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RESEARCH ARTICLE

The Impact of ERP Integration and Preservation Technology on Profit Optimization in Inventory Systems with Shortages and Deterioration

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Abstract

To determine and justify the significance of preservation technology in an ERP-integrated inventory system facing shortages and deterioration, with the goal of increasing profit while improving operational efficiency and decision-making accuracy. An enhanced inventory framework is formulated to account for shortages and product deterioration under Enterprise Resource Planning integration. This study develops an integrated inventory system and conducts a comparison analysis to determine the effectiveness of the system under four cases, namely: (i) An inventory system that accounts for shortages and deterioration, integrates preservation technology, and operates without ERP implementation (ii) An inventory system that accounts for shortages and deterioration without any investment (iii) An inventory system that considers shortages and deterioration with the integration of both preservation technology and Enterprise Resource Planning investment and (iv) An inventory system that considers shortages and deterioration with ERP integration but without the adoption of preservation technology. Secondary data obtained from Umakanta Mishra's studies are utilized to substantiate the numerical analysis. A computational example is provided to illustrate the efficacy of the inventory system in the context of deterioration, revealing that the total profit for the Cases I, II, III and IV are $289349.379, $287534.457, $290064.795 and $288249.435respectively. The results indicate that integrating preservation technologies into an ERP-based inventory system that addresses shortages and deterioration markedly improves economic and operational performance. The integration of ERP and preservation strategies in an inventory system under shortage and deterioration situations has not yet been thoroughly examined in the existing literature.

Keywords: Inventory system, Shortages, Deterioration, Enterprise Resource Planning, Profit Optimization, Preservation Technology, Operational Efficiency.

Introduction

In the current dynamic and competitive market situation, inventory management remains vital for sustaining supply chain efficiency and sustainability. Traditional methods that balance ordering and holding costs are frequently insufficient to solve contemporary difficulties, particularly when shortages, environmental concerns, and technological investments are involved (Mohamed Haythem Selmi *et al*., 2019). With increased globalization, unpredictable customer demand, and technology improvements, organizations are forced to implement integrated inventory systems capable of handling shortages, boosting operating efficiency, and maximizing profit. Previous research has stressed the significance of shortages, partial demand satisfaction, and technological investments in improving decision-making accuracy, but little attention has been given to deterioration effects in such systems. Deterioration, or the loss of value or utility of objects over time, is an unavoidable factor in real-world inventory scenarios, especially in businesses that deal with perishable commodities, time-sensitive things, and items with quality degradation (Mahdi Karimi, 2025). Neglecting deterioration in inventory systems can result in underestimating costs, poor forecasting accuracy, and wasteful resource allocation. Several studies in the literature have considered deterioration due to backordering, environmental constraints, or carbon emissions. An

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inventory system was formulated for deteriorating items considering time- and price-dependent demand along with shortages under the influence of inflation (Sumit Saha and Nabendu Sen, 2019). For instance, studies on controllable non-instantaneous degradation within emission limitations has pointed out the influence of deterioration on profit maximization and sustainability. An optimal inventory control approach was designed for deteriorating items with general time-varying demand, considering the constraints of carbon emission regulations (Chunming Xu *et al*., 2020). However, there is still a large gap in incorporating deterioration into ERP-based inventory systems that operate under shortages conditions. While ERP improves operational efficiency through better coordination, real-time data integration, and cost reduction, its relationship with deterioration-induced costs in a shortage-allowed context has not been thoroughly investigated. A system was developed that integrates controllable non-instantaneous deterioration with environmental emission considerations in the inventory system (Umakanta Mishra *et al*., 2020). Furthermore, preservation technology, which is utilized to slow deterioration and extend product usability, is critical in avoiding losses and ensuring quality in inventory systems. A production inventory framework was introduced for deteriorating products, integrating joint investment in preservation technology under a carbon taxation policy (Yujan Shen *et al*., 2019). An efficient inventory strategy was designed for deteriorating products, considering preservation technology investment influenced by price sensitivity (Priyamvada *et al*., 2022).

Enterprise resource planning (ERP) systems have evolved into transformative technologies that provide real-time information, seamless integration, and centralized control over a variety of business activities, including procurement, production, inventory management, and distribution. Shadrack Katuu (2020) analyzed the past, present and future of ERP. ERP systems help businesses accelerate operations through the exchange of information across departments, allowing for more exact demand forecasts, improved resource allocation, and efficient supply chain management. The effectiveness and reliability of inventory management were evaluated by streamlining the supply chain through the adoption of Enterprise Resource Planning (ERP) technology (Rubel, 2021). The relationship among ERP quality and performance of organizations was explored, with an emphasis on technical attributes rather than information and service components (Amer Balic *et al*., 2022). ERP lowers overstocking and understocking by combining sales, procurement, and manufacturing data, ensuring that things are kept for an optimal period of time and limiting the danger of degradation. While prior research has explored the significance of information systems and technology improvements in improving the efficiency of supply chains, a few studies have focused on the application of ERP investments into inventory systems functioning in the face of shortages or deterioration. A review was carried out on inventory management concepts and their practical implementations (J.B. Munyaka *et al*., 2022). Integrating preservation technologies into ERP-based frameworks that allow for shortages reduces degradation, waste, and improves overall system profitability.

To fill this gap, this study proposes an integrated inventory system that accounts for shortages, ERP investment, and deterioration effects. This allows the system to reflect more realistic industry conditions and provide an improved assessment of economic and operational performance. The study's objectives are

- Examine the impact of deterioration on profit optimization in an inventory system during shortages.
- Examine how preservation technology decreases deterioration-related losses and promotes sustainability in inventory management.
- Investigate how ERP investment impacts deterioration-related costs to enhance decision-making and efficiency.
- Evaluating systems with and without ERP integration under deterioration, with and without preservation technology, with a focus on management implications for sustainable supply chains.

By methodically including deterioration into the suggested framework, this study improves the practical importance of ERP-enabled inventory systems. The findings provide managers and policymakers with useful insights into establishing long-term, technology-driven inventory strategies to mitigate shortages, deterioration, and profit maximization in turbulent markets.

Methodology

An integrated inventory framework was proposed through the integration of ERP systems, deterioration impacts, and preservation technology. This study compares four cases, namely (i) An inventory system that accounts for shortages and deterioration, integrates preservation technology, and operates without ERP implementation (ii) An inventory system that accounts for shortages and deterioration without any investment (iii) An inventory system that considers shortages and deterioration with the integration of both preservation technology and Enterprise Resource Planning investment and (iv) An inventory system that considers shortages and deterioration with ERP integration but without the adoption of preservation technology. Secondary data from Umakanta Mishra's research were used to demonstrate the proposed system's effectiveness, boosting resource utilization and operational effectiveness in the face of shortages, partial demand satisfaction, and deterioration. The notations, assumptions, and mathematical formulations used to develop the proposed system are discussed here.

Notations

The notation in this paper is as follows:

Notations Descriptions

Discrete time of cycle

Discrete price for sale

Environment emissions cost

Cost incurred per ordering cycle

The actual average carbon emission price for a product unit ($/kg/time unit)

Carbon cap (kg/unit)

Carbon emissions linked with each unit purchased (kg/unit)

Cost incurred per order

Constant ordering cost ($/per order)

Opportunity cost associated with capital investment ($/unit/time unit)

Fixed holding cost ($/unit/time unit)

Unit purchase cost $(s > p_c)$ ($/unit/time unit)

Quantity ordered (unit/time unit)

Equal prepayments before getting Q

Cost of acquisition to be prepaid $(0 \le \psi \le 1)$

Prepayment period (year) length

Interest Rate on Capital ($/per year), where $0 \le R \le 1$

$A(O)$ Capital investment

amount of capital investment on Enterprise resource planning

effectiveness of Enterprise resource planning in lowering the costs

proportion of costs after investments in Enterprise resource planning

proportion of partial demand satisfaction

unit backordering cost

unit lost sales cost

backordering fraction

Preservation technology cost

Deterioration cost ($/unit/time unit)

Rate of deterioration of on-hand inventory (units)

Overall profit rate achieved with integration of preservation technology alone

Overall profit rate achieved without any investment

Overall profit rate achieved with the integration of both ERP and preservation technology

Overall profit rate achieved with integration of ERP investment alone

Assumptions

- The study involves a single, non-instantaneous degrading item.
- There is zero lead time.
- The ordering cost is a capital investment decision that impacts the reorder point. As a result, $A(O)$ is capital expenditure for minimizing order costs $A(O) = \frac{1}{\mu}\log\left(\frac{O_0}{O}\right)t_1$, for $< O \le O$, where is the whole duration of the cycle and is the percentage decrease in order cost. The capital investment to manage is $\frac{\nu}{\mu}\log\left(\frac{O_0}{O}\right)t_1$ where is the yearly opportunity cost.
- The system encounters demand at a rate of $D(s,t) = d(s)[I(t)]^{\lambda}, 0 \le I(t) \le t_1;\ I(t)$ indicates the inventory level $0 \le \lambda << 1$, which is the demand parameter used to adjust the stock levels. In addition, the demand scale parameter $d(s)(>0)$ indicates that a linear price function is more applicable in everyday scenarios than fixed demand. The market demand rate is calculated $d(s) = a - bs$ using a scaling factor , an elasticity coefficient, and the fulfilled price $s < \frac{a}{b}$. These types of demand rates $D(s,t)$ produce declining returns (decreases at higher inventory levels with a slight rise in demand rate).
- A nonlinear stock function is denoted by $h_c[S(t)]^{\sigma}$, where $h_c(>0)$ is a scaling constant for storing costs and $\sigma(>0)$ represents holding cost elasticity.
- The proposed approach considers environmental emission costs as a decision variable. If $i(\varphi_t)$ is an investment to lower environmental emissions costs, then $i(\varphi_t) = \frac{1}{\zeta}\log\left[\frac{\varphi_t^0}{\varphi_t}\right]t_1$, for $< \varphi_t \le \varphi_t$, where is a decrease in environmental emissions costs per dollar to increase $i(\varphi_t)$ and is the overall cycle duration. The environmental emission cost $i(\varphi_t)$ is a one-time cost that will yield larger profits in the future. Thus, the annual investment cost is $\tau i(\varphi_t) = \frac{\tau}{\zeta}\log\left[\frac{\varphi_t^0}{\varphi_t}\right]t_1$, where represents the opportunity cost.
- Shortages are allowed.
- is considered to be a proportion of expected cycle demand that is fulfilled directly through ordering and $\alpha \in (0,1]$. If ,no shortage occurs and , deliberate shortage will occurs.
- On hand inventory deteriorates at a steady rate.
- $P(\xi) = 1 - e^{-\lambda_1 \xi}$, where is the preservation investment cost and is the preservation Technology investment effectiveness parameter that influences deterioration rate. This function that is continuous, concave, and doubly differentiable in terms of greenhouse retailer's investment , at $P(0) = 0$ and $\lim_{\xi \to \infty} P(\xi) = 1$. Here $P'(\xi) = \lambda_1 e^{-\lambda_1 \xi}$, is regarded to need the shop to invest and $P''(\xi) = -\lambda_1^2 e^{-\lambda_1 \xi} < 0$
- Deteriorated units are not fixed during an inventory cycle.
- The firm adopts Enterprise Resource Planning (ERP) to enhance coordination, improve decision-making, and reduce operational inefficiencies across the inventory system. This centralized system minimizes shortages, prevents overstocking, and reduces the

overall cost associated with inventory mismanagement. The fraction of average shortage and ordering cost reduction resulting from ERP implementation is represented by $F=\varepsilon(1-e^{-mI_E})$, where ε, m, I_E are defined in the notation section. The use of ERP ensures a more efficient, responsive, and sustainable inventory management system by optimizing resource allocation and promoting operational transparency.

Mathematical Formulation

The greenhouse vendor pays $\kappa p\ Q$ in advance to the supplier in equal installments in years before the time of delivery, and pays the remaining balance $(1-\kappa)p_cQ$ immediately once the units arrive at time zero. The amount of stock is decreasing in proportion to the rate of demand $d(s)\left[S(t)\right]^{\lambda}$ over the period. There are no deterioration rates, and no need to invest in preservation measures. The difference in stock level in $[0,t_1]$ is completely due to demand, with the condition $S(t_1)=0$, in this case.

$$\frac{dS(t_1)}{dt}=-D(s,t), \qquad \le \ \le$$

The initial and boundary conditions are $I(0)=Q, I(t\ )=0.$

The order quantity is determined by

$Q=\alpha D_{cycle}$ where $D_{cycle}=[d(s)(1-\lambda)]^{\frac{1}{1-\lambda}}t_1^{\frac{1}{1-\lambda}}$ and represents the fraction of the expected cycle demand satisfied directly through ordering.

i.e. $Q=\alpha[d(s)(1-\lambda)]^{\frac{1}{1-\lambda}}t_1^{\frac{1}{1-\lambda}}$ where $\alpha\in(0,1]$

Total shortage costs is obtained through $(1-\alpha)D_{cycle}[c_b\beta+c_l(1-\beta)]$

Now, the overall annual profit comprises the following components:

- is cost incurred per order
- h_cS_h is inventory holding expense
- $p\ Q$ is acquisition cost
- $\varphi\ Xt$ is cost of carbon permits
- $\varphi\, eQ$ is cost incurred from carbon emissions
- $\frac{\tau}{\zeta}\log\left[\frac{\varphi_t^0}{\varphi_t}\right]t_1$ is cost of reducing environmental emissions
- $sQ_s=sQ-sQ_d$ is revenue from sales
- $C_c=R\left[\frac{\kappa p_cQ}{q}\left(\frac{l}{q}\right)(1+2+3\ldots\ldots\ldots.+q)\right]=\frac{(n+1)(\kappa lRp_cQ)}{2q}$ is capital cost per cycle.
- $c_b\beta(1-\alpha)D_{cycle}$ is the backordering cost
- $c_l(1-\beta)(1-\alpha)D_{cycle}$ is the lost sales cost
- d_cQ_d is deterioration cost
- is the preservation technology cost

Case I: System with shortages, deterioration, and preservation technology without ERP

Hence the optimization problem for shortages is given by,

Maximum subject to constraints

$$Z_1=\frac{1}{t_1}\begin{bmatrix} sQ-O-\xi t_1-h_cS_h-p_cQ-(s+d_c)Q_d-\frac{(q+1)(\kappa lRp_cQ)}{2q}-\varphi_t eQ \\ -\frac{\tau}{\zeta t_1}\log\left[\frac{\varphi_t^0}{\varphi_t}\right]t_1+\varphi_t Xt_1-(1-\alpha)D_{cycle}\left[c_b\beta+c_l(1-\beta)\right]\end{bmatrix} \tag{1}$$

The objective is to maximize the new profit per unit time by adding the capital investment cost $\frac{\nu}{\mu}\log\left(\frac{O_0}{O}\right)t_1$ to reduce . Hence, the new profit per unit time is

$$Z_1=\frac{1}{t_1}\begin{bmatrix} sQ-O-\frac{\nu}{\mu}\log\left(\frac{O_0}{O}\right)t_1-\xi t_1-h_cS_h-p_cQ-(s+d_c)Q_d-\frac{(q+1)(\kappa lRp_cQ)}{2q}-\varphi_t eQ \\ -\frac{\tau}{\zeta t_1}\log\left[\frac{\varphi_t^0}{\varphi_t}\right]t_1+\varphi_t Xt_1-(1-\alpha)D_{cycle}\left[c_b\beta+c_l(1-\beta)\right]\end{bmatrix} \tag{2}$$

The total profit per unit time taking shortages into account and excluding any investment is given by

$$Z_1=\frac{1}{t_1}\begin{bmatrix}\left[s-p_c-\frac{(q+1)(\kappa lRp_c)}{2q}-\varphi_t e\right][d(s)(1-\lambda)]^{\frac{1}{1-\lambda}}t_1^{\frac{1}{1-\lambda}}-\frac{\nu}{\mu}\log\left(\frac{O_0}{O}\right)t_1-O-\frac{\tau}{\zeta}\log\left[\frac{\varphi_t^0}{\varphi_t}\right]t_1 \\ +\varphi_t Xt_1-\frac{h_c\left[d(p)(1-\lambda)\right]^{\frac{\sigma+1-\lambda}{1-\lambda}}}{d(p)(\sigma+1-\lambda)}t_1^{\frac{\sigma+1-\lambda}{1-\lambda}}-\frac{(s+d_c)\left[1-P(\xi)\right]\theta\left[d(s)(1-\lambda)\right]^{\frac{2-\lambda}{1-\lambda}}\alpha^{2-\lambda}}{d(s)(2-\lambda)}-\xi t_1-(1-\alpha)D_{cycle}\left[c_b\beta+c_l(1-\beta)\right]\end{bmatrix} \tag{3}$$

Solution Procedure for a System to find preservation technology cost, environmental emission cost and ordering cost when :

The following theorems are proved for unique optimum solutions.

Theorem 1: For any discrete value of , , and are fixed and the profit is concave in .

The optimum solution of is found from $\frac{\partial Z_1}{\partial \xi}=0$.

$$-1+\frac{\lambda_1\theta e^{-\lambda_1\xi}(s+d_c)\left[d(s)(1-\lambda)\right]^{\frac{2-\lambda}{1-\lambda}}\alpha^{2-\lambda}(t_1-\gamma)^{\frac{2-\lambda}{1-\lambda}}}{d(s)(2-\lambda)t_1}=0 \tag{4}$$

Theorem 2: For any discrete value of , , and are fixed and the profit is concave in .

The optimum solution of is found from $\frac{\partial Z_1}{\partial \varphi_t}=0$.

$$\frac{-e\alpha\left[d(s)(1-\lambda)\right]^{\frac{1}{1-\lambda}}t_1^{\frac{1}{1-\lambda}}+\frac{\tau t_1}{\zeta\varphi_t}}{t_1}+X=0 \tag{5}$$

Theorem 3: For any discrete value of , , and are fixed and the profit is concave in .

The solution for is $\frac{\partial Z_1}{\partial O}=0 \Rightarrow -1+\frac{\nu}{\mu O}=0$ (6)

Theorem 4: The greenhouse retailer's profit function is concave with respect to , and for any given discrete value of and .

Algorithm 1: This algorithm is developed based on the previously discussed theorems to obtain the global optimal solution.

Step 1. Let

$a=2000, b=4, \lambda=0.06, \gamma=0.4, \tau=0.8, \zeta=0.001, e=2, \nu=0.7, \mu=4, p_c=2, \kappa=0.5, l=0.4, R=0.4,$
$\sigma=1.2, q=8, h_c=0.2, X=4, \varphi_t=4, O\ =4, m=0.7, \varepsilon=0.3, \alpha=0.7, \beta=0.85, c_b=4, c_l=8, \theta=0.001, d_c=0.1$

Step 2. Set $t\ =13$ and $s=13$.

Step 3. Calculate , and from equation (4),(5) and (6), respectively. Then, determine the optimal $Q=\alpha\left[d(s)(1-\lambda)\right]^{\frac{1}{1-\lambda}}t_1^{\frac{1}{1-\lambda}}$ and from equation(3).

Step 4. Increase $t_1=t_1+1$ at $s=240$ and repeat Step 3 until to the maximum value of is achieved.

Step 5. Record the updated values of $t\ , \xi, \varphi_t, O, Q$ and when $s=240$ from Step 4 and proceed to Step 6.

Step 6. Increase $s=s+$ and taking the new values of from Step 5, record ξ, φ_t, O, Q and again. Repeat Step 6 until the optimum value of is attained.

Step 7. Find optimum values of $t_1^*, s^*, \xi^*, \varphi_t^*, O^*, Q^*$ and .
Step 8. Stop.

Case II: System with shortages and deterioration without any investment

If $\xi = 0,$ then $P(\xi)$ becomes zero. Hence the case I does not involve preservation technology investment. The parameters and from equations (5) and (6), the profit function are evaluated by substituting in and the optimum solution for order quantity is calculated using $Q = \alpha\left[d(s)(1-\lambda)\right]^{\frac{1}{1-\lambda}} t_1^{\frac{1}{1-\lambda}}$

Case III: System with shortages and deterioration integrated with preservation technology and ERP investment

Hence the optimization problem for shortages with the integration of ERP investment is given by,
Maximum subject to constraints

$$Z_3 = \frac{1}{t_1}\left[\begin{array}{l} sQ - O\left(1-\varepsilon\left(1-e^{-mI_E}\right)\right) - \xi t_1 - h_c S_h - p_c Q - \left(s+d_c\right)Q_d - \frac{(q+1)(\kappa l R p_c Q)}{2q} - \varphi_t e Q \\ -\frac{\tau}{\zeta t_1}\log\left[\frac{\varphi_t^0}{\varphi_t}\right] t_1 + \varphi_t X t_1 - (1-\alpha) D_{cycle}\left[c_b\beta + c_l(1-\beta)\right]\left(1-\varepsilon\left(1-e^{-mI_E}\right)\right) - I_E t_1 \end{array}\right] \tag{7}$$

The objective is to maximize the new profit per unit time by adding the capital investment cost $\frac{\nu}{\mu}\log\left(\frac{O_0}{O}\right)t_1$ to reduce . Hence, the new profit per unit time is

$$Z_3 = \frac{1}{t_1}\left[\begin{array}{l} sQ - O\left(1-\varepsilon\left(1-e^{-mI_E}\right)\right) - \frac{\nu}{\mu}\log\left(\frac{O_0}{O}\right)t_1 - \xi t_1 - h_c S_h - p_c Q - \left(s+d_c\right)Q_d - \frac{(q+1)(\kappa l R p_c Q)}{2q} - \varphi_t e Q \\ -\frac{\tau}{\zeta t_1}\log\left[\frac{\varphi_t^0}{\varphi_t}\right] t_1 + \varphi_t X t_1 - (1-\alpha) D_{cycle}\left[c_b\beta + c_l(1-\beta)\right]\left(1-\varepsilon\left(1-e^{-mI_E}\right)\right) - I_E t_1 \end{array}\right] \tag{8}$$

The total profit per unit time accounting for shortages and incorporating the ERP system is expressed as

$$Z_3 = \frac{1}{t_1}\left[\begin{array}{l} \left[s - p_c - \frac{(q+1)(\kappa l R p_c)}{2q} - \varphi_t e\right]\left[d(s)(1-\lambda)\right]^{\frac{1}{1-\lambda}} t_1^{\frac{1}{1-\lambda}} - \frac{\nu}{\mu}\log\left(\frac{O_0}{O}\right)t_1 - O\left(1-\varepsilon\left(1-e^{-mI_E}\right)\right) - \frac{\tau}{\zeta}\log\left[\frac{\varphi_t^0}{\varphi_t}\right]t_1 + \varphi_t X t_1 \\ -\frac{h_c\left[d(p)(1-\lambda)\right]^{\frac{\sigma+1-\lambda}{1-\lambda}}}{d(p)(\sigma+1-\lambda)} t_1^{\frac{\sigma+1-\lambda}{1-\lambda}} - \frac{\left(s+d_c\right)\left[1-P(\xi)\right]\theta\left[d(s)(1-\lambda)\right]^{\frac{2-\lambda}{1-\lambda}}\alpha^{2-\lambda}\left(t_1-\gamma\right)^{\frac{2-\lambda}{1-\lambda}}}{d(p)(2-\lambda)} - \xi t_1 - (1-\alpha)D_{cycle}\left[c_b\beta + c_l(1-\beta)\right]\left(1-\varepsilon\left(1-e^{-mI_E}\right)\right) - I_E t_1 \end{array}\right] \tag{9}$$

Solution Procedure for a System to find preservation technology cost, environmental emission cost, ordering cost and enterprise resource planning investment when :

The optimum solution of , and are given by equations (4), (5) and (6) respectively and the following theorem is proved for unique optimum solution of .

Theorem 5: For any positive value of , the profit function is concave.

The optimum solution of is found from $\frac{\partial Z_3}{\partial I_E} = 0$. The solution for is

$$\frac{1}{t_1}\left[O\varepsilon m e^{-mI_E} + \left[(1-\alpha)\left[d(s)(1-\lambda)\right]^{\frac{1}{1-\lambda}} t_1^{\frac{1}{1-\lambda}}\left(c_b\beta + c_l(1-\beta)\right)\right]\varepsilon m e^{-mI_E} - t_1\right] = 0 \tag{10}$$

Algorithm 2: This algorithm aims to derive the global optimal solution, developed from the preceding theorems.
Step 1. Let

$$a = 2000, b = 4, \lambda = 0.06, \gamma = 0.4, \tau = 0.8, \zeta = 0.001, e = 2, \nu = 0.7, \mu = 4, p_c = 2, \kappa = 0.5, l = 0.4, R = 0.4,$$
$$\sigma = 1.2, q = 8, h_c = 0.2, X = 4, \varphi_t = 4, O = 4, m = 0.7, \varepsilon = 0.3, \alpha = 0.7, \beta = 0.85, c_b = 4, c_l = 8, \theta = 0.001, d_c = 0.1$$

Step 2. Set $t = 13$ and $s = 13$.
Step 3. Calculate , , and from equation (4), (5), (6) and (10) respectively. Then, determine the optimal $Q = \alpha\left[d(s)(1-\lambda)\right]^{\frac{1}{1-\lambda}} t_1^{\frac{1}{1-\lambda}}$ and from equation(9).
Step 4. Increase $t_1 = t_1 + 1$ at $s = 240$ and repeat Step 3 until to the maximum value of is achieved.
Step 5. Record the updated values of $t_1, \xi, \varphi_t, O, I_E, Q$ and when $s = 240$ from Step 4 and proceed to Step 6.
Step 6. Increase $s = s +$ and taking the new values of from Step 5, record $\xi, \varphi_t, O, I_E, Q$ and again. Repeat Step 6 until the optimum value of is attained.
Step 7. Find optimum values of $t_1^*, s^*, \xi^*, \varphi_t^*, O^*, I_E^*, Q^*$ and .
Step 8. Stop.

Case IV: System considering shortages and deterioration, enhanced with ERP investment but without preservation technology

If $\xi = 0,$, then $P(\xi)$ becomes zero. Hence, Case IV does not involve preservation technology investment but includes ERP integration. The parameters and from equations (5) and (6), the profit function are evaluated by substituting in and the optimum solution for order quantity is determined by using $Q = \alpha\left[d(s)(1-\lambda)\right]^{\frac{1}{1-\lambda}} t_1^{\frac{1}{1-\lambda}}$

Result

A numerical analysis was performed utilizing Algorithms 1 and 2, alongside the parameter values derived from Umakanta Mishra *et al.* (2020), to evaluate the efficacy of ERP-integrated inventory management in scenarios of shortage and deterioration, regardless of the combination of ERP and preservation technology. The system seeks to optimize overall profit by minimizing shortages, deterioration, and ordering expenses, while considering the enhancements in efficiency attained through ERP integration and preservation investments.

Tables 1 and 2 shows the efficiency of the suggested paradigm.

By adopting the suggested ERP-enabled inventory system with shortage management, deterioration consideration, and preservation technology, businesses can align their operational strategies with real-time responsiveness, reduce deterioration-related losses, enhance decision-making efficiency, and strengthen their competitive position in a technology-driven and demand-sensitive business environment.

Discussion

There are few studies that look at optimizing overall profit while merging Enterprise Resource Planning (ERP) systems, shortage management, deterioration, and preservation technology into an integrated inventory framework. Most existing works treat ERP as a standalone technological tool or limit their research to inventory systems that neglect deterioration and preservation issues (Amer Balic *et al.*, 2022).

Table 1: Optimal solutions derived for the system with shortages, deterioration, and preservation technology without ERP, and for the system with shortages and deterioration without any investment

						(Case I)	*(Case II)* $\xi=0, P(\xi)=0$
13	240	0.3202806	0.175	16261.761	7.822415	286345.701	285086.205
14	240	0.3187305	0.175	17595.702	7.915207	287038.454	285668.572
15	240	0.3173639	0.175	18935.744	8.001251	287626.521	286145.701
16	240	0.3160571	0.175	20281.505	8.081461	288122.091	286529.816
17	240	0.3148345	0.175	21632.648	8.156577	288534.998	286830.788
18	240	0.3136862	0.175	22988.877	8.227208	288873.642	287057.044
18	241	0.3149768	0.175	22894.826	8.227271	288967.029	287150.328
18	242	0.3162778	0.175	22800.799	8.227298	289050.226	287233.431
18	243	0.3175892	0.175	22706.794	8.227287	289123.233	287306.506
18	244	0.3189113	0.175	22612.813	8.227240	289186.052	287369.402
18	245	0.3202441	0.175	22518.855	8.227156	289238.694	287422.182
18	246	0.3215876	0.175	22424.921	8.227036	289281.162	287464.848
18	247	0.3229422	0.175	22331.011	8.226879	289313.460	287497.403
18	248	0.3243079	0.175	22237.124	8.226685	289335.589	287519.851
18	249	0.3256849	0.175	22143.261	8.226455	289347.561	287532.201
18	250	0.3270732	0.175	22049.421	8.226187	289349.379	287534.457

Table 2: Optimal solutions derived for the system with shortages and deterioration integrated with preservation technology and ERP investment, and for the system that considers shortages and deterioration with ERP integration but without the adoption of preservation technology

							(Case III)	*(Case IV)* $\xi=0, P(\xi)=0$
13	240	0.3202806	0.175	8.9281978	16261.761	7.822415	287075.168	285815.673
14	240	0.3187305	0.175	8.9349548	17595.702	7.915207	287771.422	286401.541
15	240	0.3173639	0.175	8.9412455	18935.744	8.001251	288362.764	286881.979
16	240	0.3160571	0.175	8.9471304	20281.505	8.081461	288861.404	287269.129
17	240	0.3148345	0.175	8.9526577	21632.648	8.156577	289277.217	287573.007
18	240	0.3136862	0.175	8.9578694	22988.877	8.227208	289618.607	287802.009
18	241	0.3149768	0.175	8.9520129	22894.826	8.227271	289708.909	287892.208
18	242	0.3162778	0.175	8.9461338	22800.799	8.227298	289789.023	287972.278
18	243	0.3175892	0.175	8.9402318	22706.794	8.227287	289858.948	288042.221
18	244	0.3189113	0.175	8.9343069	22612.813	8.227240	289918.684	288102.034
18	245	0.3202441	0.175	8.9283587	22518.855	8.227156	289968.246	288151.734
18	246	0.3215876	0.175	8.9223872	22424.921	8.227036	290007.633	288191.318
18	247	0.3229422	0.175	8.9163921	22331.011	8.226879	290036.851	288220.794
18	248	0.3243079	0.175	8.9103733	22237.124	8.226685	290055.902	288240.163
18	249	0.3256849	0.175	8.9043305	22143.261	8.226455	290064.795	288249.435
18	250	0.3270732	0.175	8.8982637	22049.421	8.226187	290063.536	288248.614

Furthermore, research on shortages sometimes neglect how degradation and preservation decisions interact with ERP-enabled operations, influencing forecasting, choice-making, and distribution of resources (Mishra *et al*., 2020). This generates a significant research gap because the combined effects of technical investment, deterioration, preservation measures, and shortage allowance on economic and operational performance have not been well studied. The current study fills this gap by developing an inventory system that incorporates ERP investment, degradation impacts, and preservation technology within a shortage-allowed environment. Preservation technology is critical in minimizing degradation rates and maintaining product quality, whereas ERP improves operational responsiveness by enabling real-time coordination, cost savings, and effective shortfall management. The findings show that combining ERP and preservation technologies decreases deterioration losses while also increasing overall profitability when compared to systems that do not include these investments.

Conclusion

This study develops an integrated inventory system using Enterprise Resource Planning (ERP) technology, deterioration effects, and preservation technology, and investigates its effectiveness under scarcity conditions. By incorporating ERP into the inventory framework, the system improves coordination, streamlines purchasing procedures, and allows for more informed decision making. Furthermore, the consideration of deterioration represents real-world product degradation, whereas the use of preservation technology lowers deterioration rates, preserves quality, and reduces waste. Unlike traditional systems, which frequently ignore deterioration and rely on static decision structures, this approach links inventory management to practical challenges including shortfalls, preservation investment, and financial approaches such as prepayments. A numerical analysis is provided to demonstrate the system's effectiveness of the inventory system in the context of deterioration, revealing that the total profit for the Cases I, II, III and IV are $289349.379, $287534.457, $290064.795 and $288249.435respectively. The results indicate that integrating ERP integration and preservation technology with shortage and deterioration issues significantly improves total profit and operational responsiveness when compared to systems that do not include these investments. The introduction of deterioration and preservation scenarios improves the system's ability to accurately depict genuine supply demand imbalances, increasing its practical relevance in sectors dealing with perishable and time-sensitive items. While the system presumes deterministic demand, further research could expand this framework to include stochastic demand patterns and changing deterioration rates, widening its application to more uncertain and volatile contexts. The uniqueness of this work resides in its holistic strategy, which combines ERP-driven decision support, preservation measures, and scarcity management with deterioration consequences. This integrated construction lays a solid foundation for firms looking to improve profitability while maintaining operational flexibility, lowering degradation losses, and aligning technology deployment with competitive market demands.

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