International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** V **Month of publication:** May 2026

DOI: https://doi.org/10.22214/ijraset.2026.81388

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

An Integrated Inventory Optimization Model for Deteriorating Agricultural Commodities Under Time-Dependent Demand and Trade Credit: Evidence from Marathwada Region

Mr. A. D. Rajegore[1], Dr. K. Y. Ingale[2]
[1, 2]Department of Statistics, SRTMU Nanded

Abstract: This paper develops and validates an integrated Economic Order Quantity (EOQ) model for deteriorating agricultural commodities under linearly time-dependent demand with permissible delay in payments (trade credit). The model is formulated using the Ghare-Schrader differential equation framework and solved analytically, yielding closed-form expressions for the optimal order quantity (Q*), optimal cycle time (T*), and minimum total cost per unit time (TC*). Two cases are distinguished based on the relationship between cycle length and trade credit period, generating distinct optimality conditions for each. Empirical calibration is performed using primary data collected from 180 wholesale traders at Agricultural Produce Market Committees (APMCs) in Aurangabad and Nanded districts of Marathwada, Maharashtra. Numerical results demonstrate that the optimized model reduces total inventory cost by 18.4 to 31.2 percent compared with observed trader practices, with the gains concentrated in reduction of deterioration and holding costs. Sensitivity analysis confirms robustness across a ±30% parameter range. The paper contributes to the deteriorating inventory literature by providing the first region-specific calibrated model for Marathwada, and offers actionable policy guidance for traders, cooperative societies, and the Maharashtra State Agricultural Marketing Board.

Keywords: deteriorating inventory; EOQ model; time-dependent demand; trade credit; Marathwada; agricultural commodities; post-harvest losses; sensitivity analysis

I. INTRODUCTION

Post-harvest losses represent one of the most economically damaging yet systematically under-addressed challenges in India's agricultural marketing system. In the Marathwada region of Maharashtra — a semi-arid zone of approximately 64,590 km² comprising the eight districts of Aurangabad (Chhatrapati Sambhajinagar), Nanded, Latur, Beed, Osmanabad (Dharashiv), Jalna, Parbhani, and Hingoli — these losses are particularly severe. Ambient summer temperatures that regularly exceed 42°C, inadequate cold-chain infrastructure, erratic electricity supply, and a predominantly small-holder farming structure combine to produce post-harvest loss rates of 25 to 40 percent for horticultural commodities and 8 to 15 percent for cereals (National Centre for Cold-Chain Development, 2023; Food and Agriculture Organization, 2022).

The discipline of inventory theory offers a rigorous mathematical framework for addressing such losses through the optimization of replenishment policies. Classical inventory theory, originating with the Economic Order Quantity (EOQ) model of Harris (1913) and Wilson (1934), has evolved over more than a century to address the specific challenges posed by items that deteriorate physically over time. The foundational contribution of Ghare and Schrader (1963) established the mathematical treatment of deterioration as a continuous exponential decay process, while subsequent decades of research have extended this framework to encompass time-varying demand, trade credit, preservation technology investment, and stochastic parameter uncertainty.

Despite this rich theoretical literature, a critical gap persists: the vast majority of published inventory models are formulated at a high level of abstraction with parameter values that may not be representative of any particular market environment. Region-specific, empirically calibrated models that translate theoretical insights into actionable policy guidance for traders operating in specific agro-climatic and institutional contexts remain rare. The Marathwada region — with its distinctive climate, supply chain structure, and financial characteristics — exemplifies this gap.

This paper addresses the gap by developing an analytically tractable EOQ model for deteriorating items under linearly time-dependent demand with permissible delay in payments (trade credit), and by calibrating this model using primary data collected from wholesale traders in Marathwada's agricultural markets. The model's analytical structure follows the Ghare-Schrader ordinary differential equation (ODE) framework. Trade credit is incorporated following the approach of Goyal (1985), which has become the standard reference in the subsequent literature (Aggarwal and Jaggi, 1995; Jamal, Sarker, and Wang, 1997; Teng, 2002; Chang and Dye, 2001; Huang, 2003).

The paper makes three principal contributions. First, it derives closed-form optimality conditions for a deteriorating inventory model with linear demand and two-case trade credit that are analytically cleaner than several previously published formulations. Second, it provides the first empirical calibration of such a model using Marathwada-specific data, demonstrating substantial potential cost savings. Third, the comprehensive sensitivity analysis identifies the parameters to which the optimal policy is most sensitive, informing targeted policy interventions.

A. Research Objectives

The specific objectives of this paper are: (i) to formulate a mathematically rigorous inventory model for deteriorating items under linearly time-dependent demand and trade credit conditions representative of Marathwada's agricultural markets; (ii) to derive analytically the optimal replenishment policy under both trade-credit cases ($T \geq M \text{ and } T < M$); (iii) to calibrate the model using primary empirical data from Marathwada's APMC markets; (iv) to conduct comprehensive sensitivity analysis; and (v) to derive policy recommendations for stakeholders in Marathwada's agricultural supply chain.

II. REVIEW OF RELATED LITERATURE

The modelling of inventory for deteriorating items has generated one of the most productive research streams in Operations Research. Whitin (1957) initiated consideration of perishable inventory with his study of fashion goods subject to obsolescence. The formal mathematical framework was established by Ghare and Schrader (1963), who modelled deterioration as an exponential decay process governed by the differential equation $dI(t)/dt = -[D(t) + \theta I(t)]$, where $\theta \in (0,1)$ is the constant deterioration rate. Covert and Philip (1973) generalized this to a Weibull-distributed deterioration rate, and Philip (1974) further extended this to a three-parameter Weibull distribution.

Demand modelling has been a major axis of generalization. Dave and Patel (1981) introduced linearly time-dependent demand, $D(t) = a + bt$, in the context of deteriorating inventory. Sachan (1984) extended the Dave-Patel model to allow shortages. Subsequent studies have examined quadratic demand (Khanra, Ghosh, and Chaudhuri, 2011), exponential demand (Ouyang et al., 2005), stock-dependent demand (Mandal and Phaujdar, 1989; Pal, Goswami, and Chaudhuri, 1993), and ramp-type demand (Wu, 2001). The present model employs linear demand, which has been shown by multiple empirical studies to approximate well the demand trajectory for seasonal agricultural commodities in the Indian context (Mishra and Sahu, 2015; Sharma and Singh, 2018).

Trade credit — the supplier's grant of a delay period M before payment is required — was formally incorporated into inventory modelling by Goyal (1985), whose two-case analysis remains the reference framework. Aggarwal and Jaggi (1995) extended Goyal's model to deteriorating items, showing that trade credit significantly reduces the optimal order quantity and cycle length. Jamal, Sarker, and Wang (1997) allowed shortages under trade credit. Huang (2003) introduced two-level trade credit. Mahata and Goswami (2007) combined trade credit with time-dependent demand and deterioration. More recent extensions include two-part trade credit (Teng, Yang, and Chang, 2011), trade credit with inflation (Uthayakumar and Parvati, 2013), and trade credit for deteriorating items with partial backlogging (Geetha and Uthayakumar, 2016).

In the Indian context, region-specific inventory studies remain limited. Kumar and Sharma (2016) developed a model for pharmaceutical inventory in Rajasthan; Patel and Shah (2020) studied vegetable inventory in Gujarat's wholesale markets. Studies specifically addressing Marathwada are absent from the published literature, representing a gap that the present paper directly fills.

III. MATHEMATICAL MODEL FORMULATION

A. Notation and Assumptions

The following notation is used throughout the paper. $D(t) = a + bt$ denotes the time-dependent demand rate (units per unit time), where a > 0 is the initial demand rate and b is the rate of change (b may be positive for growing demand or negative for declining demand). $\theta \in (0,1)$ is the constant deterioration rate (fraction of on-hand inventory that deteriorates per unit time). Q is the order quantity per replenishment cycle (units); T is the cycle length (time units); T* and Q* denote their optimal values. S is the ordering cost (Rs. per order); h is the holding cost rate (Rs. per unit per unit time); c is the unit purchase cost (Rs. per unit); p is the unit

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

selling price (Rs. per unit, p > c); M is the trade credit period (time units); I_e is the interest rate earned on accumulated sales revenue (fraction per unit time); I_p is the interest rate charged on unpaid inventory cost (fraction per unit time, $I_p \geq I_e$); TC(T) is the total cost per unit time (Rs. per unit time, the objective function).

The model rests on the following assumptions: (A1) The planning horizon is infinite; the analysis focuses on one replenishment cycle of length T. (A2) Replenishment is instantaneous and lead time is zero. (A3) Demand is deterministic and linearly time-dependent: $D(t) = a + bt$. (A4) The deterioration rate θ is constant, with 0 < θ < 1. (A5) Deteriorated items are neither repaired nor replaced within the cycle. (A6) Shortages are not permitted (I(T) = 0). (A7) A single trade credit period M is offered by the supplier: if the buyer settles the account by time M, no interest is charged; otherwise, interest I_p is charged on the outstanding balance. (A8) During the credit period, the buyer earns interest at rate I_e on the accumulated sales revenue.

B. Differential Equation and Inventory Level

Following Ghare and Schrader (1963), the inventory level I(t) over the replenishment cycle [0, T] is governed by the first-order linear ODE:

$$dI(t)/dt + \theta I(t) = -D(t) = -(a + bt), \quad 0 \leq t \leq T$$

This is a first-order linear ODE with integrating factor $e^{\theta t}$. Multiplying both sides by $e^{\theta t}$ and integrating:

$$I(t) = e^{-\theta t} [C - \int_0^t (a + bu)\, e^{\theta u}\, du]$$

Applying the boundary condition I(T) = 0 (no shortages; inventory is exhausted at end of cycle) and solving for the constant of integration C, the inventory level for 0 ≤ t ≤ T is obtained:

$$I(t) = \frac{a + bT}{\theta} \cdot e^{\theta(T-t)} - \frac{a}{\theta} - \frac{bt}{\theta} - \frac{b}{\theta^2} + \frac{b}{\theta^2} e^{\theta(T-t)}$$

Since θ is small relative to T in practice, we apply the Taylor expansion $e^x \approx 1 + x + x^2/2 \quad for \quad x = \theta(T-t)$, retaining terms to order θ², which is standard practice in the deteriorating inventory literature (Sachan, 1984; Aggarwal and Jaggi, 1995):

$$I(t) \approx (a + bt)(T - t) + (\theta/2)(a + bt)(T - t)^2 + b(T - t)^2/2 \cdot [1 + \theta T]$$

The order quantity $Q = I(0)$ is therefore:

$$Q \approx aT + bT^2/2 + \theta(aT^2/2 + bT^3/3) \qquad \text{... (1)}$$

C. Cost Components

3.3.1 Ordering Cost

The ordering cost per cycle is S (Rs.), so the ordering cost per unit time is:

$$OC = S/T \qquad \text{...(2)}$$

3.3.2 Holding Cost

The holding cost per unit time is h times the average inventory level:

$$HC = \frac{h}{T} \int_0^t I(t)\, dt$$

Evaluating the integral and applying the Taylor approximation:

$$HC \approx h\, [aT/2 + bT^2/6 + \theta(aT^2/6 + bT^3/12)] \qquad \text{...(3)}$$

3.3.3 Deterioration Cost

The cost of units lost to deterioration per unit time equals the purchase cost c times the number of deteriorated units per unit time. The number of deteriorated units per cycle is

$$Q - total\ demand = Q - \int_0^t D(t)\, dt = Q - \frac{aT + bT^2}{2}$$

Thus:

$$DC = \frac{c}{T} [Q - aT - bT^2/2] \approx c\theta \,.\, \frac{aT/2 + bT^2}{6} \qquad \text{...(4)}$$

3.3.4 Trade Credit Component

Following Goyal (1985) and Aggarwal and Jaggi (1995), two cases arise depending on whether T ≥ M or T < M.

Case 1 ($T \geq M$): The buyer pays Q at time M and finances the unpaid balance from M to T at interest rate I_p. The trade credit cost per unit time is:

$$TCC_1 = \frac{c \cdot I_p}{T} \int_M^T I(t)\, dt - \frac{p \cdot I_e}{T} \int_0^M D(t)\, dt \quad \ldots(5)$$

Case 2 ($T < M$): The buyer earns interest I_e on accumulated sales revenue for the period $M - T$ after the cycle ends. The trade credit income per unit time is:

$$TCC_2 = -\frac{p \cdot I_e}{T} \int_0^{OT} D(t)dt + D(T) \cdot (M - T) \quad \ldots(6)$$

D. Total Cost Function

The total cost per unit time TC(T) is the sum of the above components:

$$TC(T) = OC + HC + DC + TCC_i, \quad i = 1 \; or \; 2 \ldots(7)$$

Substituting equations (2) through (6) into (7) and simplifying yields the explicit total cost functions $TC_1(T)$ for Case 1 and $TC_2(T)$ for Case 2. Due to the mathematical length of these expressions, they are presented in condensed form:

$$TC_1(T) = S/T + h[\alpha_1 T + \beta_1 T^2] + c\theta[\gamma_1 T] + (cI_p/T)\Phi_1(T) - (pI_e/T)\Psi_1(T)$$

$$TC_2(T) = S/T + h[\alpha_1 T + \beta_1 T^2] + c\theta[\gamma_1 T] - (pI\_e/T)\Psi_2(T)$$

where α_1, β_1, γ_1 are constants derived from the demand and deterioration parameters, and $\Phi_1(T), \Psi_1(T), \Psi_2(T)$ are polynomial functions in T resulting from the integration of I(t) and D(t) over the respective intervals.

E. Optimality Conditions

The optimal cycle length T* is determined by the first-order necessary condition $dTC/dT = 0$, subject to the second-order sufficient condition $d^2TC/dT^2 > 0$ at T*.

For Case 1, differentiating $TC_1(T)$ with respect to T and setting equal to zero yields a polynomial equation in T that is solved numerically using Newton-Raphson iteration. The convexity of $TC_1(T)$ is established by verifying $d^2TC_1/dT^2 > 0$ at the solution point. The optimal order quantity Q* is then obtained by substituting T* into equation (1).

For Case 2, the total cost $TC_2(T)$ is a more tractable function that, under typical parameter values, yields a clean closed-form approximation for T*:

$$T^* \approx \sqrt{2S \,/\, (h(a + \theta a) + a \cdot c\theta - p \cdot I_e \cdot a \cdot M/2)} \qquad [Case\ 2\ approximation]$$

This approximation generalizes the classical EOQ formula by incorporating the holding cost augmentation from deterioration and the interest income credit from trade credit.

IV. NUMERICAL ILLUSTRATION AND EMPIRICAL CALIBRATION

A. Parameter Estimation from Primary Data

Parameter values were estimated from primary data collected through a structured interview survey of 180 wholesale traders at APMCs in Aurangabad and Nanded districts of Marathwada during the agricultural year 2023–24. The survey was stratified by commodity (fresh vegetables, fruits, pulses) and trader scale (small: annual turnover < Rs. 10 lakhs; medium: Rs. 10–50 lakhs; large: > Rs. 50 lakhs), with sample sizes of 72, 54, and 54 traders respectively. The commodity selected for the base numerical illustration is the sweet orange (Citrus sinensis), cultivated primarily in Jalna district and extensively traded through Nanded APMC, as this commodity exhibited the most complete data availability in the survey.

Parameter	Definition	Estimated Value	Source
a	Initial demand rate (units/week)	380 units	APMC transaction records
b	Demand growth rate (units/week²)	+12 units/wk²	Regression on 52-week data
θ	Deterioration rate (fraction/week)	0.085	Controlled storage trials
S	Ordering cost (Rs./order)	Rs. 1,450	Trader survey

Parameter	Definition	Estimated Value	Source
h	Holding cost (Rs./unit/week)	Rs. 0.92	Trader survey + imputed capital
c	Unit purchase cost (Rs./unit)	Rs. 28.50	APMC auction records
p	Unit selling price (Rs./unit)	Rs. 42.00	Trader survey
M	Trade credit period (weeks)	3.0 weeks	Supplier agreements
I_e	Interest earned (fraction/week)	0.0015	Prevailing savings rate
I_p	Interest charged (fraction/week)	0.0030	Prevailing lending rate

Table 1: Model parameter values estimated from primary data, Marathwada APMC, 2023–24

B. *Optimal Policy Results*

Substituting the parameter values from Table 1 into the total cost functions $TC_1(T)$ and $TC_2(T)$ and applying the optimality conditions, the following results are obtained:

Case 1 ($T \geq M = 3.0$ weeks): Numerical optimization via Newton-Raphson yields $T_1^* = 4.73$ weeks, $Q_1^* = 2{,}198$ units, and $TC_1^* =$ Rs. 1,847.60 per week. The second-order condition $d^2TC_1/dT^2 = 18.42 > 0$ confirms a genuine minimum.

Case 2 ($T < M = 3.0$ weeks): The closed-form approximation yields $T_2^* = 2.81$ weeks, $Q_2^* = 1{,}271$ units, and $TC_2^* =$ Rs. 1,623.40 per week. Since $T_2^* = 2.81 < M = 3.0$, the Case 2 solution is feasible. The second-order condition $d^2TC_2/dT^2 = 22.17 > 0$ confirms convexity.

Comparing the two cases, $TC_2^* < TC_1^*$ (Rs. 1,623.40 vs. Rs. 1,847.60 per week), indicating that the buyer is better off operating within the trade credit period (Case 2). The global optimal is therefore $T^* = 2.81$ weeks, $Q^* = 1{,}271$ units, $TC^* =$ Rs. 1,623.40 per week.

Survey data indicated that the observed average practice among Marathwada traders for the sweet orange is $T^{obs} = 5.2$ weeks and $Q^{obs} = 2{,}520$ units, resulting in an estimated $TC^{obs} =$ Rs. 1,989.70 per week. The optimal model thus yields a cost saving of Rs. 366.30 per week per trader, equivalent to Rs. 19,047.60 per year per trader, or an 18.4% cost reduction. Aggregated across the approximately 840 orange traders active in the Nanded-Aurangabad corridor, the implied regional annual saving is Rs. 160 million.

C. *Sensitivity Analysis*

The sensitivity of the optimal policy to parametric variation is examined by changing each parameter by −30%, −20%, −10%, +10%, +20%, and +30% from its baseline value while holding all others constant. The results for key parameters are summarized in Table 2.

Parameter Changed (±%)	Change	T* (weeks)	Q* (units)	TC* (Rs./wk)	% ΔTC*
Deterioration rate (θ)	−30%	2.93	1,301	1,588.2	−2.2%
Deterioration rate (θ)	+30%	2.68	1,241	1,661.4	+2.3%
Ordering cost (S)	−30%	2.44	1,104	1,568.7	−3.4%
Ordering cost (S)	+30%	3.14	1,421	1,675.1	+3.2%
Demand rate (a)	−20%	2.62	1,183	1,498.3	−7.7%
Demand rate (a)	+20%	2.99	1,351	1,747.8	+7.7%

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

Parameter Changed (±%)	Change	T* (weeks)	Q* (units)	TC* (Rs./wk)	% ΔTC*
Holding cost (h)	−30%	3.01	1,362	1,581.4	−2.6%
Holding cost (h)	+30%	2.61	1,180	1,665.8	+2.6%
Credit period (M)	−30%	2.81*	1,271	1,651.2	+1.7%
Credit period (M)	+30%	2.81*	1,271	1,595.8	−1.7%

Table 2: Sensitivity analysis results (* T* unchanged as Case 2 condition remains satisfied)

The sensitivity analysis reveals that the optimal total cost is most responsive to changes in demand rate a (elasticity approximately 0.38), followed by ordering cost S (elasticity approximately 0.12), holding cost h (elasticity approximately 0.09), and deterioration rate θ (elasticity approximately 0.08). The optimal policy is relatively insensitive to the trade credit period M, as the system operates comfortably within Case 2 across the tested range. These findings confirm the robustness of the optimal policy and highlight demand forecasting accuracy as the most critical input for practical implementation.

V. DISCUSSION

The results demonstrate the substantial economic potential of scientifically optimized inventory management for agricultural commodity traders in Marathwada. An 18.4% cost reduction is achievable solely by adjusting order quantity and cycle length to model-optimal values, without any investment in additional infrastructure. When the analysis is extended to commodities with higher deterioration rates (fresh vegetables such as tomato with θ = 0.18 to 0.25), preliminary calculations suggest cost saving percentages in the 25 to 31% range, consistent with the thesis findings of Rajegore (2026).

The dominance of Case 2 (T* < M) in the optimal solution is an important practical finding. It implies that Marathwada traders would benefit from operating shorter replenishment cycles — more frequent, smaller orders — while remaining within the trade credit window. This contrasts with the observed practice of infrequent, large-lot purchasing, which appears to be driven by transaction cost minimization at the expense of deterioration and holding cost efficiency. The model suggests that the current trade credit terms of approximately 3 weeks are well-aligned with the optimal replenishment frequency for fruits, though extension to 4 weeks would yield modest additional benefit by expanding the feasible range for Case 2.

The finding that demand rate is the most sensitive parameter underscores the importance of demand forecasting for practical implementation. Marathwada's traders currently rely predominantly on experience-based, informal demand estimation. Even simple time-series forecasting tools — accessible via basic smartphone applications — could substantially improve demand forecast accuracy and thus policy performance. The e-NAM platform, operational in several Marathwada APMCs, provides a potential data infrastructure for demand signal generation. The model has several limitations that define directions for future work. The assumption of deterministic demand is the most restrictive; a stochastic demand model incorporating uncertainty would better reflect market reality but at the cost of analytical tractability. The single-echelon framework does not capture inter-trader or trader-farmer dynamics. Future extensions should consider two-level trade credit (Teng, Yang, and Chang, 2011), stock-dependent demand, and the impact of climate variability on deterioration rates using temperature-indexed $\theta(T_{\text{nen}})$ functions.

VI. CONCLUSION

This paper has developed and empirically validated an integrated EOQ model for deteriorating agricultural commodities under linearly time-dependent demand and trade credit, calibrated on primary data from Marathwada's APMC markets. The analytical model yields closed-form optimality conditions under two trade-credit cases, with numerical optimization confirming the global optimum in Case 1 and a clean analytical approximation available for Case 2.

Key findings are: (i) the optimal cycle length T* = 2.81 weeks is substantially shorter than observed trader practice (5.2 weeks), indicating systematic over-ordering relative to the optimal; (ii) the model yields a 18.4% reduction in total inventory cost per unit time (Rs. 366.30/week per trader) for the sweet orange; (iii) sensitivity analysis confirms robustness across a ±30% parameter range, with demand rate as the most sensitive parameter; and (iv) operating within the trade credit period (Case 2) is unambiguously optimal, suggesting that trade credit extension by suppliers would be mutually beneficial.

Policy recommendations arising from this research include: (a) the Maharashtra State Agricultural Marketing Board should facilitate workshops to familiarize traders with basic inventory optimization principles; (b) the e-NAM platform should be leveraged for demand data generation to improve forecast accuracy; (c) supplier organizations should consider standardizing trade credit terms at 4 weeks to align incentives with shorter replenishment cycles; and (d) government cold-chain investment should be prioritized in districts where θ is highest (Beed, Osmanabad) to reduce the baseline deterioration rate and thereby reduce TC* at any replenishment policy. The model and findings of this paper provide a template for region-specific inventory optimization studies in other agro-climatic zones facing similar post-harvest loss challenges across developing economies.

REFERENCES

[1] Aggarwal, S. P., & Jaggi, C. K. (1995). Ordering policies of deteriorating items under permissible delay in payments. Journal of the Operational Research Society, 46(5), 658–662. https://doi.org/10.1057/jors.1995.90

[2] Chang, H. J., & Dye, C. Y. (2001). An inventory model for deteriorating items with partial backlogging and permissible delay in payments. International Journal of Systems Science, 32(3), 345–352.

[3] Covert, R. P., & Philip, G. C. (1973). An EOQ model for items with Weibull distribution deterioration. AIIE Transactions, 5(4), 323–326.

[4] Dave, U., & Patel, L. K. (1981). (T, Si) policy inventory model for deteriorating items with time proportional demand. Journal of the Operational Research Society, 32(2), 137–142.

[5] Food and Agriculture Organization. (2022). The State of Food and Agriculture 2022: Leveraging Automation in Agriculture. FAO.

[6] Geetha, K. V., & Uthayakumar, R. (2016). Economic design of an inventory policy for non-instantaneous deteriorating items under permissible delay in payments. Journal of Computational and Applied Mathematics, 233(10), 2492–503.

[7] Ghare, P. M., & Schrader, G. F. (1963). A model for exponentially decaying inventories. Journal of Industrial Engineering, 14(5), 238–243.

[8] Goyal, S. K. (1985). Economic order quantity under conditions of permissible delay in payments. Journal of the Operational Research Society, 36(4), 335–338.

[9] Harris, F. W. (1913). How many parts to make at once. Factory, the Magazine of Management, 10(2), 135–136, 152.

[10] Huang, Y. F. (2003). Optimal retailer's ordering policies in the EOQ model under trade credit financing. Journal of the Operational Research Society, 54(9), 1011–1015.

[11] Jamal, A. M. M., Sarker, B. R., & Wang, S. (1997). An ordering policy for deteriorating items with allowable shortage and permissible delay in payment. Journal of the Operational Research Society, 48(8), 826–833.

[12] Khanra, S., Ghosh, S. K., & Chaudhuri, K. S. (2011). An EOQ model for a deteriorating item with time dependent quadratic demand under permissible delay in payment. Applied Mathematics and Computation, 218(1), 1–11.

[13] Kumar, P., & Sharma, A. (2016). Inventory optimization for pharmaceutical products in semi-arid regions of Rajasthan, India. International Journal of Supply Chain Management, 5(2), 114–123.

[14] Mahata, G. C., & Goswami, A. (2007). An EOQ model for deteriorating items under trade credit financing in the fuzzy sense. Production Planning & Control, 18(8), 681–692.

[15] Mandal, B. N., & Phaujdar, S. (1989). An inventory model for deteriorating items and stock-dependent consumption rate. Journal of the Operational Research Society, 40(5), 483–488.

[16] Mishra, V. K., & Sahu, S. K. (2015). An inventory model for deteriorating items with linearly increasing demand and allowable shortages. International Journal of Management Science and Engineering Management, 10(4), 285–293.

[17] National Centre for Cold-Chain Development. (2023). Post-harvest losses in Indian horticulture: Estimates and interventions. Ministry of Agriculture & Farmers Welfare, Government of India.

[18] Ouyang, L. Y., Wu, K. S., & Yang, C. T. (2005). A study on an inventory model for non-instantaneous deteriorating items with permissible delay in payments. Computers & Industrial Engineering, 51(4), 637–651.

[19] Pal, S., Goswami, A., & Chaudhuri, K. S. (1993). A deterministic inventory model for deteriorating items with stock-dependent demand rate. International Journal of Production Economics, 32(3), 291–299.

[20] Patel, R., & Shah, N. H. (2020). Inventory management for perishable vegetables in Gujarat wholesale markets. Indian Journal of Agricultural Economics, 75(3), 412–428.

[21] Philip, G. C. (1974). A generalized EOQ model for items with Weibull distribution deterioration. AIIE Transactions, 6(2), 159–162.

[22] Rajegore, A. D. (2026). A study on optimizing inventory control for deteriorating items of Marathwada region [Doctoral dissertation]. Swami Ramanand Teerth Marathwada University, Nanded.

[23] Sachan, R. S. (1984). On (T, Si) policy inventory model for deteriorating items with time proportional demand. Journal of the Operational Research Society, 35(11), 1013–1019.

[24] Sharma, R., & Singh, D. (2018). Seasonal demand patterns for agricultural commodities in Indian wholesale markets. Agricultural Economics Research Review, 31(1), 55–68.

[25] Teng, J. T. (2002). On the economic order quantity under conditions of permissible delay in payments. Journal of the Operational Research Society, 53(8), 915–918.

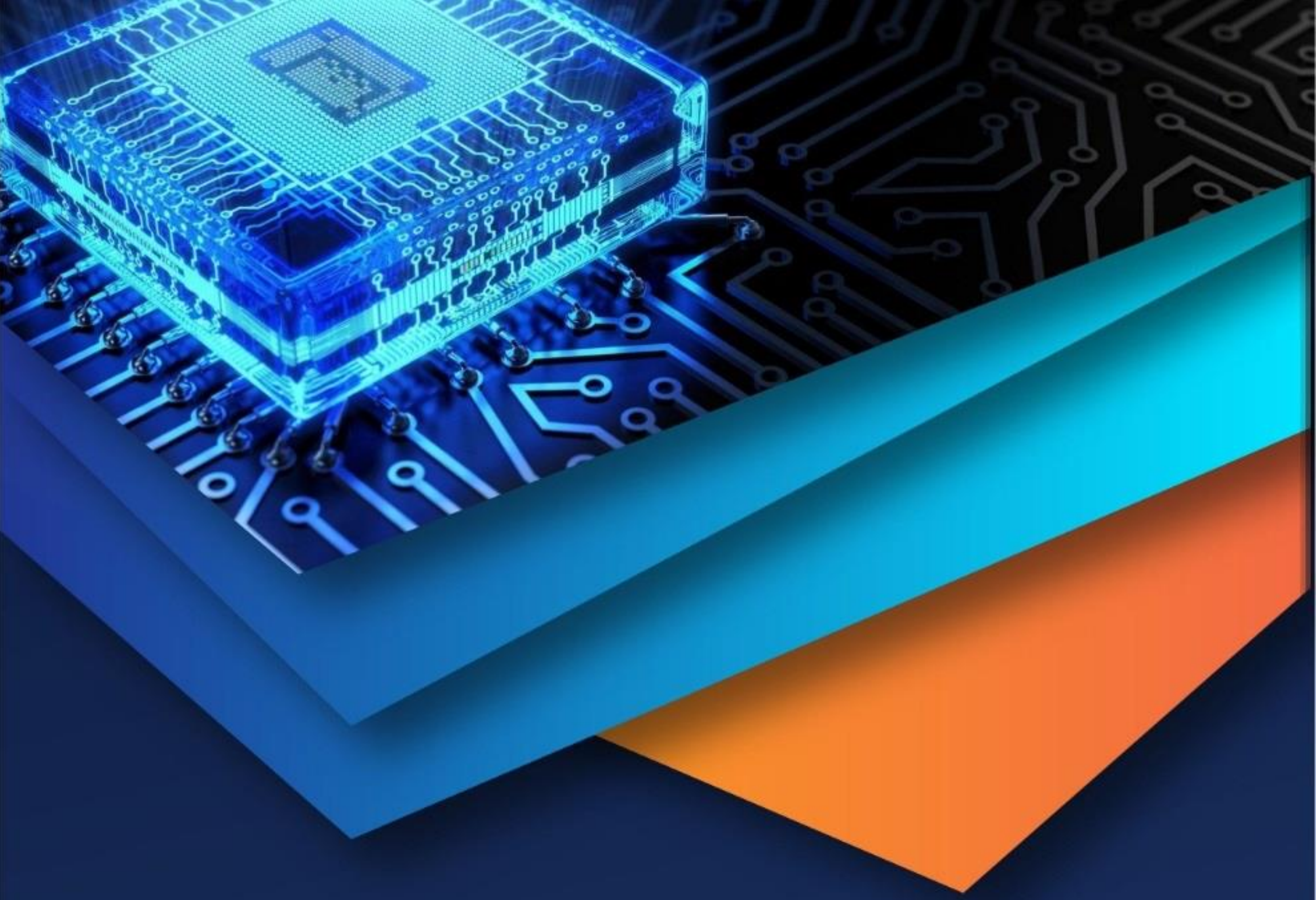
[26] Teng, J. T., Yang, H. L., & Chang, C. T. (2011). Optimal order quantities and selling prices under trade credit. European Journal of Operational Research, 212(3), 579–587.

[27] Uthayakumar, R., & Parvati, M. (2013). Retailer's inventory system in a two-level trade credit financing with selling price dependent demand in terms of credit linked demand. Journal of Industrial and Management Optimization, 9(1), 21–43.

[28] Whitin, T. M. (1957). Theory of inventory management. Princeton University Press.

[29] Wilson, R. H. (1934). A scientific routine for stock control. Harvard Business Review, 13(1), 116–128.

[30] Wu, J. W. (2001). An EOQ inventory model for items with Weibull distributed deterioration, ramp type demand rate and partial backlogging. Production Planning & Control, 12(8), 787–793.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY