Integratedinventorymodelwithinflationfordeterioratingitems

Abstract

The integrated inventory model works like a multi-tier supply chain involving a manufacturer, buyer, supplier, and customer. In the proposed article, integrated inventory management for perishable items has been developed. It is an essential responsibility of every supply chain member to ensure that any inventory can be delivered to the customer smoothly and on time. The model of inflation fluctuations takes into account inflation as one of its factors.This model considers the movement of inventory from production to supply in real data; Numerical examples have been explored to facilitate a practical understanding of this model in real-life situations, and the aggregate cost from the entire supply chain has been calculated. The model concludes with a sensitivity analysis, revealing the effects on the overall model stemming from alterations in key parameters that exert significant influence.

Keywords: Multi echelon; Inflation; deteriorating items

1. Introduction

In thecurrentlandscapeofheightenedcompetitionacrossvarious industries, itisundeniably crucial forbusinessestoefficientlyreach a maximumnumberofcustomers, providingproductsorservices at competitive prices and meeting customerdemandswithinstipulated timelines.Theinvolvementof a supplychainsystemwithmultipletiers has beensignificant in variousaspectsbeacausethemulti-echelonsupplychainmanagementfunctions as anentity, akintoanorganization, whereallitsmembers share theresponsibilityof meeting customerrequirements.Manyauthorsdiscussedaboutinventorymanagment base don economiccondition.Asghar et al. (2020) present an automatedInventory Management (I.M.) systembasedonpolicyeconomicproduction, specificallydesignedtoencompasshigh-technologyitems.Mallick et al. (2020) created an Inventory Management (IM) modelthatincludespermissibledelays in payment and accountsfor time-dependentdemand.Thesupplychainmanagementfunctionsakintoanorganization, and itisthecollectiveresponsibilityofallitsmemberstomeetcustomerneeds and ensureeachstageofthesupplychainsystemishighlyprofitableMashud et al. (2020) explored a sustainableInventory Management (IM) approachconsideringcontrollableemissionsforimperfectproducts. Sarkar and Chung (2021) formulated a sustainableInventory Management (IM) model, combining a versatileproductionsystemwiththeintegrationoftechnologyfocusedonreducingcarbonemissions.
Mishra et al. (2020) created a sustainableproductionInventory Management (IM) modelfocusingon a singular itemtype. In thismodel, allitems are conveyedtoconsumersusing a single transportationmode, and considerations are madeforshortageswhileconcurrentlyaddressingthereductionofcarbonemissions.In thebroadercontext, theSupplyChainInventoryModel (SCIM) has traditionallytakenintoaccountvarioussub-systems. However, withrecentadvancements in transmission and informationtechnologies, theintegrationofthesefunctions has become a common and noticeabletrend.Thesupplychain (SC) has

gainedparamountimportanceforresearchersamidsttheevolvingmarketdynamics. SupplyChainInventoryModels (SCIM) are instrumental in optimizingvariousscenarios, rangingfromtheproducer'sworkflowtoeffectivelymanagingchallengesposedby natural disasters.SCIM excelsin accuratelydiagnosingproblems and disruptionswithinorganizations. Itplays a pivotal role in swiftly, safely, and efficientlydeliveringgoodstotheirdestination. Inventory Management (IM) operates in a unique and unpredictableenvironment, providingoptimalsolutionsforeffectivemanagement in suchconditionsManyresearchershaveexploredinventorymodelsbyconsideringtheperspectivesofproducers, retailers, and buyers.Chou (2000) formulatedanintegratedInventory Management (IM) approachspecificallydesignedfordeterioratingitems. Ontheotherhand, Rani and Kishan (2011) presented a Multi-EchelonInventory Management (MEIM) modelfocusedondeterioratingitems, accountingfor variable demand in theirformulation. Singh and Singh (2010) created a SupplyChainInventoryModel (SCIM) incorporatingimperfectproductionwithinanenvironmentcharacterizedbyinflation and a fuzzysense.Jaggi et al. (2012) innovativelydevelopedanInventory Management (IM) systemspecificallydesignedforitemsexperiencingdeterioration in a fuzzyenvironment, incorporatingtheinfluenceof time-varyingdemand.Gupta and Singh (2013) devised a comprehensive Inventory Management (IM) modelincorporatingfuzzy variables, variable holding costs, and three-parameter Weibull deterioration, allwithinthecontextofinflation.Maihami et al. (2019) exploredthe Multi-EchelonSupplyChainModel (MESCM) focusingondeterioratingitemswithin a probabilisticenvironment. Meanwhile, Sarkar et al. (2019) presented a collaborativeInventory Management (IM) modelforan online-to-offline closed-loopsupplychain.Jiang et al. (2019) devised a sustainableSupplyChainInventoryModel (SCIM) takingintoaccountcarbonfootprintconsiderations. In a separatestudy, Sebatjane and Adetunji (2020) created a Multi-EchelonInventory Management (MEIM) modelincorporatingdemandthatisdependentonprice, withintheframeworkofaneconomicgrowthquantitymodel.Sana, S. S. (2020) presented a structuralmodelfor Multi-EchelonInventory Management (MEIM). Lu et al. (2020) formulated a multistagesustainableproductionmodelincorporatingcarbonreduction and a Stackelberggame, wheredemandiscontingentonprice. Additionally, Padiyar et al. (2023) delvedintotheadvantagesofpreservation, greenpractices, and qualityimprovementinvestments in a fuzzy and learningenvironment.

Inflationiscalculated as theyearlypercentagerise.As inflation increases, everypriceyouownbuys a littlepercentageof a goodorservice. J**aggi*et al.* (2006)**suggestedthebeststrategyforrestockinginventory.ofdamageditemsunderinflationusing a discounted cash flowapproachfora finitehorizon. Kumar *et al.* (2009) exploredaninventorymodelinvolvingquadraticdemandforperishablegoods, consideringfactorslikeinflation and tradecredits.Yang and team (2010) examined a modelfordeterminingthelotsizeofperishableitems, consideringtheimpactofinflation. Gilding (2014) explored a modeladdressinginflation and thescheduleforinventoryreplenishmentwithin a limitedplanningtimeframe.Thispaperaimstodiscoverthebestreplenishmentscheduleforaninventory managementsystem, considering time-dependentdemand and assuming a finite planninghorizon.Itisalsoshownthatbytakinginflationintoaccount has a profoundeffectonthesolutionoftheproblema. Palanivel and Uthayakumar (2016) introduced a two-warehouseinventorymanagementmodelfor non-instantaneousdeterioratingitems, incorporatingcreditperiods, inflation, and partialbacklogging. Singh et al. (2018) developed a two-warehouseinventorymanagementmodelfordamageditems, considering variable demand and partialbacklogging in thepresenceofinflation.

Inventory serves as a crucial physicalresourceessentialforthesmoothoperationofanybusiness. In themarket, variousproductshavespecificlifespansor safety periods. Once thisperiodends, theseproductsexperience a decline and fallintothecategoryofdeterioratingitems.Numerousproducts in themarket can be returned in case ofdamage, yetsome, likedairyproducts and medicines, cannot be returned after spoilage. Severalauthorshavedevisedinventorymodelsspecificallyfordeterioratingproducts. Rau et al. (2003)developedthe Multi-EchelonInventoryModel (MEIM) tailoredfor defective goods.Singh and Gupta (2016) formulatedan IM with error in qualityinspection. Theyhavealsotakendemand as a functionofsellingprice and volumen agility. Mishra (2018) developed a threerateofproduction IM fordeteriorating ítems undersellingpricedependentdemand. Panda *et al*. (2019) createdaninventorymanagementmodelfordeterioratingítems withwarehouse. Theyhavealsotakendemand as a functionofprice. Rani et al. (2020)devisedaninventorymanagementmodel, implementinggreensupplychainmanagementfordeterioratingproducts. Theyincorporateddemand as a functionofthecreditperiod. Shaikh et al. (2020)exploredaninventorymanagementmodelfordeterioratingitems, consideringpreservationtechnology and shortages. Theirmodelinvolveddemand as a ramptype and incorporated a tradecreditpolicy. Gupta and team (2020) presentedaninventorymanagementmodeladdressingstorageissues, partialbacklogging, and tradecreditpolicyfordeterioratingitems. Padiyar et al. (2021) createdaninventorymanagementmodelincorporatingprice-dependentconsumptionfordeterioratingitems, consideringshortages in a fuzzyenvironment.

2. Assumptions and notation

2.1 Theinventorymanagementmodelisdevelopedbasedonthefollowingkeyassumptions:

- Thedevelopmentofthismodelincorporates a supplychainframework, with a focusontwoprimary roles: theproducer and thebuyer. Theproduceroperatesakinto a company, overseeingthemanufacturingofinventory and itsdistributiontoeachbuyer.
- Shortage are notallowed
- Productionrateisconstant
- Inflationisconsidered

2.2 In developingthismodel, thefollowing symbols are utilized:

P: Productionrateattributedtotheproducer
D: Rateofdemandfromtheproducer
θ_1 : Deteriorationratefortheproducer
h□ : Holding costincurredbytheproducer
d□ : Deteriorationcostfortheproducer
T□ : Fixedtransportcostfortheproducer
t_a: Variable transportationcostassociatedwithtransferringinventoryfromtheproducertothe αthbuyer
L_a: Demandratefortheαthbuyer

θ_2 : Deterioratingrateapplicabletoeachbuyer
J: Total numberofshipmentstothebuyerfromtheproducer
R: Overallcountofshipmentstothesupplierfromthebuyer
h_a: Holding costforthe αthbuyer
d_a: Deteriorationcostforthe αthbuyer
A_a: Orderingcostforthe αthbuyer

3 Mathematicalmodel

Theprimaryaim in formulatingthismodelwastoensurethe prompt and securedeliveryofproductsfromtheproductionhousetotheendconsumer. Consequently, a multi-echelonsupplychainmodelwasdevised.In whichtheproducer prepares theinventory in theproductionhouse and fulfillsthedemand as per therequirementofthebuyer,
Thissupplychainoperatesontwolevels, withthecompanyserving as themanufacturer, and thebuyersorganizedintodistinctgroups. Eachbuyer places ordersforinventorybasedontheirspecificdemandfromthecompany.

3.1. Modelforproducers

In thepresentedinventorymodel, a sole produceristaskedwithmanufacturinginventorytailoredtothe individual requirementsofeachbuyer.The complete inventorycycleiscategorizedintotwosegments, delineating time intervals $[0, T_1]$ and $[T_1, T]$.Duringthe time interval $[0, T_1]$, thequantityisinfluencedby a combinedimpactofproduction, deterioration, and demand. In thesubsequent time interval $[T_1, T]$, theinventoryissolelyaffectedbydemand and deterioration.Producer inventorymodel can be representedbythefollowingfirstorder linear differentialequations**;**

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

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

Utilizingtheboundaryconditions$I_{P1}(0)=0$, $I_{P2}(T)=0$,
Solutionofequation (1) and (2) are

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

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

(a) Holding cost: The holding costinvolvesthe expenses associatedwiththemeticulousstorage and upkeepofinventory, covering hardware and material handlingequipment, as well as IT software applications. Furthermore, the holding costfortheproduceris

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

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

(b) Deteriorationcost: Deterioration cost arises from the loss of usability in items, rendering them useless. Therefore, the deteriorating cost for the producer is...

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

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

(c) Transportationcost:

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

Theoverallprofitcostfortheproduceriscontingentonalltheaforementionedcosts. Thus, the total profitcostfortheproduceris:

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

3.2 ModelforBuyers

Thereis a total of m buyers, and eachbuyeroperateswithinitsdistinctsupplychain, whereinvaryingnumbersofsuppliers are involved.At theinitiationofthecycle, the αthbuyerreceivesunitinventorybythe multi producers, whichittransportto a total of R shipmentstotheirdesignatedgroupofsuppliers.Therepresentationofthebuyer'sinventorymodeliscapturedbythefollowingequation:

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

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

Solutionofequation (9) is

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

Buyer’s totalcostdependsonfollowingfactors;

(a) Holding cost:

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

$$H_B=\sum_{\alpha=1}^{m}\sum_{\chi=1}^{j}h_\alpha\frac{L_\alpha}{\theta_2}\left[\begin{array}{c}e^{\theta_2T_2}\left(\frac{e^{-(\theta_2+r)(\chi-1)T_2}-e^{-(\theta_2+r)\chi T_2}}{\theta_2+r}\right)\\ +\left(\frac{e^{-r\chi T_2}-e^{-r(\chi-1)T_2}}{r}\right)\end{array}\right] \quad (11)$$

(b) Deteriorationcost: deterioratingcostarises as a resultofitemsdeterioratingtothepointofbecomingunusable. Consequently, thedeterioratingcostforthebuyeris

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

$$D_B=\sum_{\alpha=1}^{m}\sum_{\chi=1}^{j}d_\alpha L_\alpha\left[\begin{array}{c}e^{\theta_2T_2}\left(\frac{e^{-(\theta_2+r)(\chi-1)T_2}-e^{-(\theta_2+r)\chi T_2}}{\theta_2+r}\right)\\ +\left(\frac{e^{-r\chi T_2}-e^{-r(\chi-1)T_2}}{r}\right)\end{array}\right] \quad (12)$$

(d) Orderingcost: Orderingcostencompassesthe total expenses incurred in theprocessoforderingitems, includingthecostsassociatedwithlocatingtheproducer and inspectingtheinventory. Thus, the total orderingcostforthebuyeris

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

Total costforbuyersisdependon, orderingcost, holdingcost, and deterioratingcostso total costforbuyeris:

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

Total cost in thissupplychainis

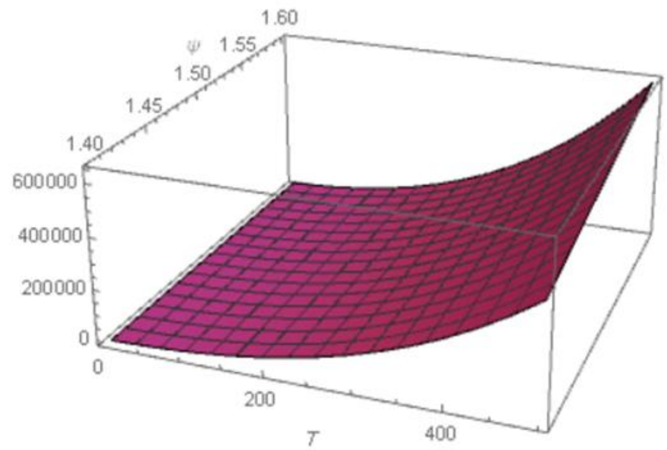
TPC$=TCP + TCB$ (16)

4. Numericalexample

This section demonstrates the stability and effectiveness of the proposed models through the implementation of a continuous review inventory system. Utilizing numerical values for the parameters, along with appropriate units, the mathematical model developed is illustrated as follows:

Here T and T_1 are decision variable and $T_2 = \frac{T}{J}$, J=2, r = 0.15, Using190the software Mathematica -12.0 forsolvingtheproblem.

P= 100, D =95, θ_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$, θ_2=0.35, L_1= 65, L_2= 40, h_1= 0.4$/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, $T_1 = 16$, $T_2 = 8$.



5. Sensitivityanalysis

Table1. Sensitivity analysis with respect to diverse 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)T1*	*(Time)T*	*Total cost(TC)*
θ_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)T1*	*(Time)T*	*Total cost(TC)*
θ_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:

- Iftheproductionrateincreases, thenitisseenthattheproductionperiodisincreasing and at thesame time the total costisdecreasing.
- Throughsensitivity, itwasfoundthatifthedemandrateincreases, thentheproduction time periodisdecreasing and at thesame time the total costisincreasingbutthereis no effectonthecyclelength T.
- After slightlyincreasingtheDeteriorationRateacceptabletotheproducer, itwasfoundthattheproduction lead time wasdecreasing and the total cost and cyclelength T werealsocontinuouslydecreasing.
- After slightlyincreasingtheDeteriorationrateacceptabletothebuyer, itwasfoundthattheproduction time periodisdecreasing and the total costisalsodecreasingbutthecyclelength T iscontinuouslyincreasing.

7. Conclusion

Thisstudy has formulated a supplychainmodeltofacilitatethepromptdeliveryofinventorytoeachbuyer. Themodelinvolves a producer and multiplebuyers, withtheinclusionofinflationtoaccountforinflationaryfluctuationsTograspthepracticalimplicationsofthismodel, a numericalexampleispresented, and the total costfromthesupplychainisderived. Thestudyconcludesthatthe total costisminimizedwhentheproductionrateincreases.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). Anautomatedsmart EPQ basedinventorymodelfortechnologydependentproductunderstochasticfailure and repairrate. *Symmetry*. 12, 388.
2. Mallick, R. K., Patra, K., &Mondal, S. K. (2020). Mixture inventorymodeloflost sale and back orderwithstochastic lead time demando n permisible delay in payments. *AnnalsofOperationsResearch*. 292, 341-369.
3. Mashud, A. H., Roy, D., Daryanto, Y., & Ali, M. H. (2020). Asustainableinventorymodelwithimperfectproducts, deterioration, and controlable emissions. *Mathematics.* 8, 2049.
4. Sarkar, M., & Chung, B. D. (2021). Effectofrenewableenergyto reduce carbonemissionunder a flexible productionsystem: A step towardsustainability. *Energies*. 14, 215.
5. Mishra, U. (2018). Optimizing a threerateofproductioninventorymodelundermarketselling Price and advertisingcostwithdeteriorating ítems. *International Journalof Management Science and Engineering Management.* 13,4, 295-305.
6. Gupta, M. Tiwari, S., &Jaggi, C. K. (2020). Retailer'sorderingpoliciesfor time varyingdeteriorating ítems withpartialbacklogging and permisible delay in payments in a twowarehouseenvironment. *AnnalsofOperationsResearch*. 295, 139-161.
7. Sarkar, B., Ullah, M., & Choi, S. B. (2019). Jointinventory and pricingpolicyforan online to offline closedloopsupplychainmodelwithrandom defective rate and returnabletransport ítems. *Mathematics.* 7, 497,
8. Jiang, Y., Zhao, Y., Dong, M., & Han, S. (2019). Sustainablesupplychainnetworkdesignwithcarbonfootprintconsideration: A case study in china. *MathematicalProblems in Engineering*. Artical ID 3162471.
9. Sebatjane, M., &Adetunji, O. (2020). A threeechelonsupplychainforeconomicgrowingquantitymodelwith Price and freshnessdependentdemand: pricing, ordering, and shipmentdecisions. *OperationsResearchPerspectives*. 7, 100153.
10. Sana, S. S. (2021). A structuralmathematical modelo n twoechelonsupplychainsystem. AnnalsofOperationsResearch. https://doi.org/10.1007/s10479-020-03895-z.
11. Lu, C. J., Lee, T. S., Gu, M., & Yang, C. T. (2020). A multistagesustainableproductioninventorymodelwithcarbonemissionreduction and Price dependentdemandunderstackelberggame. *AppliedSciences.* 10, 4878.
12. Padiyar, S.V.S., Bhagat, N. and Rajput, N.(2021) 'Integratedsupplychainmodelforimperfectproduction and fuzzyparameterswithprobabilisticdemandpattern and variable

productionrateundertheenvironmentofinflation', JournalofEmergingTechnology and Innovative Research,8(11), 630-641.

13. Padiyar , S.V.S., Kuraie, V.C. , Bhagat, N. , Singh, S.R. and Dem H.(2022) ' greenintegratedmodelforimperfectproductionprocessunderreliability' JournalofMathematical Control Science&Applications, 8(1),1-13.
14. Padiyar, S.V.S., Singh, S.R. and Punetha, N.(2021) 'Inventorysystemwithpricedependentconsumptionfordeterioratingitemswithshortageunder fuzzyenvironment', Int. J. SustainableAgricultural 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): Productioninventorymodelwithlimitedstorageproblemforperishableitemsunderlearning and inspectionwithfuzzyparameters, DesignEngineering 2021(9),12821-12839.
16. Padiyar, S.V.S., Kuraie, V.C., Bhagat, N., Singh, S.R. and Chaudhar, R. (2022)'Anintegratedinventorymodelforimperfectproductionprocesshavingpreservationfac ilitiesunderfuzzy and inflationaryenvironment', Int. J. MathematicalModelling 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-EchelonSupplyChain Management withDeterioratedProductsundertheEffectofInflation. Mathematics, 11(104),1-19.
18. Padiyar, S.V.S., Bhagat, N., Singh, S.R. and Punetha, N.(2023) 'Multi echelonfuzzyinventorymodelforperishableitems in a supplychainwithimperfectproduction and exponentialdemandrate', 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).ImperfectProductionProcess in anIntegratedInventorySystemHaving Multivariable DemandwithLimited Storage Capacity, DesignEngineering 2021(9.),1505-1527.
20. Jain, K., Makholia, D., Mishra,R., Kumar, A., Kashyap, R. C., Bhagat, N., and Padiyar, S. V. S. (2023). Reviewon Green InventoryModel and Reverse Logistic, Eur. Chem. Bull.12(10),4254-4267.
21. Ummeferva, Singh, S. R., Padiyar, S. V. S. (2023). Twoleveltradecreditpolicyapproachfor a productioninventorymodelundergreeningdegreedependentdemand and reliabity. Eur. Chem. Bull. 12(10),4278-4291.
22. Padiyar, S. V. S., Bhagat, N., Singh, S. R., Gupta, V., &Sarkar, B.(2022). Jointreplenishmentstrategyfordeterioratingmulti-itemthroughmulti-echelonsupplychainmodelwithimperfectproductionunder imprecise and inflationaryenvironment, RAIRO,56(4),3071-3096.
23. Padiyar, S. V. S., Bhagat, N., &Punetha, N. (2023). A multistagesustainableinventorymodelwithbackorder, fuzzyparameters and decision variable fordeterioratingitemswithimperfectproduction and reliability, International journalofappliesdecision sciences.16(4), 445-473.
24. Kumar, A., Joshi, K., Bhagat, N., Punetha, N., and Padiyar, S. V. S., (2022).Mathematicalmodelling and analysisongreeninventorymodelwithshortagespaceforimperfectqualityofdeterioratingitem swith trapezoidal typedemand. Neuro Quantology, 20(14), 2468-2478.

25. Kurai, V. C., Padiyar, S. V. S., Bhagat, N., and Rajput, N. (2021). Imperfectproductioninventorymodelwithsellingpricedependentdemandrate and reliabilityundertheinflationary and fuzzyenvironment. IJESC,11(12), 29109-29116.
26. Padiyar, S.V.S., Gupta, V., and Rajput, N.(2023), Multi echelonsupplychaininventorymodelforperishableitemswithfuzzydeteriorationrate and imperfectproductionwithtwowarehouseunderinflationaryenvironment. International Journal of Business Performance and SupplyChainModelling. 14(2),144-172.
27. Padiyar, S. V. S., Bhagat, N., Singh, S. R., Punetha, N., and Dem, H.(2023) Productionpolicyforanintegratedinventorysystemundercloudyfuzzyenvironment. Int. J. ofAppliedDecisionSciences. 16(3), 255-299.
28. Padiyar, S. V. S., Joshi, A., and Rajput, N. (2022). A fuzzyinventoryproblembasedonmanagementfordeterioratingitemwith Remanufacture process. StochasticModelling&Application. 26(8),442-462.
29. Padiyar, S. V. S., Padiyar, N. B., Adhikari, M. Joshi,D., and Singh, R. (2021). A mathematicalimperfectproductioninventoryproblemforperishableitemsconsideringtwodifferentwarehouseunderfuzzyenvironment. 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 productioninventorymodelforwith remanufacture process and backorderingunderthe 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 closedloopsupplychainmodelwithrework, wastedisposal, and carbonemissions. OperationsResearchPerspectives. 7, 100155.
32. Singh, S.R., & Gupta, V. (2016). Vendor–buyermodelwith error in qualityinspection and sellingpricedependentdemandrateundertheeffectofvolumeagility. *Int. J. Oper. Quant. Manag.* 22(4), 357-371.
33. Yang, H.L., Teng, J.T., &Chern, M.S. (2010). Aninventorymodelunderinflationfordeterioratingitemswith stock-dependentconsumptionrate and partialbackloggingshortages. *International JournalofProductionEconomics*, 123(1), 8-19.
34. Jaggi, C.K., Aggarwal, K.K., &Goel, S.K. (2006). Optimalorderpolicyfordeterioratingitemswithinflationinduceddemand. *International JournalofProductionEconomics,* 103(2), 707-714.
35. Kumar, M., Singh, S.R., & Pandey, R. K. (2009). Aninventorymodelwithquadraticdemandratefordeterioratingitemswithtradecredits and inflation. *JournalofInterdisciplinaryMathematics*, 12 (3), 331-343.
36. Rau, H., Wu, M. Y., &Wee, H. M. (2003). Integratedinventorymodelfordeterioratingitemsunder a multi-echelonsupplychainenvironment. *International JournalofProductionEconomics*, 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). Inventorymodelfordeterioratingitems in greensupplychainwithcreditperioddependentdemand. *International JournalofAppliedEngineeringResearch*, *15*(2), 157-172.
43. Chou, T. H. (2000). Integratedtwo–stageinventorymodelfordeterioratingitems. *Master'sThesis, Chung Yuan Christian UniversityTaiwan, ROC*.
44. Rani, M., &Kishan, H. (2011). A multi echelonsupplychaininventorymodelwith variable demandratefordeterioratingitems. *Pure and AppliedMathematiksciencevol,* LXXIV, No1-2.31-44.
45. Singh, C., & Singh, S. R. (2010). Twoechelonsupplychainmodelwithimperfectproduction, forweibulldistributiondeterioratingitemsunder imprecise and inflationary. *International JournalofOperationResearch and optimization*, 1(1), 9-25.
46. Jaggi, C. K., Pareek, S., Sharma, N., &Nidhi. (2012). Fuzzyinventorymodelfordeterioratingitemswith time varyingdemand and shortage. *American JournalofOperationalResearch*, 2(6), 81-92.
47. Maihami, R., Govindan, K., &Fattahi, M. (2019). Theinventory and pricingdecisions in a three-echelonsupplychainofdeterioratingitemsunderprobabilisticenvironment. *TransportationResearchPart E: Logistic and TransportationReview,* 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). Anintegratedinventorymodelwithfuzzy variables, three-parameter Weibull deterioration and variable holding costunderinflation. *International JournalofOperationResearch*, 18(4),
50. Singh, S. R., & Gupta, V. (2014). Supplychainproductionmodelwithpreservationtechnologyunderfuzzyenvironment. *International Journalof Industrial EngineeringComputations*, 5(3), 459-474.
51. Singh, S.R., Gupta, V., & Gupta, P. (2013). Threestagesupplychainmodelwithtwowarehouse, imperfectproduction, variable demandrate and inflation. *International Journalof Industrial EngineeringComputations.* 4, 81-92.
52. Singh, S. R., & Rana, K. (2020). Effectofinflation and variable holding costonlife time inventorymodelwith multi variable demand and lost sales. *Int J RecentTechnol Eng*, *8*, 5513-5519.
53. Padiyar, S.V.S, Singh, S.R., &Punetha, N. (2021). Inventorysystemwithpricedependentcunsumptionfordeterioratingitemswithshortagesunder fuzzyenvironment. Int J ofSustainable Management and Informatics, 7, 3, 218-231.