpha T^{\beta-1}-1)^2-\alpha(\beta-1)T^{\beta-2}\right\}}{(\alpha T^{\beta-1}-1)^2}-\frac{2\beta}{3}\right] \\ -cT^2\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{3\beta T}{4}+1\right)-\frac{cT^3}{3}\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta(\alpha T^{\beta-1}-1)^2-\alpha(\beta-1)T^{\beta-2}\right\}}{(\alpha T^{\beta-1}-1)^2}-\frac{3\beta}{4}\right] \\ +\alpha\left[\begin{array}{l} aT^\beta\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+1}{\beta T}+\beta\right)+\frac{aT^{\beta+1}}{\beta+1}\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta(\alpha T^{\beta-1}-1)^2-\alpha(\beta-1)T^{\beta-2}\right\}}{(\alpha T^{\beta-1}-1)^2}+\frac{\beta+1}{\beta T^2}\right] \\ +bT^{\beta+1}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+2}{(\beta+1)T}+\beta\right)+\frac{bT^{\beta+2}}{\beta+2}\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta(\alpha T^{\beta-1}-1)^2-\alpha(\beta-1)T^{\beta-2}\right\}}{(\alpha T^{\beta-1}-1)^2}+\frac{\beta+2}{(\beta+1)T^2}\right] \\ -cT^{\beta+2}\left(\frac{e^{-\beta T+\alpha T^\beta}}{\alpha T^{\beta-1}-1}-\frac{\beta+3}{(\beta+2)T}+\beta\right)-\frac{cT^{\beta+3}}{\beta+3}\left[\frac{e^{-\beta T+\alpha T^\beta}\left\{\beta(\alpha T^{\beta-1}-1)^2-\alpha(\beta-1)T^{\beta-2}\right\}}{(\alpha T^{\beta-1}-1)^2}+\frac{\beta+3}{(\beta+2)T^2}\right]\end{array}\right]\end{array}\right]=0 \quad (12)$$

The value of T which we have obtained gives the minimum cost. so, it satisfies the below condition

$$\frac{d^2TC(T)}{dT^2}>0 \quad (13)$$

Algorithm:

Step1: Input the values of $\alpha, \beta, h, a, b, c, N_O, C, and\ K$ in equation (12), then we get the value of T. By changing the Parameter values of $\alpha, \beta, h, a, b, c, N_O, C, and\ K$, then we get changed values of T*.

Step2: Input the values of $\alpha, \beta, h, K\ and\ T$ in equation (4), then we get the value of I_0.By changing the Parameter values of $\alpha, \beta, h, K\ and\ T$, then we get changed values of I_0*.

Step3: Input the values of $\alpha, \beta, h, K, C\ and\ T$ in equation (7), then we get the value of DC. By changing the Parameter values of $\alpha, \beta, h, K, C\ and\ T$, then we get changed values of DC*.

Step4: Input the values of $\alpha, \beta, a, b, c, K\ and\ T$, in equation (9), then we get the value of THC. By changing the Parameter values of $\alpha, \beta, a, b, c, K\ and\ T$, then we get changed values of THC*.

Step5: Input the values of $\alpha, \beta, a, b, c, h, K, C, N_O\ and\ T$ in equation (10), then we get the value of TC. By changing the Parameter values of $\alpha, \beta, a, b, c, h, K, C, N_O\ and\ T$, then we get changed values of TC*.

Step6: Input the values of $K, h, \beta, and\ T$ in equation of D(t), then we get the value of D(t). By changing the

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Parameter values of $K, h, \beta, and\ T$, then we get changed values of D(t)*.

Numerical Example:

In order to express the varying model fabricated an example is testify considering the beneath factors. Let us take K=250, C=200, $N_O =$ 5000, h=0.05, a=500, b=150, c=110, $\alpha = 0.015, and\ \beta = 4.0$. The previously mentioned parameter values are sensible yet these qualities taken arbitrarily. we solved the proposed issue according to algorithm calculation as well as the assistance of MATHEMATICA 12.0 programming by changing different parameter values.,

Table 1.

Parameter	% Change	Value	T*	TC*	THC*	DC*
α	-50%	0.075	2.19392	44850.8	16557300.0	1174420.0
	-25%	0.1125	1.90296	59755.4	1242010.0	821330.0
	0%	0.15	1.7067	52068.5	900271.0	573126.0
	25%	0.1875	1.56442	41605.8	682539.0	424810.0
	50%	0.225	1.45569	32367.8	541609.0	332344.0
β	-50%	2.0	2.90261	-17809.9	481477.0	357765.0
	-25%	3.0	2.15734	-5288.21	939454.0	659814.0
	0%	4.0	1.7067	52068.5	900271.0	573126.0
	25%	5.0	1.4937	80593.1	769948.0	471828.0
	50%	6.0	1.37943	96945.4	706477.0	428018.0
a	-50%	250	1.52586	-40236.7	202498.0	Does not depend
	-25%	375	1.62222	-13044.9	433267.0	
	0%	500	1.7067	52068.5	900271.0	
	25%	625	1.76913	218103.0	1821880.0	
	50%	750	1.8085	588440.0	3451780.0	
b	-50%	75	.64657	280.118	530299.0	
	-25%	112.5	1.67681	20700.0	684541.0	
	0%	150	1.7067	52068.5	900271.0	
	25%	187.5	1.73498	100991.0	1202400.0	
	50%	225	1.76037	176717.0	1619940.0	
c	-50%	55	1.75797	166209.0	1569380.0	Does not depend.
	-25%	82.5	1.73317	96454.0	1178010.0	
	0%	110	1.7067	52068.5	900271.0	
	25%	137.5	1.6799	23707.0	704058.0	
	50%	165	1.6538	5110.95	563865.0	
N_O	-50%	2500	1.7959	-18998.6	Does not depend.	
	-25%	3750	1.7063	51475.0		
	0%	5000	1.7067	52068.5		
	25%	6250	1.7071	52660.9		
	50%	7500	1.70749	53255.7		

C	-50%	100	1.84865	1288160.0		2045980.0
	-25%	150	1.78644	242666.0		940310.0
	0%	200	1.7067	52068.5		573126.0
	25%	250	1.63637	-8316.53		434111.0
	50%	300	1.58248	-41196.6		374726.0
K	-50%	125	1.73295	21934.7	539897.0	357527.0
	-25%	187.5	1.71482	37533.3	712348.0	459082.0
	0%	250	1.7067	52068.5	900271.0	573126.0
	25%	312.5	1.70208	66302.9	1092600.0	690719.0
	50%	375	1.69909	80413.1	1286750.0	809776.0
h	-50%	0.025	1.70727	50703.7	881303.0	578230.0
	-25%	0.0375	1.70698	51386.9	890709.0	575650.0
	0%	0.05	1.7067	52068.5	900271.0	573126.0
	25%	0.0625	1.70642	52752.1	909931.0	570611.0
	50%	0.075	1.70615	53434.1	919749.0	568150.0

Graph Results:

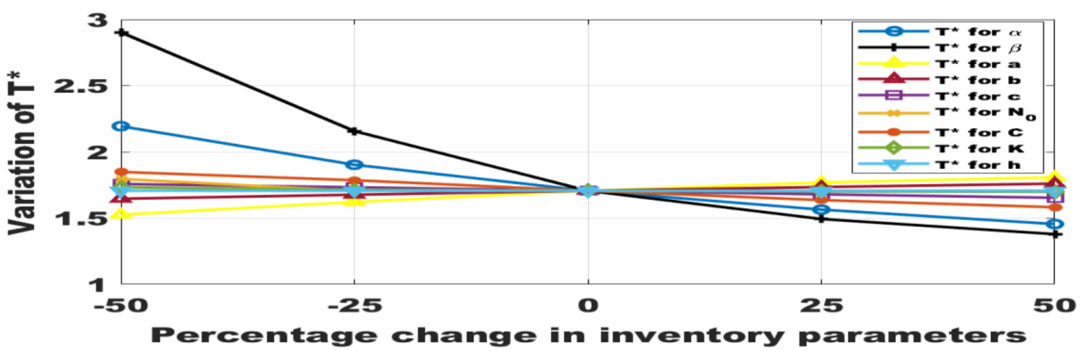

Figure 1.

Figure 1 represents that the variation of inventory time T* verses the parameter values $\alpha, \beta, a, b, c, N_0, C, K$ *and* h. Due to partial impact of the COVID-19 situation, Percentage increases the scale (α) parameter and shape (β) parameter values, then gradually decreases the value of the inventory time T*. Whereas by Percentage increasing the value of h, N_0, K, *and* c does not impact on inventory time T*. In this figure by Percentage increases the parameter values of a, and b, then the inventory time T* increases very slowly. But by Percentage increasing the parameter value of C, then the value of the inventory time T* slowly decreases.

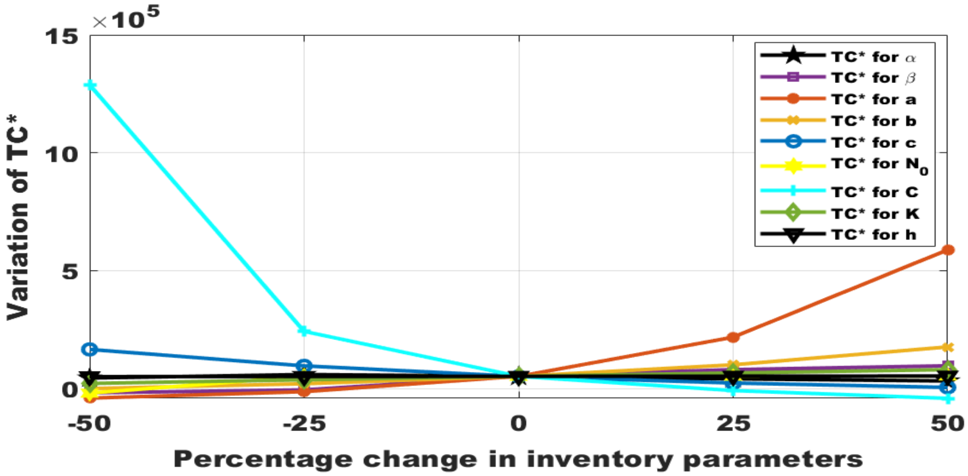

Figure2.

Figure 2. represents that the variation of total inventory variable cost TC^* verses the parameter values $\alpha, \beta, a, b, c, N_0, C, K$ *and* h. In this figure by Percentage increases the parameter value C, then the value of the variation of total inventory variable cost TC^* rapidly decreases. Whereas by Percentage increases the value of C, then the value of TC^* decreases very slowly. By Percentage increasing the value of parameter, a, and b then the variation of total inventory variable cost TC^* increases gradually. But by Percentage increases the parameter values α, β, N_0, K *and* h, then the variation of total inventory variable cost TC^* is not influence.

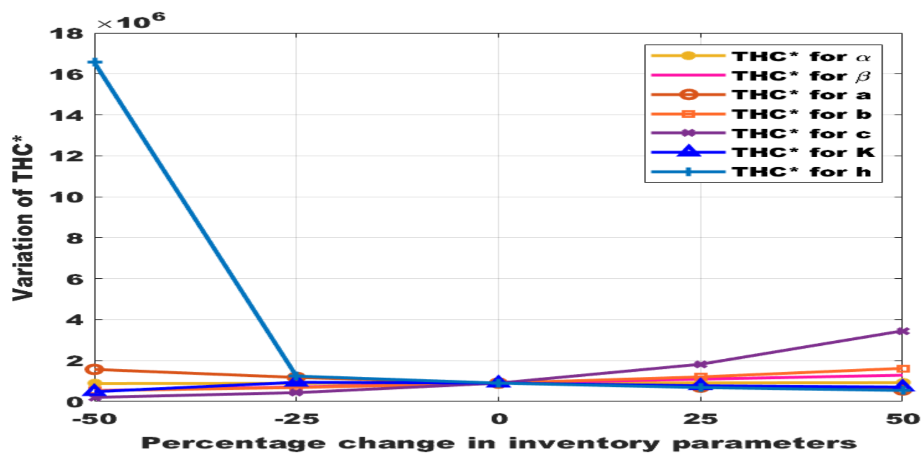

Figure 3.

Figure 3. represents that the variation of total Holding cost THC^* verses the parameter values $\alpha, \beta, a, b, c, K$ *and* h. Due to the impact of Pandemic situation, by Percentage increases the parameter value h, then the value of the total Holding cost THC^* rapidly decreases after certain limit it behaves like constant. Whereas by Percentage increases the value of C, then the value of THC^* increases gradually. By Percentage increasing the value of parameter, α, β, a, b and K, then the variation of total Holding cost THC^* effected negligibly.

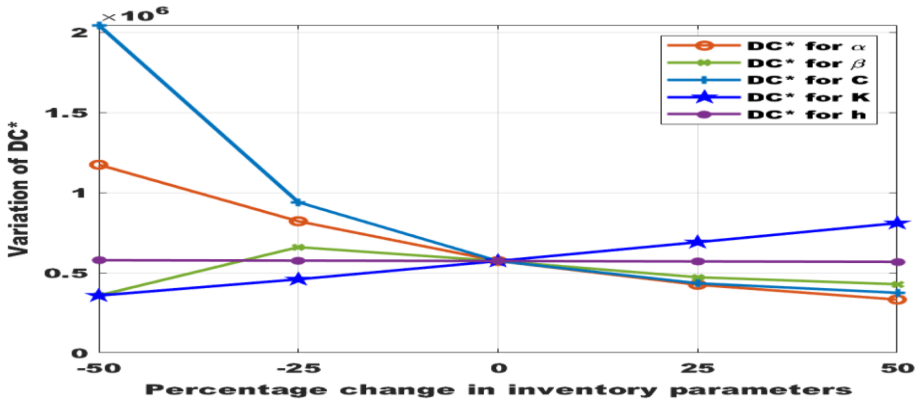

Figure 4.

Figure 4. represents that the variation of cost of deterioration DC^* verses the parameter values α, β, C, K *and* h**.** In this figure by Percentage increases the parameter value C and α, then the value of the cost of deterioration DC^*rapidly decreases. Whereas by Percentage increases the value of K, then the value of DC^* increases gradually. By Percentage increasing the value of parameterβ, then the variation of cost of deterioration DC^*increases gradually up to a certain limit point then decreases slowly. But by Percentage increases the parameter value h, the value of cost of deterioration DC^* does not changes.

Table 2.

Parameter	% Change	Value	T*	TC*	THC*	DC*	I*
α	-50%	0.075	2.19392	44850.8	16557300.0	1174420.0	1970.65
	-25%	0.1125	1.90296	59755.4	1242010.0	821330.0	1565.45
	0%	0.15	1.7067	52068.5	900271.0	573126.0	1240.86
	25%	0.1875	1.56442	41605.8	682539.0	424810.0	1027.44
	50%	0.225	1.45569	32367.8	541609.0	332344.0	883.371
β	-50%	2.0	2.90261	-17809.9	481477.0	357765.0	954.502
	-25%	3.0	2.15734	-5288.21	939454.0	659814.0	1237.02
	0%	4.0	1.7067	52068.5	900271.0	573126.0	1240.86
	25%	5.0	1.4937	80593.1	769948.0	471828.0	1162.01
	50%	6.0	1.37943	96945.4	706477.0	428018.0	1132.75
K	-50%	125	1.73295	21934.7	539897.0	357527.0	717.744
	-25%	187.5	1.71482	37533.3	712348.0	459082.0	970.97
	0%	250	1.7067	52068.5	900271.0	573126.0	1240.86
	25%	312.5	1.70208	66302.9	1092600.0	690719.0	1515.49
	50%	375	1.69909	80413.1	1286750.0	809776.0	1792.09
h	-50%	0.025	1.70727	50703.7	881303.0	578230.0	1214.84
	-25%	0.0375	1.70698	51386.9	890709.0	575650.0	1227.84
	0%	0.05	1.7067	52068.5	900271.0	573126.0	1240.86
	25%	0.0625	1.70642	52752.1	909931.0	570611.0	1253.84

	50%	0.075	1.70615	53434.1	919749.0	568150.0	1266.85

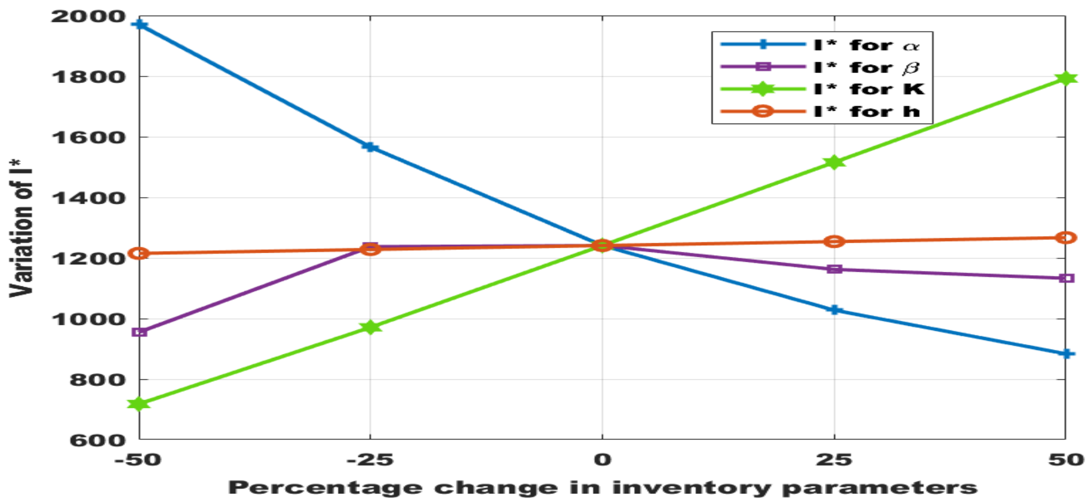

Figure 5.

Figure 5. represents that the variation of inventory cost I^* verses the parameter values α, β, K and h. When the percentage value of the scale parameter α increases, then the value of I^* decreases, whereas the percentage increase in value of the shape variable β , then the value of the I^* increases up to a certain limit, after that point it start to decreases in slowly. But by percentage increases the parameter value K, then the value of the inventory I^* increases proportionally and by percentage increases the value of the parameter h, then the value of inventory I^* remains constant.

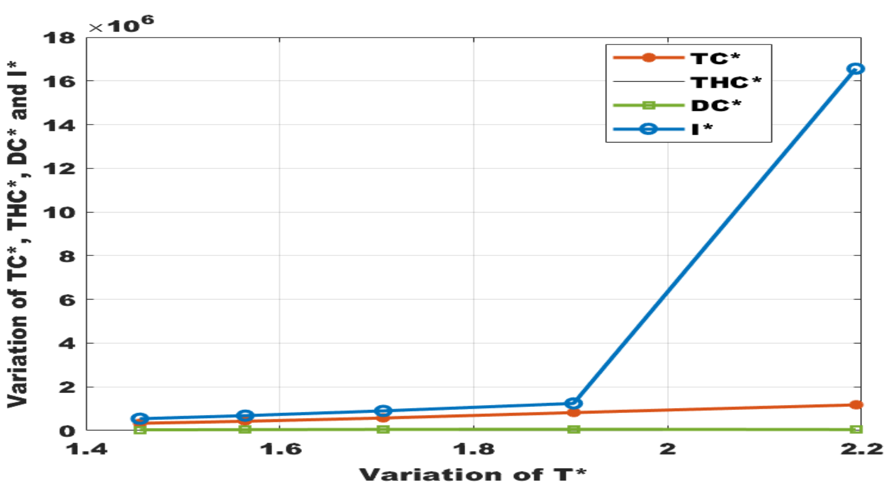

Figure 6.

Figure 6. represents that the variation of total inventory cycle time T^* verses total inventory cost of the cycle TC^* , total Holding cost of the cycle THC^* and the Inventory I^*. When percentage increase in cycle time of the inventory T^*, then the value of I^* gradually increases up to a certain limit point. After that point increases rapidly but the value of total inventory cost TC^* increases very slowly. Whereas T^* does not effects on DC^*.

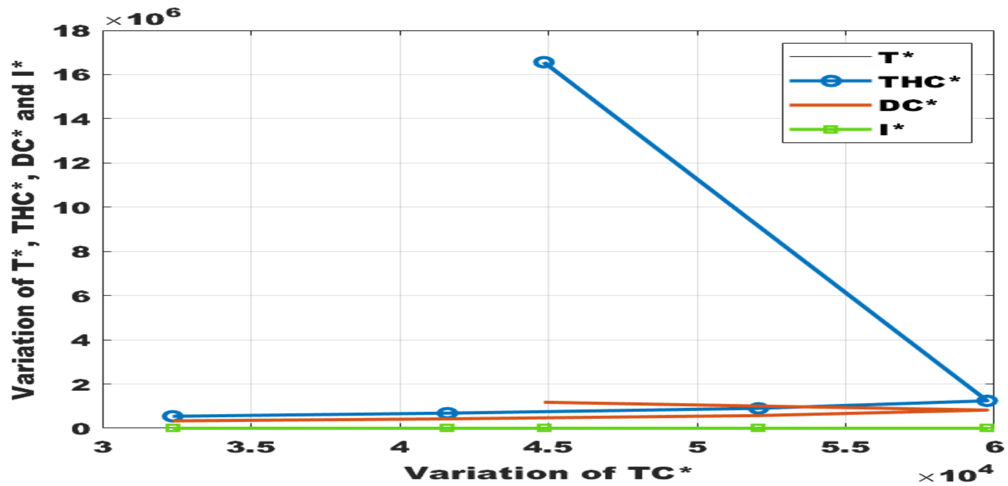

Figure 7.

Figure 7. represents that the variation of total inventory cost TC^* verses total inventory cycle time T^* , total Holding cost of the cycle THC^* and the Inventory I^*. When percentage increase in total inventory cost TC^*, then the value of THC^* increases constantly up to a certain limit point. After that point increases rapidly but the value of DC^* increases very slowly. Whereas TC^* does not effects on I^*.

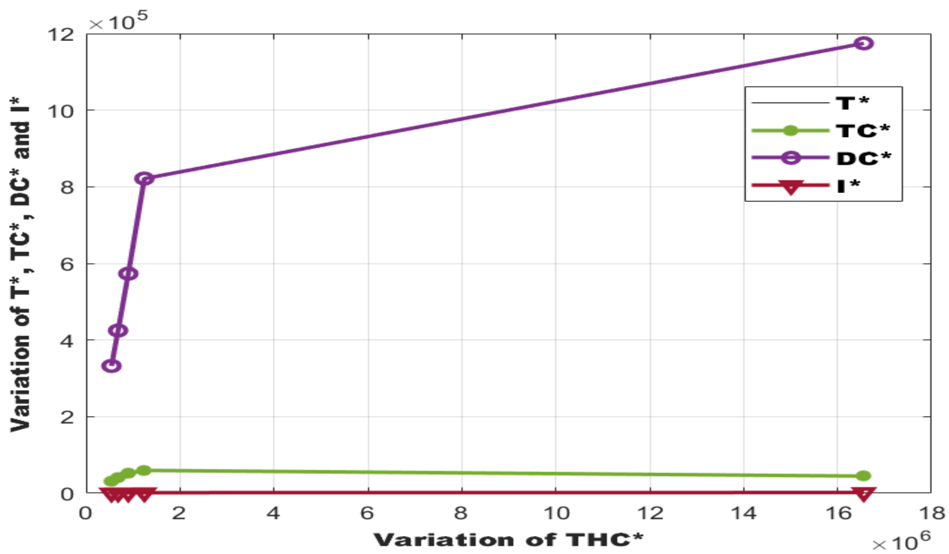

Figure 8.

Figure 8. represents that the variation of total inventory Holding cost THC^* verses total inventory cycle time T^* , total inventory cost of the cycle TC^* and the Inventory I^*. When percentage increase in total inventory Holding cost THC^*, then the value of DC^* increases exponentially up to a certain limit point. After that point rate of growth increases gradually. but the growth of total inventory cost TC^* and inventory I^* remain constant. Whereas THC^* does not effects on T^*.

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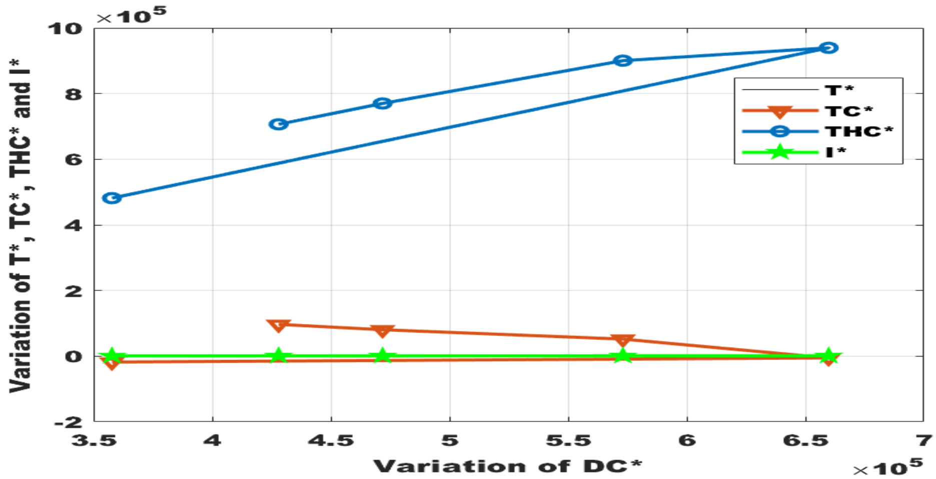

Figure 9.

Figure 9. represents that the variation of DC^* verses total inventory cycle time T^*, total inventory cost of the cycle TC^* ,total holding cost $THC^*$and the Inventory I^*. When percentage increase in DC^*, then the value of THC^* and TC^* increases up to a certain limit point. After that point rate of growth decreases gradually. But the growth of inventory I^* decreases very slowly. Whereas DC^* does not effects on T^*.

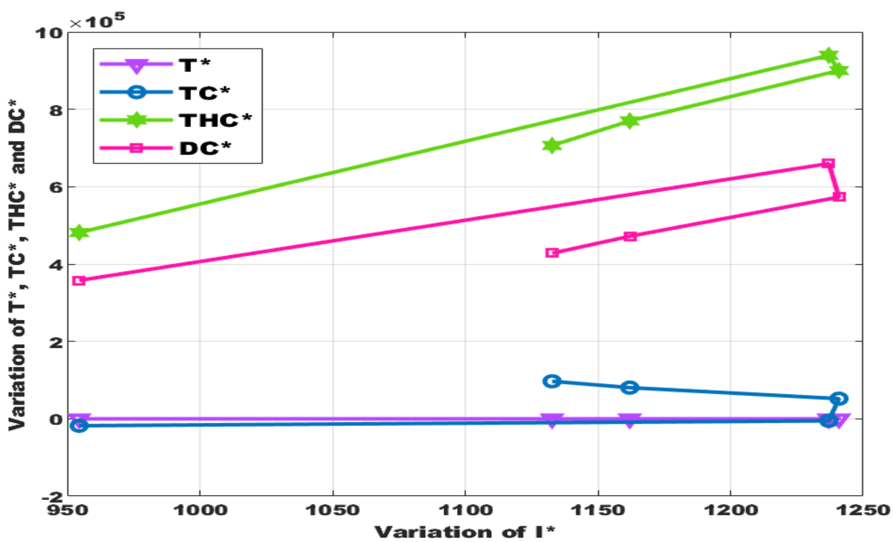

Figure 10.

Figure 10. represents that the variation of inventory I^* verses total inventory cycle time T^*, total inventory cost of the cycle TC^* ,total holding cost $THC^*$and DC^*. When percentage increase in I^*, then the value of THC^* and DC^* increases up to a certain limit point. After that point rate of growth decreases gradually. But the growth of Total inventory cost TC^* increases constantly up to a certain limit point then after its growth slightly increases then it starts to decrease. Whereas TC^* does not effects on increases in I^* value.

Conclusion:

The proposed research model has been designed an inventory model which decides the deterioration rate is Two parameter Weibull Deterioration function of time and shortages are not permitted. The rate of demand taken as Degrading over time. This type of assumption is valid with small time retailers who sell perishable items like vegetables, breads, mobile, high-tech products, oil, insulin, organic honey, Some of the clinical goods like special types of Vaccines (BCG, Hep-B*, OPV series, Rota series, Penta series, DPT Booster series, IPV series, etc. for children and Covid vaccines for people above 18^{+}years), seasonal fruits and milks where the quality of the goods degrades over time due to direct spoilage or physical decay factored by covid-19 induced decrease in sell and increase in holding time. The parabolic holding cost is a realistic assumption as holding cost does not remain constant by provisioning for larger storage facilities in order to arrest the degradation of in-stock commodities. In real time marketing, it is often found that the demand for products of popular brands or fashionable items such as, shoes, clothes etc. leads to backordering during situations of shortage in availability of these items. We have used MATHEMATICA 12.0 for analysis of data and used MATLAB software for plotting the graphs. The objective of this study is to reduce the total optimal inventory cost as a major performance of this model in which shortages are not allowed. Most items saw a decrease in demand as a result of COVID-19. To reduce deterioration, retailers must give preservation of deteriorating goods a priority. As a result, decision-makers take into account if it is possible to build a more sophisticated preservation facility within their available budget.This model can be expanded for more research by taking into account fuzzy or interval environments as well, and then it can be solved applying soft computing Techniques.

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