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Ramp Type Demand and three-parameter Weibull distribution deterioration Inventory system

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Abstract:
Inventory control is one of the important parts of any business organization. This article investigates the sensitivity analysis of an inventory model to increasing type demand for degrading items. In this inventory system, three parameters of the spoilage rate of the Weibull distribution are assumed and shortages are allowed with a partial delay rate. To get the optimal order quantity and optimal range of the average total cost function and this is important for proper coverage, consider numerical examples that confirm the actual use the results of this research work. Finally, the results show that the sensitivity analysis of the optimal solution for the system parameters is performed.
Keywords: Ramp type demand, Inventory, Weibull distribution, Partial backlogging.

Introduction

Inventory management is a very difficult task for all companies, as it is rare to find a company that does not use, store, distribute or sell substances of one kind or another. As a result, companies are becoming more aware of the stock, which is important for the performance of many sports and is part of their management power. The deterioration of tangible items in inventory can be a very sensitive feature in inventory management. It is determined that the demand for the commodity of seasonal products over the entire period is variable in nature. In the inventory literature after improving the classical version of the financial order quantity (EOQ), researchers significantly investigated many inventory modeling factors using the assumption on the constant demand for the price. The ramp kind demand for may be very typically visible whilst a few clean objects come to the marketplace.

In case of ramp kind demand for price, the demand for will increase linearly at the start after which the marketplace grows right into a strong degree such that the demand for turns into a consistent till the give up of the stock cycle. Ramp kind demand for sample is the aggregate of distinctive styles of demand for which include growing demand for observed with the aid of using a consistent demand for in successive time durations over the whole time horizon. Ghare and Schrader (1963) first proposed an EOQ model and after that, Covert and Philip (1973) extended the continuous reduction cost of Ghare and Schrader to a two-parameter Weibull distribution. Wee and Law (2001) studied a deteriorating version of Weibull's EOQ, calling for ratio-based thinking about the time cost of money.

Sugapriya (2008) studied a version of the EPQ for a non-immediate decline in which prices sustain changes over time. This is a matter of crafting an item that doesn't degrade immediately, where crafting costs and needs match. Manna et al. (2009) developed an EOQ version for utilities that do not degrade immediately with a time-based demand charge. In the version, the shortage is allowed and a late part. Hill (1995) first proposed a time established demand sample with the aid of using thinking about it because the aggregate of one of a kind sorts of demand including growing demand accompanied. Mandal and Pal (1998) extended the stock version with the need for item degradation and allowing rarity. Wu and Ouyang (2000) expanded the stock version to include unique replenishment policies: (a) clothing starts with no shortage and (b) clothing starts to be scarce. Dang et al. (2007) highlighted some questionable consequences of Mandal and Pal (1998), and Wu and Ouyang (2000) and then addressed the same problem using a strict green advertising approach to find out the best solution.

Wu (2001) further studied the security version with a steep-like demand price curve such that the decline is accompanied by a decline of the Weibull distribution and partial backlogging. Giri et al. (2003) extended the ramp-like version of the demand reserve with a more general Weibull decline distribution. They cited an example of demand for elegant goods, which would first increase exponentially which it would become constant instead of growing exponentially, where inside the first part, demand will increase with time and then it will become constant and near the end inside the last part it decreases and asymptotically. Manna and Chaudhuri (2006) proposed a production stock version with a demand pattern graded on a ramp-type duration where the finished producer price depends on demand. Demand will increase linearly over time in the first period, then it will become constant for the last time in the production cycle. They point out that this type of inquiry form is often accompanied by the use of a new customer item icon that is about to hit the market. Recently, Deng et al. (2007) studied a standard version to correct the incompleteness of the given modes using Yadav and Malik (2014).

Dyes et al. (2007) analyzed a stock system in which the demand and price of spoilage are non-stop and the characteristics differ in cost and time respectively, and the shortage complete delay. Panda et al. (2008) improved an inventory version of the ordering phase to occur for a finite period of time. Skouri et al. (2009) decided that a stock version with a well-known ramp-like demand price, price decline over time (Weibull) and partial lag of unsatisfied demand are considered. The literature review has demonstrated that optimal order quantities and optimal results always depend on inventory control/management of the supply and demand sectors. A very important discussion from Sana (2010) on optimal selling price policy and considering lot size under partial backlog conditions. A mathematical model for the optimal seller credit duration in the supply chain as well as product failure cycle times with maximum shelf life conditions. In the same year, Sarkar and Sarkar (2013) discussed a partially lagged inventory system, assuming a time-varying spoilage rate and a screen-dependent demand rate. Tang et al. (2014) presents the optimal price policy for spoiled products when investing in preservation technology.

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Ghoreishi et al. (2014) reviewed a model with an optimal ordering and pricing policy for items with no immediate quality loss, where inflation and customer returns are taken into account. Subsequently, Chen and Teng (2015) developed an inventory system with credit decisions for products damaged over time using upstream and downstream trade credit financing. Sarkar et al. (2015), and Kumar et al. (2016) inventory system analysis with products that do not deteriorate immediately with storage costs that vary over time. Since demand for the product is generally not fixed, Malik et al. (2016), Vasishth et al. (2015); Mathur et al. (2019); Malik et al. (2021); Kumar et al. (2022); Tyagi et al. (2022); measure optimal order quantity for best results. In the same study, Vashisth et al. (2016) demonstrate inventory system with multivariable demand in trade credit policy. Malik et al. (2019, 22), Yadav et al. (2022) and Verma et al. (2022) demonstrated the inventory management system with various business policies and environment.

ASSUMPTIONS AND NOTATIONS

Assumptions

- Demand rate $D(t)=\begin{cases} f(t) & t<\mu \\ f(\mu) & t\geq \mu \end{cases}$
- Weibull distribution function $f(t)=\alpha\beta(t-\gamma)^{\beta-1}e^{-\alpha(t-\gamma)^{\beta+1}}$ $\quad \alpha,\beta>0,\ \ t>\gamma$

  Deterioration rate is $\theta(t)=\dfrac{f(t)}{1-F(t)}=\alpha\beta(t-\gamma)^{\beta-1}$ $\quad \alpha,\beta>0,\ \ t>\gamma$

  $F(t)$ being the distribution function of Weibull distribution.
- Shortages are allowed and are backlogged at a rate $g(x)$.

Notations

T	Total Cycle time
t_1	Time when inventory level reaches zero.
A	Ordering cost.
c_h	Holding cost
c_s	Shortage cost
c_d	Deterioration cost
c_o	Opportunity cost
μ	ramp type demand parameter
I_m	Maximum inventory level

MATHEMATICAL MODEL

Here we consider two cases:

Case I ($t_1 \leq \mu$)

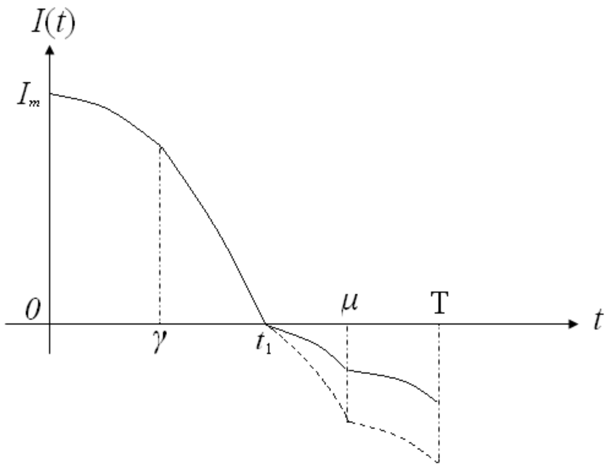

Figure 1: Inventory level when $t_1 \le \mu$

The differential equations for the proposed system are given by:

$$I'(t) = -f(t) \qquad 0 \le t \le \gamma \qquad \ldots(1)$$

$$I'(t) + \alpha\beta(t-\gamma)^{\beta-1} I(t) = -f(t) \text{ with } I(t_1) = 0, \quad \gamma \le t \le t_1 \qquad \ldots(2)$$

$$I'(t) = -f(t)g(T-t) \qquad t_1 \le t \le \mu \qquad \ldots(3)$$

$$I'(t) = -f(\mu)g(T-t) \qquad \mu \le t \le T \qquad \ldots(4)$$

Solutions of the equations (1) to (4) are

$$I(t) = \int_t^{\gamma} f(x)dx + \int_{\gamma}^{t_1} f(x)e^{\alpha(x-\gamma)^{\beta}} dx \qquad \ldots(5)$$

$$I(t) = e^{-\alpha(t-\gamma)^{\beta}} \int_t^{t_1} f(x)e^{-\alpha(x-\gamma)^{\beta}} dx \qquad \ldots(6)$$

$$I(t) = -\int_{t_1}^{t} f(x)g(T-x)dx \qquad \ldots(7)$$

$$I(t) = -f(\mu)\int_{\mu}^{t} g(T-x)dx - \int_{t_1}^{\mu} f(x)g(T-x)dx \qquad \ldots(8)$$

Holding cost of the inventory during $[0, t_1]$ is

$$H = c_h\int_0^{\gamma}\left[\int_t^{\gamma} f(x)dx + \int_{\gamma}^{t_1} f(x)e^{\alpha(x-\gamma)^{\beta}} dx\right]dt$$

$$+c_h\int_{\gamma}^{t_1} e^{-\alpha(t-\gamma)^{\beta}} \left[\int_t^{t_1} f(x)e^{-\alpha(x-\gamma)^{\beta}} dx\right] dt \qquad \ldots(9)$$

Deterioration cost during $[0, t_1]$ is $D = c_d\int_{\gamma}^{t_1} f(t)e^{-\alpha(t-\gamma)^{\beta}} dt - c_d\int_{\gamma}^{t_1} f(t)dt \qquad \ldots(10)$

Shortage cost during $[t_1, T]$ is

$$S = c_s\int_{t_1}^{\mu}\left[\int_{t_1}^{t} f(x)g(T-x)dx\right]dt$$

$$+c_s\int_{\mu}^{T}\left[f(\mu)\int_{\mu}^{t}g(T-x)dx-\int_{t_1}^{\mu}f(x)g(T-x)dx\right]dt \qquad \ldots(11)$$

Opportunity cost is $O=c_o\int_{t_1}^{\mu}[1-g(T-t)]f(t)dt+c_o f(\mu)\int_{\mu}^{T}[1-g(T-t)]\,dt$ ...(12)

Total cost is

$$TC_1(t_1) = H + D + S + O$$

$$=c_h\int_0^{\gamma}\left[\int_t^{\gamma}f(x)dx+\int_{\gamma}^{t_1}f(x)e^{\alpha(x-\gamma)^{\beta}}dx\right]dt+c_h\int_{\gamma}^{t_1}e^{-\alpha(t-\gamma)^{\beta}}\left[\int_t^{t_1}f(x)e^{-\alpha(x-\gamma)^{\beta}}dx\right]dt$$

$$+c_d\int_{\gamma}^{t_1}f(t)e^{-\alpha(t-\gamma)^{\beta}}dt-c_d\int_{\gamma}^{t_1}f(t)dt+c_s\int_{t_1}^{\mu}\left[\int_{t_1}^{t}f(x)g(T-x)dx\right]dt$$

$$+c_s\int_{\mu}^{T}\left[f(\mu)\int_{\mu}^{t}g(T-x)dx+\int_{t_1}^{\mu}f(x)g(T-x)dx\right]dt$$

$$+c_o\int_{t_1}^{\mu}[1-g(T-t)]f(t)e^{-R\,t}dt+c_o f(\mu)\int_{\mu}^{T}[1-g(T-t)]\,dt$$

...(13)

Case II ($t_1 \geq \mu$): The inventory level in this case are as follows:

$I'(t)=-f(t)$ with $I(\gamma_-) = I(\gamma_+)$ $\quad 0\le t\le\gamma$ ...(14)

$I'(t)+\alpha\beta(t-\gamma)^{\beta-1}I(t)=-f(t)$ with $I(\mu_-) = I(\mu_+)$ $\quad \gamma\le t\le\mu$ ...(15)

$I'(t)+\alpha\beta(t-\gamma)^{\beta-1}I(t)=-f(\mu)$ with $I(t_1) = 0$ $\quad \mu\le t\le t_1$ ...(16)

$I'(t)=-f(\mu)g(T-t)$ $\quad \mu\le t\le T$ ...(17)

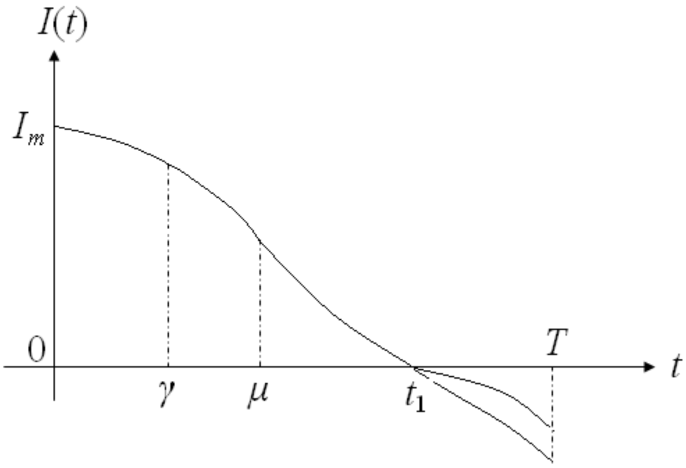

Figure 2: Inventory level when $t_1 > \mu$

Solutions of the equations (14) – (17) are:

$$I(t)=\int_t^{\gamma}f(x)dx+\int_{\gamma}^{\mu}f(x)e^{\alpha(x-\gamma)^{\beta}}dx+f(\mu)\int_{\mu}^{t_1}e^{\alpha(x-\gamma)^{\beta}}dx \qquad 0\le t\le\gamma \qquad \ldots(18)$$

$$I(t)=e^{-\alpha(t-\gamma)^{\beta}}\left[\int_t^{\mu}f(x)e^{\alpha(x-\gamma)^{\beta}}dx+f(\mu)\int_{\mu}^{t_1}e^{\alpha(x-\gamma)^{\beta}}dx\right] \qquad \gamma\le t\le\mu \qquad \ldots(19)$$

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$$I(t) = e^{-\alpha(t-\gamma)^\beta} f(\mu)\int_t^{t_1} e^{\alpha(x-\gamma)^\beta} dx \qquad \mu \le t \le t_1 \qquad \ldots(20)$$

$$I(t) = -f(\mu)\int_{t_1}^{t} g(T-x)dx \qquad \mu \le t \le T \qquad \ldots(21)$$

Holding cost of the inventory during $[0, t_1]$ is

$$H = c_h\Bigg[\int_0^\gamma\left[\int_t^\gamma f(x)dx + \int_\gamma^\mu f(x)e^{\alpha(x-\gamma)^\beta}dx + f(\mu)\int_\mu^{t_1} e^{\alpha(x-\gamma)^\beta}dx\right]dt$$
$$+\int_\gamma^\mu e^{-\alpha(t-\gamma)^\beta}\left[\int_t^\mu f(x)e^{\alpha(x-\gamma)^\beta}dx + f(\mu)\int_\mu^{t_1} e^{\alpha(x-\gamma)^\beta}dx\right]dt$$
$$+\int_\mu^{t_1} e^{-\alpha(t-\gamma)^\beta}\left[f(\mu)\int_t^{t_1} e^{\alpha(x-\gamma)^\beta}dx\right]dt\Bigg] \qquad \ldots(22)$$

Deterioration cost during $[0, t_1]$ is

$$D = c_d\left[\int_\gamma^\mu f(t)\left(e^{\alpha(t-\gamma)^\beta}-1\right)dt + f(\mu)\int_\mu^{t_1}\left(e^{\alpha(t-\gamma)^\beta}-1\right)dt\right] \qquad \ldots(23)$$

Shortage cost during $[t_1, T]$ is
$$S = c_s f(\mu)\int_{t_1}^{T}\left[\int_{t_1}^{t} g(T-x)dx\right]dt \qquad \ldots(24)$$

Opportunity cost is
$$O = c_o f(\mu)\int_{t_1}^{T}[1-g(T-t)]dt \qquad \ldots(25)$$

The total cost is

$$TC_2(t_1) = H + D + S + O$$
$$= c_h\Bigg[\int_0^\gamma\left[\int_t^\gamma f(x)dx + \int_\gamma^\mu f(x)e^{\alpha(x-\gamma)^\beta}dx + f(\mu)\int_\mu^{t_1} e^{\alpha(x-\gamma)^\beta}dx\right]dt$$
$$+\int_\gamma^\mu e^{-\alpha(t-\gamma)^\beta}\left[\int_t^\mu f(x)e^{\alpha(x-\gamma)^\beta}dx + f(\mu)\int_\mu^{t_1} e^{\alpha(x-\gamma)^\beta}dx\right]dt$$
$$+\int_\mu^{t_1} e^{-\alpha(t-\gamma)^\beta}\left[f(\mu)\int_t^{t_1} e^{\alpha(x-\gamma)^\beta}dx\right]dt\Bigg]$$
$$+c_d\left[\int_\gamma^\mu f(t)\left(e^{\alpha(t-\gamma)^\beta}-1\right)dt + f(\mu)\int_\mu^{t_1}\left(e^{\alpha(t-\gamma)^\beta}-1\right)dt\right]$$
$$+c_s f(\mu)\int_{t_1}^{T}\left[\int_{t_1}^{t} g(T-x)dx\right]dt + c_o f(\mu)\int_{t_1}^{T}[1-g(T-t)]dt \qquad \ldots(26)$$

Total present value of the system over $[0, T]$ is:

$$TC(t_1) = \begin{cases} TC_1(t_1) & if \quad t_1 \le \mu \\ TC_2(t_1) & if \quad t_1 > \mu \end{cases} \qquad \ldots(27)$$

Optimal replenishment policy:

For minimizes the total cost function $TC(t_1)$, using equation (13), we have

$$\frac{dTC_1(t_1)}{dt_1} = f(t_1)\, h(t_1) \qquad \ldots(28)$$

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where $h(t_1)=c_h e^{\alpha(t_1-\gamma)^\beta}\left[\int_\gamma^{t_1} e^{-\alpha(t-\gamma)^\beta}e^{-R\,t}dt+\frac{1-e^{-R\gamma}}{R}\right]-\frac{c_s}{R}g(T-t_1)(e^{-R\,t_1}-e^{-R\,T})$

$$+c_d e^{-R\,t_1}(e^{\alpha(t_1-\gamma)^\beta}-1)-c_o(1-g(T-t_1))\,e^{-R\,t_1} \qquad \ldots(29)$$

We have

$$h(0)=-\frac{c_s}{R}g(T)(1-e^{-R\,T})-c_o+c_o g(T)<0 \qquad (\text{as } 0\le g(x)\le 1) \qquad \ldots(30)$$

and $h(T)=c_h e^{\alpha(T-\gamma)^\beta}\left[\int_\gamma^{T} e^{-\alpha(t-\gamma)^\beta}e^{-R\,t}dt+\frac{1-e^{-R\gamma}}{R}\right]+c_d e^{-R\,T}(e^{\alpha(T-\gamma)^\beta}-1)>0$

…(31)

NUMERICAL EXAMPLES

Example 1. Here α=0.01, β=2, γ=0.3 year, μ=0.9 year (in first case) and μ=0.6 year (in second case), c_h =\$ 3 per unit/ year, $f(t)=3\,e^{4.5t}$, and $g(x)=e^{-0.2x}$, c_d =\$ 5 per unit/ year, c_s =\$ 15 per unit/ year, c_o =\$ 20 per unit/year, and R=0.2, T=1 year, solving equation (29) obtain t_1^*=0.8472>μ, Q^*=54.4905 and $TC(t_1^*)$=82.5102.

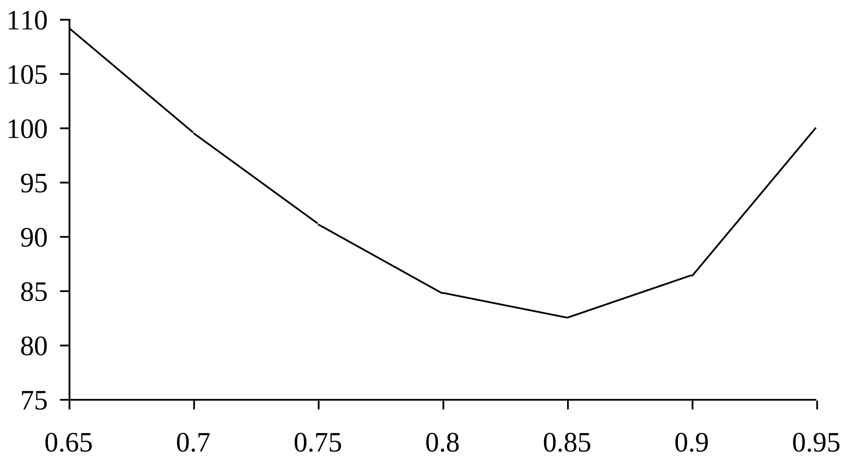

Figure 3: Graphical representation of TC when $t_1^* \le \mu$

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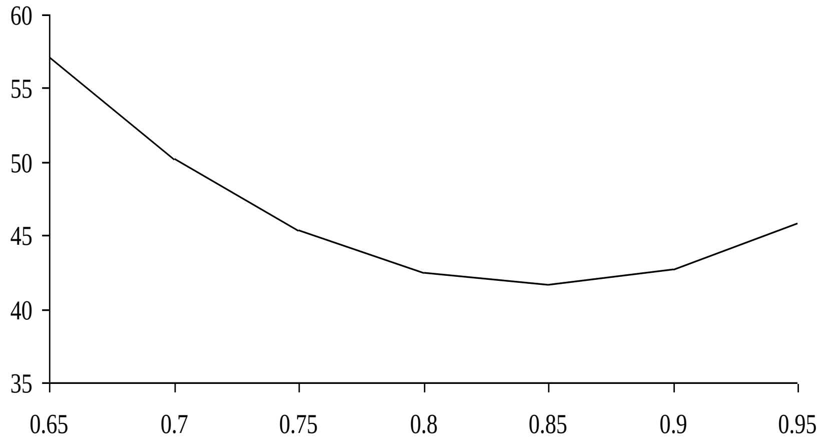

Figure 4: Graphical representation of TC when $t_1^* > \mu$

SENSITIVITY ANALYSIS

Optimum solutions are t_1^* = 0.8365, S = 28.5567, Q = 53.3679, TC = 80.3635

Table 1: When $t_1 \leq \mu$

Parameters	% Change	t_1^*	S^*	Q^*	TC_1^*
α	–50	0.8385	28.5785	53.3782	80.3431
	–25	0.8372	28.5627	53.3536	80.3578
	+25	0.8356	28.5462	53.3789	80.3782
	+50	0.8338	28.5628	53.3892	80.4025
β	–50	0.8268	28.4978	53.5289	80.5291
	–25	0.8327	28.5135	53.4572	80.4792
	+25	0.8397	28.6382	53.2568	80.0385
	+50	0.8403	28.7824	53.2273	79.7834
γ	–50	0.8310	28.4959	53.2904	81.0385
	–25	0.8352	28.5294	53.2793	80.7832
	+25	0.8379	28.5783	53.2572	80.0934
	+50	0.8437	28.5901	53.2189	79.6793
c_h	–50	0.9083	32.3782	53.8859	73.6951
	–25	0.8578	30.7924	53.5393	78.7607
	+25	0.8189	26.8934	53.2466	92.6378
	+50	0.7893	23.6782	53.1112	99.7160

Optimum solutions are t_1^* = 0.8365, S = 18.3899, Q = 25.0453, TC = 40.3890

Table 2: When $t_1 > \mu$

Parameters	% Change	t_1^*	S^*	Q^*	TC_2^*
α	–50	0.8395	19.3227	24.1581	40.0727
	–25	0.8387	18.8971	25.0235	40.3236
	+25	0.8360	18.0589	25.1345	40.6734
	+50	0.8328	17.3004	25.5599	40.9682
β	–50	0.8268	16.4978	27.8309	41.1389
	–25	0.8327	17.5135	26.4942	40.8723
	+25	0.8397	18.6382	24.6278	40.0527
	+50	0.8403	19.7824	23.2473	39.3894
γ	–50	0.8164	17.3064	28.0566	41.8003
	–25	0.8269	18.3089	26.0387	40.6961
	+25	0.8445	19.3148	24.5214	39.5918
	+50	0.8572	20.3185	23.0156	39.2558
c_h	–50	0.8954	20.2628	26.1275	28.1439
	–25	0.8511	19.8303	26.0744	38.0072
	+25	0.8155	17.8946	25.9782	43.5945
	+50	0.7859	16.5706	24.9233	47.7773

CONCLUSION

In this article, we have enhanced the order-phase inventory model for items that are in decline. We have degraded the three-parameter Weibull distribution. It can be applied to items with any initial damage value and to items that begin to degrade the most after a certain period of time. Issuance is relatively well known because the ask price is an incremental property of time, and the delay price is any non-incremental characteristic of time availability, as well as subsequent replenishment. The proposed version can be extended in many ways, for example, we can also keep in mind the horizon of the completed production plans. We can also add a deterministic demand function to stochastic demand models. Alternatively, we can generalize the version to allow for authorized payment deferrals.

REFERENCES

1. Chen, S. C., & Teng, J. T. (2015). Inventory and credit decisions for time-varying deteriorating items with up-stream and down-stream trade credit financing by discounted cash flow analysis. *European Journal of Operational Research*, *243*(2), 566-575.

2. Covert R. P. and Philip G.C. (1973), "An EOQ model for items with Weibull distribution deterioration", *AIIE Transaction* 5, 323–326.
3. Deng P. S., Robert H. J. and Lin P. C. (2007), "A note on the inventory model for deteriorating items with ramp type demand rate", *European Journal of Operational Research* 178, 112–120.
4. Deng P. S., Robert H. J. and Lin P. C. (2007), "A note on the inventory model for deteriorating items with ramp type demand rate", *European Journal of Operational Research* 178, 112–120.
5. Dye C. Y., Ouyang L. Y. and Hsieh T. P. (2007), "Inventory and pricing strategies for deteriorating items with shortages: A discounted cash flow approach", *Computers & Industrial Engineering* 52, 29–40.
6. Ghare P. M. and Schrader G. F. (1963), "A model for exponential decaying inventory", *Journal of Industrial Engineering* 14, 238–243.
7. Ghoreishi, M., Mirzazadeh, A., & Weber, G. W. (2014). Optimal pricing and ordering policy for non-instantaneous deteriorating items under inflation and customer returns. *Optimization*, *63*(12), 1785-1804.
8. Giri B. C., Jalan A. K. and Chaudhuri K. S. (2003), "Economic Order Quantity model with Weibull deterioration distribution, shortage and ramp-type demand", *International Journal of Systems Science*, 34, 4, 237-243.
9. Hill R. M. (1995), "Optimal EOQ models for deteriorating items with time-varying demand. Journal of the Operational Research Society", 47, 1228-1246.
10. Kumar, P., Naik, P. J., & Malik, A. K. (2022). An Improved Inventory Model for Decaying Items with Quadratic Demand and Trade Credits. Forest Chemicals Review, 1848-1857.
11. Kumar, S., Malik, A. K., Sharma, A., Yadav, S. K., Singh, Y. (2016, March). An inventory model with linear holding cost and stock-dependent demand for non-instantaneous deteriorating items. In AIP Conference Proceedings (Vol. 1715, No. 1, p. 020058). AIP Publishing LLC.
12. Malik, A. K., Mathur, P., Kumar, S. (2019, August). Analysis of an inventory model with both the time dependent holding and sales revenue cost. In IOP Conference Series: Materials Science and Engineering (Vol. 594, No. 1, p. 012043). IOP Publishing.
13. Malik, A. K., Singh, P. R., Tomar, A., Kumar, S., & Yadav, S. K. (2016, March). Analysis of an inventory model for both linearly decreasing demand and holding cost. In AIP Conference Proceedings (Vol. 1715, No. 1, p. 020063). AIP Publishing LLC.
14. Malik, A. K., Sharma, M., Tyagi, T., Kumar, S., Naik, P. J., & Kumar, P. (2022). Effect of Uncertainty in Optimal Inventory Policy for Manufacturing Products. International Journal of Intelligent Systems and Applications in Engineering, 10(1s), 102-110.
15. Malik, A., Bano, T., Pandey, M. K., & Bansal, K. K. (2021). Inflation based Inventory model among non-instantaneous decaying items with linear demand rate. Annals of Optimization Theory and Practice.
16. Mandal B. and Pal A. K. (1998), "Order level inventory system with ramp type demand for deteriorating items", Journal of Interdisciplinary Mathematics, 1, 49-66.

17. Manna S. K., Lee C. C. and Chiang C. (2009), "EOQ model for non-instantaneous deteriorating items with time-varying demand and partial backlogging", International Journal of Industrial and Systems Engineering, 4, 3, 241 – 254.
18. Manna, S. K. and Chaudhuri K. S. (2006), "An EOQ model with ramp type demand rate, time dependent deterioration rate, unit production cost and shortages", European Journal of Operational Research, 171, 557-566.
19. Mathur, P., Malik, A. K., & Kumar, S. (2019, August). An inventory model with variable demand for non-instantaneous deteriorating products under the permissible delay in payments. In IOP Conference Series: Materials Science and Engineering (Vol. 594, No. 1, p. 012042). IOP Publishing.
20. Ouyang L. Y., Wu K. S. and Yang C. T. (2008), "Retailer's ordering policy for non-instantaneous deteriorating items with quantity discount, stock-dependent demand and stochastic backorder rate", Journal of the Chinese Institute of Industrial Engineers, 25, 1, 62-72.
21. Panda S., Senapati S. and Basu M. (2008), "Optimal replenishment policy for perishable seasonal products in a season with ramp-type time dependent demand", Computers and Industrial Engineering, 54, 2, 301-314.
22. Sana, S. S. (2010). Optimal selling price and lot size with time varying deterioration and partial backlogging. Applied Mathematics and computation, 217(1), 185-194.
23. Sarkar, B., & Sarkar, S. (2013). An improved inventory model with partial backlogging, time varying deterioration and stock-dependent demand. Economic Modelling, 30, 924-932.
24. Sarkar, B., Mandal, B., & Sarkar, S. (2015). Quality improvement and backorder price discount under controllable lead time in an inventory model. Journal of Manufacturing Systems, 35, 26-36.
25. Skouri K. et al. (2009), "Inventory models with ramp type demand rate, partial backlogging and Weibull deterioration rate", European Journal of Operational Research, 192, 1, 79-92.
26. Tyagi, T., Kumar, S., Malik, A. K., & Vashisth, V. (2022). A Novel Neuro-Optimization Technique for Inventory Models in Manufacturing Sectors. Journal of Computational and Cognitive Engineering.
27. Vashisth, V., Tomar, A., Chandra, S., Malik, A. K. (2016). A trade credit inventory model with multivariate demand for non-instantaneous decaying products. Indian Journal of Science and Technology, 9(15), 1-6.
28. Vashisth, V., Tomar, A., Soni, R., Malik, A. K. (2015). An inventory model for maximum life time products under the Price and Stock Dependent Demand Rate. International Journal of Computer Applications, 132(15), 32-36.
29. Verma, P., Chaturvedi, B. K., & Malik, A. K. (2022). Comprehensive Analysis and Review of Particle Swarm Optimization Techniques and Inventory System, International Journal on Future Revolution in Computer Science & Communication Engineering, 8(3), 111-115.
30. Wang, W. C., Teng, J. T., & Lou, K. R. (2014). Seller's optimal credit period and cycle time in a supply chain for deteriorating items with maximum lifetime. European Journal of Operational Research, 232(2), 315-321.

31. Wee H. M. and Law S-T. (2001), "Replenishment and pricing policy for deteriorating items taking into account the time value of money", International Journal of Production Economics, 71, 213-220.
32. Wu K. S. (2001), "An EOQ model for items with Weibull distribution deterioration, ramp-type demand rate and partial backlogging", Production Planning & Control, 12, 8, 787-793.
33. Wu K. S. and Ouyang L. Y. (2000), "A replenishment policy for deteriorating items with ramp type demand rate for deteriorating items", The Proceedings of the National Science Council, Part A: Physical Science Engineering, 24, 4, 279-286.
34. Zhang, J., Bai, Z., & Tang, W. (2014). Optimal pricing policy for deteriorating items with preservation technology investment, Journal of Industrial & Management Optimization, 10(4), 1261.
35. Yadav, S.R. and Malik, A.K. Operations Research, Oxford University Press, New Delhi, 2014.
36. Yadav, V., Chaturvedi, B. K., & Malik, A. K. (2022). Advantages of fuzzy techniques and applications in inventory control. International Journal on Recent Trends in Life Science and Mathematics, 9(3), 09-13.