

# Integrated inventory model with inflation for deteriorating items

**Abstract** The integrated inventory model works like a multi-tier supply chain, involving a manufacturer, buyer, supplier, and a customer. In the proposed article, integrated inventory management for perishable items has been developed. It is an important responsibility of every member of the supply chain to ensure that any inventory can be delivered to the customer smoothly and on time. Inflation is also factored into the model of inflation fluctuations.

This model is considering the movement of inventory from production to supply in real data, numerical example has been discussed to understand this model in real life and the total cost from the supply chain has been derived. Sensitivity analysis is also shown at the end of the model to find out the impact on the model due to changes in some parameters that strongly influence the model.

**Keywords:** Multi echelon; Inflation; Deteriorating items

## 1. Introduction

The competition that has arisen in every trade at present, one thing is certain it becomes more important for every business to reach its customers in maximum quantity at reasonable prices and at the time required by the customer. The multi-echelon supply chain system has been playing an important role in all these things because the multi-echelon supply chain management itself acts like an organization and it is the responsibility of all the members working in this organization to fulfill all the needs of the customer. Many authors discussed about inventory management based on economic condition. Asghar et al. (2020) developed a smart automatic inventory model (IM) based on economic production policy that covers high technology items like mobile phones, computers, electronic devices, etc. Mallick et al. (2020) formulated an IM with permissible delay in payment and time dependent demand. The supply chain management itself acts like an organization and it is the responsibility of all the members who are working in the organization, to fulfill all the needs of the customers and to make every step of the supply chain system highly profitable. Mashud et al. (2020) investigated a sustainable IM under controllable emission for products which are imperfect. Sarkar and Chung (2021) developed a sustainable IM with flexible production system under carbon reduction technology. Mishra et al. (2020) formulated a sustainable production IM with single type of items, where all the items are transported to consumer by only one transportation mode with shortage under the reduction of carbon emissions. In general, the supply chain inventory model (SCIM) considered different sub-systems. Recently due to the changes in transmission and information technologies, the consolidations of these functions are in normal appearance. The supply chain (SC) has become very important for researchers in changing market scenario. SCIM streamline every situation from producer's flow to natural disasters. SCIM is able to correctly diagnose problem and disruptions from organization. It plays an important role in delivering goods to their destination very quickly, safely and efficiently. Inventory management (IM)

worked in such a queer and unpredictable atmosphere and expound the optimal solution of IM. Most of these researchers have discussed the inventory model with the help of producer, retailer and buyer. Chou (2000) developed the integrated IM for deteriorating item. Rani and Kishan (2011) described a MEIM for deteriorating items. Demand is variable in his model. Singh and Singh (2010) developed an SCIM with imperfect production in the environment of inflation and fuzzy sense. Jaggi *et al.* (2012) developed the IM for deteriorating items in fuzzy sense by using time varying demand. Gupta and Singh (2013) formulated an integrated IM with fuzzy variables, variable holding cost and three-parameter Weibull deterioration under inflation. Maihami *et al.* (2019) discussed the MESCIM with deteriorating items under probabilistic environment. Sarkar *et al.* (2019) introduced a joint IM for online to offline closed loop supply chain. Jiang *et al.* (2019) formulated a sustainable SCIM under carbon footprint consideration. Sebatjane and Adetunji (2020) developed a MEIM with price dependent demand for economic growing quantity model. Sana, S. S. (2020) introduced a structural model on MEIM. Lu *et al.* (2020) developed a multistage sustainable production model for under carbon reduction and stackelberg game. In this model demand depends on price. Padiyar *et al.* (2023) discussed the benefits of preservation Green and quality improvement investment in fuzzy and learning environment.

Inflation is measured as an annual percentage increase. As inflation increases, every price you own buys a little percentage of a good or service. Jaggi *et al.* (2006) proposed the optimal inventory replenishment policy of damaged items under inflation using a discounted cash flow approach for a finite horizon. Kumar *et al.* (2009) discussed an IM with quadratic demand for deteriorating goods with inflation and trade credits. Yang *et al.* (2010) discussed a model for lot size for deterioration items which is studied under inflation. Gilding (2014) investigated a model on inflation and the inventory replenishment schedule within a finite planning horizon. The subject of this paper is to find out the optimal replenishment schedule for an IM, here demand is time-dependent and finite time planning horizon is assumed. It is also shown that by taking inflation into account has a profound effect on the solution of the problem. Palanivel and Uthayakumar (2016) proposed a two-warehouse IM for non-instantaneous deteriorating items with the credit period, inflation and partial backlogging. Singh *et al.* (2018) formulated a two-warehouse IM for damaged items with variable demand and partial backlogging under inflation.

Inventory is a form of physical resource that keeps any business running efficiently. There are many types of products in the market, which have their own time period to survive or be safe, after this all these products are seen to decline, and all these products are called deteriorating items. There are many products in the market that can be returned in the event of damage. But there are lots of products that are not returned after spoilage such as dairy products and medicines etc. Many authors have developed several IMs for deteriorating products. Rau *et al.* (2003) formulated the multi-echelon inventory model (MEIM) for bad goods. Singh and Gupta (2016) formulated an IM with error in quality inspection. They have also taken demand as a function of selling price and volume agility. Mishra (2018) developed a three rate of production IM for deteriorating items under selling price dependent demand. Panda *et al.* (2019) developed an IM for deteriorating items with warehouse. They have also taken demand as a function of price. Rani *et al.* (2020) formulated an IM by making green SCM for the deteriorating products. They have taken demand as a function of credit period. Shaikh *et al.* (2020) discussed an IM for deteriorating items under preservation technology and shortage. They have used demand as a ramp type and policy of trade credit. Gupta *et al.* (2020) introduce an IM with the help of storage problem and partial backlogging for the deteriorating items and

policy of trade credit. Padiyar et al. (2021) developed an IM with price dependent consumption for deteriorating items with shortages under fuzzy environment.

## 2. Assumptions and notation

2.1 The following assumptions are mainly made to develop the IM.

- Supply chain has been used to develop this model, in which 2 members have been kept in the main role, which is producer, and buyer, in which the producer works like a company and manufactures the inventory and delivers it to each buyer.
- Shortage are not allowed
- Production rate is constant
- Inflation is considered

2.2 In this entire model, the model is developed using the following notation.

- P Production rate for producer  
D Demand rate for producer  
 $\theta_1$  Deterioration rate for producer  
 $h_p$  Holding cost for producer  
 $d_p$  Deterioration cost for producer  
 $T_p$  Fixed transport cost for producer  
 $t_\alpha$  Variable transportation cost in transporting inventory from producer to  $\alpha^{\text{th}}$  buyers  
 $L_\alpha$  Demand rate for  $\alpha^{\text{th}}$  buyer  
 $\theta_2$  Deteriorating rate for each buyers  
J Total number of shipment to the buyer from producer  
R Total number shipment to supplier from buyer  
 $h_\alpha$  Holding cost of  $\alpha^{\text{th}}$  buyer  
 $d_\alpha$  Deteriorating cost of  $\alpha^{\text{th}}$  buyer  
 $A_\alpha$  Ordering cost of  $\alpha^{\text{th}}$  buyer

## 3 Mathematical model

The main objective of developing this model was to ensure that any product is delivered timely and safely from the production house to the final consumer, hence the multi-echelon supply chain model was created. In which the producer prepares the inventory in the production house and fulfill the demand as per the requirement of the buyer, This supply chain is created at two levels, in which the company is playing the role of a manufacturer and the buyer is divided into different groups. Here each buyer orders the inventory as per the demand requirement from the company

### 3.1. Model for producers

In this proposed inventory model, we have one producer, they produce inventory according to the needs of each buyer.

Classification of the entire inventory cycle into two different parts which gives time intervals  $[0, T_1]$  and  $[T_1, T]$ . In the time interval  $[0, T_1]$  there is mixed impact of production, deterioration and demand on the quantity, while during the time interval  $[T_1, T]$  the inventory is only affected by the demand and deterioration. Producer inventory model can be represented by the following first order linear differential equations;

$$\frac{dI_{P1}(t)}{dt} = P - D - \theta_1 I_{P1}(t), \quad 0 \leq t \leq T_1 \quad (1)$$

$$\frac{dI_{P2}(t)}{dt} = -D - \theta_1 I_{P2}(t), \quad T_1 \leq t \leq T \quad (2)$$

With the help of boundary conditions  $I_{P1}(0)=0$ ,  $I_{P2}(T)=0$ ,

Solution of equation (1) and (2) are

$$I_{P1}(t) = \frac{(P-D)}{\theta_1} [1 - e^{-\theta_1 t}] \quad (3)$$

$$I_{P2}(t) = \frac{D}{\theta_1} [e^{\theta_1(T-t)} - 1] \quad (4)$$

(a) Holding cost: Holding cost involved in careful storage and maintenance of inventory including hardware equipment, material handling equipment, IT software applications and the holding cost for producer is

$$H_P = h_p \left[ \int_0^{T_1} I_{P1i}(t) e^{-rt} dt + \int_{T_1}^T I_{P2i}(t) e^{-rt} dt \right]$$

$$H_P = h_p \left[ \frac{(P-D)}{\theta_1} \left\{ \left( \frac{1-e^{-rT_1}}{r} \right) + \left( \frac{e^{-(\theta_1+r)T_1}-1}{\theta_1+r} \right) \right\} + \frac{D}{\theta_1} \left\{ e^{\theta_1 T} \left( \frac{e^{-(\theta_1+r)T_1}-e^{-(\theta_1+r)T}}{\theta_1+r} \right) + \left( \frac{e^{-rT}-e^{-rT_1}}{r} \right) \right\} \right] \quad (5)$$

(b) Deterioration cost: Deterioration cost involves due to the deterioration of items that become useless so the deteriorating cost for producer is

$$D_P = \theta_1 d_p \left[ \int_0^{T_1} I_{P1i}(t) e^{-rt} dt + \int_{T_1}^T I_{P2i}(t) e^{-rt} dt \right]$$

$$D_P = \theta_1 d_p \left[ \frac{(P-D)}{\theta_1} \left\{ \left( \frac{1-e^{-rT_1}}{r} \right) + \left( \frac{e^{-(\theta_1+r)T_1}-1}{\theta_1+r} \right) \right\} + \frac{D}{\theta_1} \left\{ e^{\theta_1 T} \left( \frac{e^{-(\theta_1+r)T_1}-e^{-(\theta_1+r)T}}{\theta_1+r} \right) + \left( \frac{e^{-rT}-e^{-rT_1}}{r} \right) \right\} \right] \quad (6)$$

(c) Transportation cost:

$$TPC_P = T_P + \sum_{\alpha=1}^m (I_{B\alpha}) t_\alpha \left( \frac{1-e^{-rjT_2}}{1-e^{-rT_2}} \right) \quad (7)$$

Total profit cost for producer is dependsonallabovecost so the total profit cost for producer is:

$$TCP = \frac{1}{T} [H_P + D_P + TPC_P] \quad (8)$$

### 3.2 Model for Buyers

There are total m buyers but each buyer has its own separate supply chain, under which there are different number of suppliers. At the beginning of the cycle  $\alpha^{th}$  buyer receives  $Q_{B\alpha}$  unit inventory by the multi producers, which it transport to a total of R shipments to own group of suppliers.

Buyer's inventory model can be represented by the following equation.

$$\frac{dI_{B\alpha}(t)}{dt} = -L_\alpha - \theta_2 I_{B\alpha}(t), \quad 0 \leq t \leq T_2 \quad (9)$$

Where  $\alpha=1,2,3 \dots m$ , and  $I_{B\alpha}(T_2) = 0$ ,

Solution of equation (9) is

$$I_{B\alpha}(t) = \frac{L_\alpha}{\theta_2} (e^{\theta_2(T_2-t)} - 1), \quad (10)$$

Buyer's total cost depends on following factors;

(a) Holding cost:

$$H_B = \sum_{\alpha=1}^m \sum_{\chi=1}^j h_{\alpha} \left[ \int_{(\chi-1)T_2}^{\chi T_2} I_{B\alpha}(t) e^{-rt} dt \right]$$

$$H_B = \sum_{\alpha=1}^m \sum_{\chi=1}^j h_{\alpha} \frac{L_{\alpha}}{\theta_2} \left[ e^{\theta_2 T_2} \left( \frac{e^{-(\theta_2+r)(\chi-1)T_2} - e^{-(\theta_2+r)\chi T_2}}{\theta_2+r} \right) + \left( \frac{e^{-r\chi T_2} - e^{-r(\chi-1)T_2}}{r} \right) \right] \quad (11)$$

(b) Deterioration cost: deteriorating cost involves due to the deterioration of items that become useless so the deteriorating cost for buyer is

$$D_B = \sum_{\alpha=1}^m \sum_{\chi=1}^j d_{\alpha} \theta_2 \left[ \int_{(\chi-1)T_2}^{\chi T_2} I_{B\alpha}(t) e^{-rt} dt \right]$$

$$D_B = \sum_{\alpha=1}^m \sum_{\chi=1}^j d_{\alpha} L_{\alpha} \left[ e^{\theta_2 T_2} \left( \frac{e^{-(\theta_2+r)(\chi-1)T_2} - e^{-(\theta_2+r)\chi T_2}}{\theta_2+r} \right) + \left( \frac{e^{-r\chi T_2} - e^{-r(\chi-1)T_2}}{r} \right) \right] \quad (12)$$

(d) Ordering cost: Ordering cost is the total cost involved in ordering the items including the cost of finding producer and inspection of the inventory so total ordering cost for the buyer is

$$O_B = \sum_{\alpha=1}^m A_{\alpha} \quad (13)$$

Total cost for buyer is depend on, ordering cost, holding cost, and deteriorating cost so total cost for buyer is:

$$TCB = \frac{1}{T} [H_B + D_B + O_B] \quad (14)$$

Total cost in this supply chain is

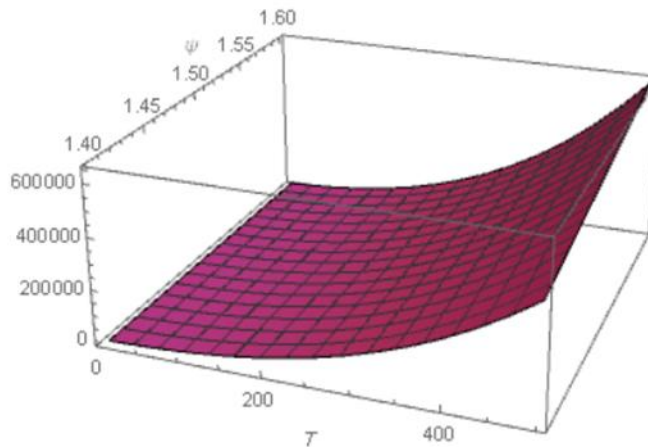
$$TPC = TCP + TCB \quad (16)$$

#### 4. Numerical example

The stability and viability of the proposed models are illustrated in this section using a continuous review inventory system. Numerical values for the parameters with appropriate units can be used to illustrate the mathematical model developed as follows:

Here  $T$  and  $T_1$  are decision variable and  $T_2 = \frac{T}{J}$ ,  $J=2$ ,  $r = 0.15$ , Using 190 the software Mathematica -12.0 for solving the problem.

$P=100$ ,  $D=95$ ,  $\theta_1=0.5$ ,  $h_p=0.2$ \$/unit,  $d_p=0.15$ \$/unit,  $t_1=0.5$ \$/unit,  $t_2=0.6$ \$/unit,  $T_p=1.8$ \$,  $\theta_2=0.35$ ,  $L_1=65$ ,  $L_2=40$ ,  $h_1=0.4$ \$/unit,  $h_2=0.5$ \$/unit,  $d_1=0.2$ \$/unit,  $d_2=0.15$ \$/unit,  $A_1=0.7$ \$,  $A_2=0.5$ \$, We get  $TC=190$  \$,  $T=30$ ,  $T_1=16$ ,  $T_2=8$ .



**Fig .1stability and viabilityoftheproposedmodels**

**5. Sensitivityanalysis**

Table1. Sensitivity analysis with respect to various parameters

Parameters	% Change	$(Time)T_1$	$(Time)T$	Total cost(TC)
P=100	-20	13.65	31	192.675
	-10	14.932	30.87	192.543
	10	16.55	30.01	189.51
	20	16.90	30.0025	188.57

Parameters	% Change	$(Time)T_1$	$(Time)T$	Total cost(TC)
D=95	-20	14.152	30.515	184.56
	-10	14.27	30.515	185.432
	10	15.9	30.515	192.90
	20	15.93	30.515	191.959

Parameters	% Change	$(Time)T_1$	$(Time)T$	Total cost(TC)
$\theta_1=0.5$	-20	15	32.12	190.187
	-10	15	32.679	190.146
	10	15	30.675	190.135
	20	15	28.567	190.134

Parameters	% Change	$(Time)T_1$	$(Time)T$	Total cost(TC)
$\theta_2=0.35$	-20	15.988	30.95	190.865
	-10	15.95	30.5	190.756
	10	15.07	30.565	190.189

	20	15.05	32.567	190.156
--	----	-------	--------	---------

## 6. Observation:

- If the production rate increases, then it is seen that the production period is decreasing and at the same time the total cost is decreasing.
- Through sensitivity, it was found that if the demand rate increases, then the production time period is decreasing and at the same time the total cost is increasing but there is no effect on the cycle length  $T$ .
- After slightly increasing the Deterioration Rate acceptable to the producer, it was found that the production lead time was decreasing and the total cost and cycle length  $T$  were also continuously decreasing.
- After slightly increasing the Deterioration rate acceptable to the buyer, it was found that the production time period is decreasing and the total cost is also decreasing but the cycle length  $T$  is continuously increasing.

## 7. Conclusion

This study developed a supply chain model through which the inventory can be delivered to every buyer at the earliest as possible. Here, there is a producer and multiple buyers. Inflation is also added to the model for inflationary fluctuations. To understand this model in real life, numerical example is discussed and the total cost from the supply chain has been extracted. Through this study, it is concluded that the total cost is found to be minimum when the production rate increases.

The model can be extended by incorporating sustainability factors into the supply chain model, including inflation in a fuzzy environment along with the environmental impact of production and distribution decisions and using machine learning to improve decision making and incorporating advanced analytics techniques such as artificial intelligence for inventory optimization.

## References

1. Asghar, I., & Kim, J. S. (2020). An automated smart EPQ based inventory model for technology dependent product under stochastic failure and repair rate. *Symmetry*. 12, 388.
2. Mallick, R. K., Patra, K., & Mondal, S. K. (2020). Mixture inventory model of lost sale and back order with stochastic lead time demand and permissible delay in payments. *Annals of Operations Research*. 292, 341-369.
3. Mashud, A. H., Roy, D., Daryanto, Y., & Ali, M. H. (2020). A sustainable inventory model with imperfect products, deterioration, and controllable emissions. *Mathematics*. 8, 2049.
4. Sarkar, M., & Chung, B. D. (2021). Effect of renewable energy to reduce carbon emission under a flexible production system: A step towards sustainability. *Energies*. 14, 215.
5. Mishra, U. (2018). Optimizing a three rate of production inventory model under market selling Price and advertising cost with deteriorating items. *International Journal of Management Science and Engineering Management*. 13, 4, 295-305.

6. Gupta, M. Tiwari, S., & Jaggi, C. K. (2020). Retailer's ordering policies for time varying deteriorating items with partial backlogging and permissible delay in payments in a two warehouse environment. *Annals of Operations Research*. 295, 139-161.
7. Sarkar, B., Ullah, M., & Choi, S. B. (2019). Joint inventory and pricing policy for an online to offline closed loop supply chain model with random defective rate and returnable transport items. *Mathematics*. 7, 497,
8. Jiang, Y., Zhao, Y., Dong, M., & Han, S. (2019). Sustainable supply chain network design with carbon footprint consideration: A case study in china. *Mathematical Problems in Engineering*. Artical ID 3162471.
9. Sebatjane, M., & Adetunji, O. (2020). A three echelon supply chain for economic growing quantity model with Price and freshness dependent demand: pricing, ordering, and shipment decisions. *Operations Research Perspectives*. 7, 100153.
10. Sana, S. S. (2021). A structural mathematical model on two echelon supply chain system. *Annals of Operations Research*. <https://doi.org/10.1007/s10479-020-03895-z>.
11. Lu, C. J., Lee, T. S., Gu, M., & Yang, C. T. (2020). A multistage sustainable production inventory model with carbon emission reduction and Price dependent demand under stackelberg game. *Applied Sciences*. 10, 4878.
12. Padiyar, S.V.S., Bhagat, N. and Rajput, N.(2021) 'Integrated supply chain model for imperfect production and fuzzy parameters with probabilistic demand pattern and variable production rate under the environment of inflation', *Journal of Emerging Technology and Innovative Research*, 8(11), 630-641.
13. Padiyar, S.V.S., Kuraie, V.C., Bhagat, N., Singh, S.R. and Dem H.(2022) 'green integrated model for imperfect production process under reliability' *Journal of Mathematical Control Science & Applications*, 8(1), 1-13.
14. Padiyar, S.V.S., Singh, S.R. and Punetha, N.(2021) 'Inventory system with price dependent consumption for deteriorating items with shortage under fuzzy environment', *Int. J. Sustainable Agricultural Management and Informatics*, 7( 3), 218-231,
15. Padiyar, S. V. S., Kuraie, V. C., Rajput, N., Padiyar, N. B., Joshi, D. and Adhikari, M.(2021): Production inventory model with limited storage problem for perishable items under learning and inspection with fuzzy parameters, *Design Engineering* 2021(9), 12821-12839.
16. Padiyar, S.V.S., Kuraie, V.C., Bhagat, N., Singh, S.R. and Chaudhar, R. (2022) 'An integrated inventory model for imperfect production process having preservation facilities under fuzzy and inflationary environment', *Int. J. Mathematical Modelling and Numerical Optimisation*, 12(3), 252-286.
17. Padiyar, S.V.S.; Vandana; Singh, S.R.; Singh, D.; Sarkar, M.; Dey, B.K.; Sarkar, B.(2023) Three-Echelon Supply Chain Management with Deteriorated Products under the Effect of Inflation. *Mathematics*, 11(104), 1-19.
18. Padiyar, S.V.S., Bhagat, N., Singh, S.R. and Punetha, N.(2023) 'Multi echelon fuzzy inventory model for perishable items in a supply chain with imperfect production and exponential demand rate', *Int. J. Process Management and Benchmarking*, 14(1), 23-51.

19. Kuraie, V. C., Padiyar, S. V. S., Bhagat, N., Singh, S.R., and Katariya, C. (2021). Imperfect Production Process in an Integrated Inventory System Having Multivariable Demand with Limited Storage Capacity, *Design Engineering* 2021(9.), 1505-1527.
20. Jain, K., Makholia, D., Mishra, R., Kumar, A., Kashyap, R. C., Bhagat, N., and Padiyar, S. V. S. (2023). Review on Green Inventory Model and Reverse Logistic, *Eur. Chem. Bull.* 12(10), 4254-4267.
21. Ummeferva, Singh, S. R., Padiyar, S. V. S. (2023). Two level trade credit policy approach for a production inventory model under greening degree dependent demand and reliability. *Eur. Chem. Bull.* 12(10), 4278-4291.
22. Padiyar, S. V. S., Bhagat, N., Singh, S. R., Gupta, V., & Sarkar, B. (2022). Joint replenishment strategy for deteriorating multi-item through multi-echelon supply chain model with imperfect production under imprecise and inflationary environment, *RAIRO*, 56(4), 3071-3096.
23. Padiyar, S. V. S., Bhagat, N., & Punetha, N. (2023). A multistage sustainable inventory model with backorder, fuzzy parameters and decision variable for deteriorating items with imperfect production and reliability, *International journal of applied decision sciences*. 16(4), 445-473.
24. Kumar, A., Joshi, K., Bhagat, N., Punetha, N., and Padiyar, S. V. S., (2022). Mathematical modelling and analysis on green inventory model with shortages space for imperfect quality of deteriorating item with trapezoidal type demand. *Neuro Quantology*, 20(14), 2468-2478.
25. Kuraie, V. C., Padiyar, S. V. S., Bhagat, N., and Rajput, N. (2021). Imperfect production inventory model with selling price dependent demand rate and reliability under the inflationary and fuzzy environment. *IJESC*, 11(12), 29109-29116.
26. Padiyar, S.V.S., Gupta, V., and Rajput, N. (2023), Multi echelon supply chain inventory model for perishable items with fuzzy deterioration rate and imperfect production with two warehouse under inflationary environment. *International Journal of Business Performance and Supply Chain Modelling*. 14(2), 144-172.
27. Padiyar, S. V. S., Bhagat, N., Singh, S. R., Punetha, N., and Dem, H. (2023) Production policy for an integrated inventory system under cloudy fuzzy environment. *Int. J. of Applied Decision Sciences*. 16(3), 255-299.
28. Padiyar, S. V. S., Joshi, A., and Rajput, N. (2022). A fuzzy inventory problem based on management for deteriorating item with Remanufacture process. *Stochastic Modelling & Application*. 26(8), 442-462.
29. Padiyar, S. V. S., Padiyar, N. B., Adhikari, M. Joshi, D., and Singh, R. (2021). A mathematical imperfect production inventory problem for perishable items considering two different warehouse under fuzzy environment. *International journal of Innovative Research in Technology*. 8(7), 330-339.
30. Padiyar, S. V. S., Ginwal, R., Kumar A., and Bhagat, N. (2021). Green production inventory model for with remanufacture process and backordering under the reverse logistics. *Bulletin Monumental*. 22(8), 192-197
31. Jauhari, W. M., Adam, N. A. F. P., Rosyidi, C. N., Pujawan, N., & Shah, N. H. (2020). A closed loop supply chain model with rework, waste disposal, and carbon emissions. *Operations Research Perspectives*. 7, 100155.

32. Singh, S.R., & Gupta, V. (2016). Vendor–buyer model with error in quality inspection and selling price dependent demand rate under the effect of volume agility. *Int. J. Oper. Quant. Manag.* 22(4), 357-371.
33. Yang, H.L., Teng, J.T., & Chern, M.S. (2010). An inventory model under inflation for deteriorating items with stock-dependent consumption rate and partial backlogging shortages. *International Journal of Production Economics*, 123(1), 8-19.
34. Jaggi, C.K., Aggarwal, K.K., & Goel, S.K. (2006). Optimal order policy for deteriorating items with inflation induced demand. *International Journal of Production Economics*, 103(2), 707-714.
35. Kumar, M., Singh, S.R., & Pandey, R. K. (2009). An inventory model with quadratic demand rate for deteriorating items with trade credits and inflation. *Journal of Interdisciplinary Mathematics*, 12 (3), 331-343.
36. Rau, H., Wu, M. Y., & Wee, H. M. (2003). Integrated inventory model for deteriorating items under a multi-echelon supply chain environment. *International Journal of Production Economics*, 86, 155-168.
37. Shaikh, A. K., Panda, G. C., Khan, M. A., Mashud, A. H., & Biswas, A. (2020). An inventory model for deteriorating items with preservation facility of ramp type demand and trade credit. *International Journal in Operational Research*, 17(4).
38. Agarwal, A., Sangal, I., Singh, S.R., & Rani, S. (2018). Two warehouse inventory model for lifetime deterioration and inflation with exponential demand and partial lost sales. *International Journal of Pure and Applied Mathematics*, 118 (22), 1253-1265.
39. Singh, S., sharma, S., & Pundir, S.R. (2018). Two-warehouse inventory model for deteriorating items with time dependent demand and partial backlogging under inflation. *International Journal of mathematical modelling and computations*, 08(02), 73-88.
40. Palanivel, M., & Uthayakumar, R. (2016). Two-warehouse inventory model for non–instantaneous deteriorating items with optimal credit period and partial backlogging under inflation. *Journal of Control and decision*, 3(2), 132-150.
41. Gilding, B.H. (2014). Inflation and the optimal inventory replenishment schedule within a finite planning horizon. *European Journal of Operational Research*, 234(3), 683-693.
42. Rani, S., Ali, R., & Agarwal, A. (2020). Inventory model for deteriorating items in green supply chain with credit period dependent demand. *International Journal of Applied Engineering Research*, 15(2), 157-172.
43. Chou, T. H. (2000). Integrated two–stage inventory model for deteriorating items. *Master's Thesis, Chung Yuan Christian University Taiwan, ROC.*
44. Rani, M., & Kishan, H. (2011). A multi echelon supply chain inventory model with variable demand rate for deteriorating items. *Pure and Applied Mathematics science vol, LXXIV, No 1-2*, 31-44.
45. Singh, C., & Singh, S. R. (2010). Two echelon supply chain model with imperfect production, for weibull distribution deteriorating items under imprecise and inflationary. *International Journal of Operation Research and optimization*, 1(1), 9-25.
46. Jaggi, C. K., Pareek, S., Sharma, N., & Nidhi. (2012). Fuzzy inventory model for deteriorating items with time varying demand and shortage. *American Journal of Operational Research*, 2(6), 81-92.

47. Maihami, R., Govindan, K., & Fattahi, M. (2019). The inventory and pricing decisions in a three-echelon supply chain of deteriorating items under probabilistic environment. *Transportation Research Part E: Logistic and Transportation Review*, 131, 118-138.
48. Gupta, V., & Sangal, I. (2016). Vendor –supplier cooperative inventory model with two warehouse and variable demand rate under the environment of volume agility. *Proceeding of Fifth International Conference on Soft Computing for Problem Solving (ICSCPS)* 109-123.
49. Gupta, V., & Singh, S. R. (2013). An integrated inventory model with fuzzy variables, three-parameter Weibull deterioration and variable holding cost under inflation. *International Journal of Operation Research*, 18(4),
50. Singh, S. R., & Gupta, V. (2014). Supply chain production model with preservation technology under fuzzy environment. *International Journal of Industrial Engineering Computations*, 5(3), 459-474.
51. Singh, S.R., Gupta, V., & Gupta, P. (2013). Three stages supply chain model with two warehouse, imperfect production, variable demand rate and inflation. *International Journal of Industrial Engineering Computations*, 4, 81-92.
52. Singh, S. R., & Rana, K. (2020). Effect of inflation and variable holding cost on life time inventory model with multi variable demand and lost sales. *Int J Recent Technol Eng*, 8, 5513-5519.
53. Padiyar, S.V.S, Singh, S.R., & Punetha, N. (2021). Inventory system with price dependent consumption for deteriorating items with shortages under fuzzy environment. *Int J of Sustainable Management and Informatics*, 7, 3, 218-231.