Model for Fuzzy Inventory pharmaceutical products with two-echelon supply chain in healthcare industries

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Abstract: This paper presents model for fuzzy inventory pharmaceutical products with two-echelon supply chain in healthcare industries. Pharmacies run under a parameter within pharmacy sales and purchase cycles that can help to improve growth of sales and profit. Connected model of pharmaceuticals in a two-stage supply chain in the healthcare sector between pharmaceutical company and hospital pharmacy. Fuzzy logic is a powerful tool for optimal profit. The output of this study is to optimize joint total profit (JTP) of model by calculating optimal order time and quantity. Finally, a numerical example with sensitivity analysis is provided to illustrate the proposed study.

Keywords: Inventory model, demand rate, triangular fuzzy number, graded mean method, joined total profit (JTP), pharmaceutical company, hospital pharmacy.

1. Introduction:

A pharmacy sales cycle generally considered the following arena pharmacy purchase data, dispensing transactions, rate of description, pharmacy rates, and consumer billing. The sum of inventory that a pharmacy maintains can have a significant business index, as a drug is in inventory has a minimum pay out / indemnification value until it is hand out. Some drugs, such as cancer drugs, are very high expensive and have a limited shelf life. Hospital pharmacy and the disposal of expired drugs can have likely cost effects. Tracking system of inventory model properly connected to the coding system facilitates an effective pharmacy sales span and a sales rectitude program. The calibration of the two systems helps identify coding and inventory issues. Both of these areas can represent danger areas for hospital pharmacies.

Proper medicine detectability and accountability should be integral part of hospital pharmacy operation to manage proper inventory system, comply with internal and state regulatory needs, and minimize medication errors to verify compliance standards are met Quality and patient safety. Proper drug control requires pharmacies to keep up complete and accurate records of medicine purchased, collected, stockpile, distributed, hand out, and throw away within the event of medicine recalls or adverse events. Cost governance techniques in pharmaceutical purchases, let alone strict inventory controls, can result in economic improvements.

The right use of drugs is important to realize positive leads to patients. When joined stock administration, organizations can decrease the threat for administrative non –compliance and infer advance budgetary benefits fundamentally clinic work. As healthcare looks to fulfil the quiet care of execution. Healthcare inner reviewers can give vital affirmation that drug store forms are effective and successful, touchy stock is ensured and defended and patient care targets are met.

Chiang et al. [4] furnished by storage quantity and order quantity as triangular fuzzy numbers are the pair of cases in optimal solutions of fuzzifying can be handled numerically through the Nedler-Mead algorithm. Dutta et al. [5] decided on the best order quantity In the presence of fuzzy random variable demand, a novel methodology is created for the inventory model, with the optimum reached utilising a graded mean integration representation. Then, Liu [15] developed a fuzzy integration marketing and production planning problem based on the extension principle method. The inventory model for items with ramp type demand, three-parameter Weibull distribution deterioration and starting with shortage was given by Jain S and Kumar [9]. Jarrett PG [10] proposed an analysis of international health care logistics implementing just-in-time systems in the health care management. Deterministic pharmaceutical inventory model for variable deteriorating items with time-dependent demand and time-dependent holding cost in healthcare industries was studied by Karuppasamy et al [11]. Model of inventory for both variable holding and sales revenue cost, Asian J. Management was proposed by Kumar [12]. Type-2 in biomedicine, Indian journal of public health & development was taken as Lathamaheswari [13]. Mandal et al [16] investigated an Order level inventory system with ramp type demand rate for deteriorating items.

Ouyang and Chang [17] Dealing with lead time can be reduced by additional crashing cost is exponential function of lead time both lead time and the order quantity are considered as the decision variables. Singh S R et al. [23] suggested an inventory model for decaying items with reliable production process, Stochastic demand rate is assumed during the development and the impact of inflation is also taken into accountability. Skouri, K et al.[24] described a deteriorating-items production-inventory system in which the demand rate is a linearly ramp type function of time and the production rate is proportionate to the demand rate. The two models were discussed: one without shortages and the other with shortages. Tripathy C K et al.[25] concluded that the retailer is allowed to settle the account against the purchases made, an inventory model for Weibull degrading items with constant demand is created. Shortages are not permitted, and the salvage value of deteriorating units is assigned.

Uthayakumar et al.[26] solved by a pharmaceutical inventory model using quadratic demand, linear holding cost and shortages with healthcare industries. Karuppasamy et al [27] discussed inventory model for variable deteriorating pharmacy items with demand rate and time dependent holding cost under trade credit in healthcare industries. Yao, J. S. et al.[30] deal with inventory without backorder with fuzzy total cost and fuzzy storing cost defuzzified by centroid and signed distance . Yao and Chiang [36] developed an EOQ model in which total demand and unit cost consist of triangular fuzzy numbers. They used the signed distance and the center of gravity as defuzzification methods.

Assumptions and notation

(i) $D(t) = ae^{bt}$, D(t) is demand function with time depend.
(ii) Information on the demand and the buyer's inventory position is provided to the supplier.
(iii) No shortage allowed.
(iv) The scope of planning is unlimited. Only the typical length plan is taken into account, all other cycles are the same.
(v) Buyer bears the transport costs and other handling costs.
(vi) Lead time is assumed to be zero.

Notation

$I_{PC_1}(t)$	**:** Initial inventory of Pharmaceutical company at any time t, $0 \leq t \leq T_1$.
$I_{PC_2}(t)$	**:** After production inventory of Pharmaceutical company at any time t, $0 \leq t \leq T_2$.
$I_{HP_1}(t)$	**:** Pharmacy inventory in Hospital at any time t in cycle $0 \leq t \leq T_3$
$D(t) = ae^{bt}$	**:** Hospital pharmacy's demand rate
P	**:** Pharmaceutical company production rate.
C	**:** Hospital pharmacy's ordering cost per replenishment cycle.
C_t	**:** Hospital pharmacy's variable shipping cost per unit.
C_T	**:** Hospital pharmacy's fixed shipping cost per shipment.
n	**:** Number of dispatching from the pharmaceutical company to the hospital pharmacy per production cycle, a decision variable.
q	**:** Amount of shipment from pharmaceutical company to from the hospital pharmacy per shipment.
h_1	**:** Pharmaceutical company holding cost parameters
h_2	**:** Hospital pharmacy holding cost parameters
H_{hp}	: Hospital pharmacy holding cost / unit time.
H_{pc}	**:** Pharmaceutical company holding cost / unit time.
θ	**:** Deteriorating rate of the item.
Q	**:** Hospital pharmacy order quantity, a decision variable.
S	**:** Pharmaceutical company setup cost /production cycle
p	**:** Hospital pharmacy selling price/ unit.
c	**:** Pharmaceutical company product cost/unit.
v	**:** Pharmaceutical company supply price / unit.
T_3	: Duration of hospital pharmacy refill cycle , a decision variable
T_2	: Duration of pharmaceutical company Production time/ production cycle
T_1	: Duration of pharmaceutical company Production time/ production cycle.
t_k	: Duration of pharmaceutical company Cycle time need to manufacture q units.
JTP	**:** Joint total profit / unit time.

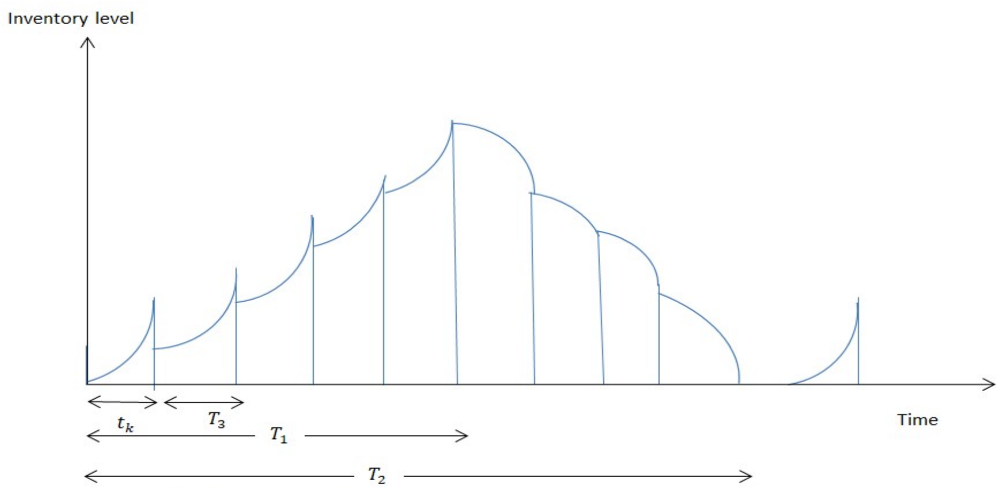


Figure 1. The Pharmaceutical Company inventory systems in an entire production cycle.

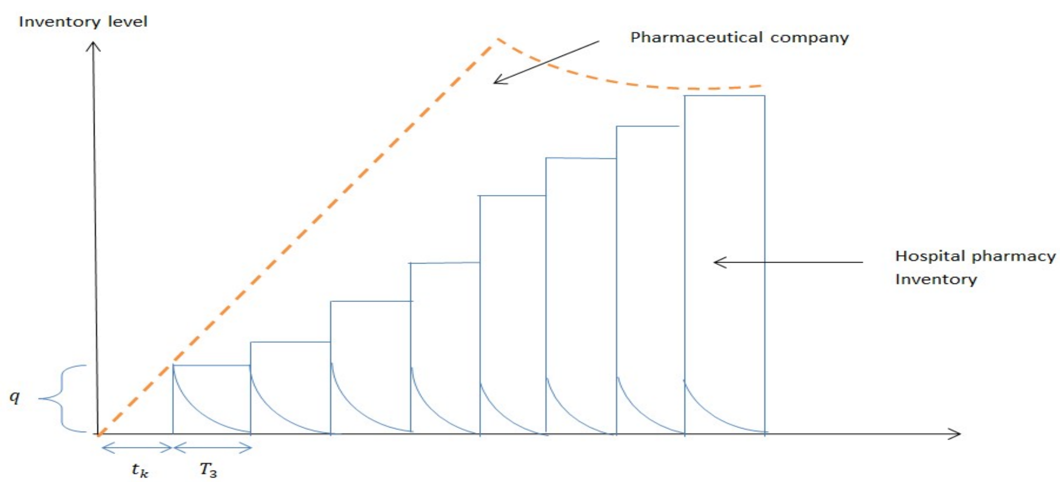


Figure 2. The Pharmaceutical company and Hospital pharmacy cumulative inventory

Definition 2.1 A fuzzy number $\tilde{A} = (a, b, c), where\ a < b < c$ and defined on $\mathbb{R}$, is called a triangular fuzzy number if its membership function is

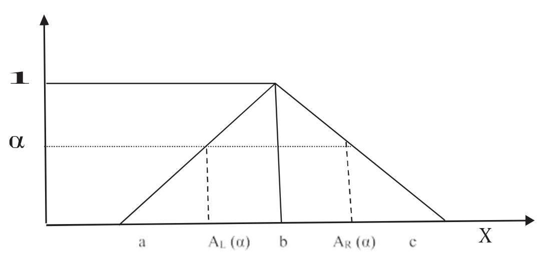


Figure 3 triangular fuzzy number . α–cut

$$\mu_A = \begin{cases} \frac{x-a}{b-a} & a \le x \le b \\ \frac{c-x}{c-b} & b \le x \le c \\ 0 & otherwise \end{cases}$$

Definition 2.2 A fuzzy number $\tilde{A} = (a, b, c)$ is a triangular fuzzy number, then the graded mean integration representation of $\tilde{A}$ is defined as

$$P(\tilde{A}) = \frac{a+4b+c}{6}$$

1. Mathematical formulation of model

Let $I_{PC_1}(t)$, $I_{PC_2}(t)$ are the inventory level of Pharmaceutical company at $(0,T_1)$, (T_1,T_2) respectively ,which is managed by the following equations

$$\frac{dI_{PC_1}(t)}{dt} + \theta I_{PC_1}(t) = (p-1)ae^{bt} \qquad 0 \le t \le T_1 \qquad (1)$$

With $I_{PC_1}(0) = 0$ and $I_{PC_1}(t_k) = q$

$$\frac{dI_{PC_2}(t)}{dt} + \theta I_{PC_2}(t) = 0 \qquad T_1 \le t \le T_2 \qquad (2)$$

With $I_{PC_2}(T_2) = nq$

$$I_{PC_1}(t) = \frac{a(P-1)}{b+\theta}\{e^{bt} - e^{-\theta t}\} \qquad (3)$$

$$q = \frac{a(P-1)}{b+\theta}\{e^{bt_k} - e^{-\theta t_k}\} \qquad (4)$$

$$t_k = \frac{q}{a(p-1)} \qquad (5)$$

$$I_{PC_2}(t) = nq\{e^{\theta(T_2-t)}\} \qquad (6)$$

$$I_{PC_1}(T_1) = I_{PC_2}(T_1)$$

$$\frac{a(P-1)}{b+\theta}\{e^{bT_1} - e^{-\theta T_1}\} = nq\ \{e^{\theta(T_2-T_1)}\}$$

$$T_1 = \frac{1}{b+\theta}\log\{\frac{b+\theta}{a(P-1)}(nq)\{e^{\theta(T_2)} + 1\}\ \} \qquad (7)$$

Let $I_{HP}(t)$ be the inventory level of Hospital pharmacy at $(0,T_3)$ which is managed by the following equations

$$\frac{dI_{HP}(t)}{dt} + \theta I_{HP}(t) = -ae^{bt} \qquad 0 \le t \le T_3 \qquad (8)$$

$with\ \ I_{HP}(T_3) = 0\ \&\ I_{Hp}(0) = q$

$$I_{Hp}(t) = \frac{-ae^{bt}}{b+\theta} + \frac{ae^{(b+\theta)T_b}}{b+\theta}\ e^{-\theta t} \qquad (9)$$

$$T_3 = \frac{1}{b+\theta}\log\left\{\frac{q(b+\theta)}{a} + 1\right\} \qquad (10)$$

Sales revenue of pharmaceutical company per production cycle is $vQ\ =\ vnq$

Setup costs of pharmaceutical company per production cycle are S.

The production costs of the paramedical company per production cycle are

$$C\,P\,T_1 = \frac{C\,P}{b+\theta}\log\{\frac{b+\theta}{a(P-1)}(nq)\left\{e^{\theta(T_2)}+1\right\}\} \tag{11}$$

Holding cost: The total inventory of the pharmaceutical company by production cycle equals the accumulated inventory of from the pharmaceutical company minus the accumulated inventory of from the hospital pharmacy.

$$H_{pc} = h_1\left\{\int_0^{T_1} I_{PC_1}(t)dt + \int_{T_1}^{T_2} I_{PC_2}(t)dt + q\{1+2+3+\cdots+(n-1)\}\right\} \tag{12}$$

$$H_{pc} = h_1\left\{\frac{a(P-1)}{b+\theta}\left\{\frac{(e^{bT_1}-1)}{b}+\frac{(e^{-\theta T_1}-1)}{\theta}\right\} + nq\frac{(e^{\theta(T_2-T_1)}-1)}{\theta}+\frac{qT_3\,n(n-1)}{2}\right\} \tag{13}$$

The total profit of the pharmaceutical company per production cycle denoted by $TP_1(T_2, q.n)$ is

$$TP_1(T_2,q,n) = \left\{vnq - S_1 - \frac{CP}{b+\theta}\log\{\frac{b+\theta}{a(P-1)}(nq)\left\{e^{\theta(T_2)}+1\right\} - h_1\left\{\frac{a(P-1)}{b+\theta}\left\{\frac{(e^{bT_1}-1)}{b}+\frac{(e^{-\theta T_1}-1)}{\theta}\right\} + nq\frac{(e^{\theta(T_2-T_1)}-1)}{\theta}+\frac{qT_3\,n(n-1)}{2}\right\}\right\} \tag{14}$$

The total profit of the Hospital pharmacy per replenishment cycle

$$PDT_3 = \frac{Pae^{bt}}{b+\theta}\log\{\frac{q(b+\theta)}{a}+1\} \tag{15}$$

Hospital pharmacy order costs per refill cycle are A.

Hospital pharmacy purchase costs are vq

Hospital pharmacy transport costs, including fixed and variable costs per refill cycle, are indicated by

$$C_T + C_t q. \tag{16}$$

The Hospital pharmacy's holding cost is

$$H_{hp} = h_2\int_0^{T_3} I_{HP}(t)dt$$

$$H_{hp} = h_2\int_0^{T_3} I_{HP}(t)dt$$

$$H_{hp} = h_2\left\{\frac{a}{b+\theta}\left\{\frac{(1-e^{bT_3})}{b}+\frac{(e^{(b+\theta)T_3}-e^{bT_3})}{\theta}\right\}\right\} \tag{17}$$

A production cycle consists of n replenishment cycles, the total profit of the hospital pharmacy per production cycle (denoted by $TC_2(T_2,q,n)$) is

$$TP_2(T_2,q,n) = \left\{\frac{Pae^{bt}}{b+\theta}\log\left\{\frac{q(b+\theta)}{a}+1\right\} - n(A+C_T) - nq(C_t+v) - h_2\left\{\frac{a}{b+\theta}\left\{\frac{(1-e^{bT_3})}{b}+\frac{(e^{(b+\theta)T_3}-e^{bT_3})}{\theta}\right\}\right\}\right\} \tag{18}$$

The seller and buyer have determined to share expedient to enter into mutually profitable support, the joined total profit per unit time $JTP(T_2, q, n)$ split by the duration of the cycle $(T_3 + T_2)$ is provided by

$$JTP(T_2, q, n) = [TP_1 (T_2, q, n) + TP_2(T_2, q, n)]/(T_3 + T_2).$$

$$JTP(T_2, q, n) = \frac{1}{T_2+T_3}\left(\left\{vnq - S_1 - \frac{CP}{b+\theta}\log\left\{\frac{b+\theta}{a(P-1)}(nq)\left\{e^{\theta(T_2)}+1\right\}\right\} - h_1\left\{\frac{a(P-1)}{b+\theta}\left\{\frac{(e^{bT_1}-1)}{b} + \frac{(e^{-\theta T_1}-1)}{\theta}\right\} + nq\frac{(e^{\theta(T_2-T_1)}-1)}{\theta} + \frac{qT_3\, n(n-1)}{2}\right\}\right\} + \left\{\frac{Pae^{bt}}{b+\theta}\log\left\{\frac{q(b+\theta)}{a}+1\right\} - n(A + C_T) - nq(C_t + v) - h_2\left\{\frac{a}{b+\theta}\left\{\frac{(1-e^{bT_3})}{b} + \frac{(e^{(b+\theta)T_3} - e^{bT_3})}{\theta}\right\}\right\}\right\}\right) \quad (19)$$

2. Fuzzy system and method of solution

This Fuzzy system and solution method ue to uncertainty, it is difficult to define all variables

Let $\widetilde{h_1} = (h_{11}, h_{12}, h_{13})$, $\widetilde{h_2} = (h_{21}, h_{22}, h_{23})$, $\tilde{C} = (C_1, C_2, C_3)$, $\tilde{S} = (S_1, S_2, S_3)$, $\tilde{\theta} = (\theta_1, \theta_2, \theta_3)$

Fuzzy numbers in the triangular model. Then, the total profit of the system is given in the fuzzy sense

$$\widetilde{JTP}(T_2, q, n) = \left(\frac{1}{T_2+T_3}\right)\left(\left\{vnq - \tilde{S} - \frac{\tilde{C}P}{b+\tilde{\theta}}\log\left\{\frac{b+\tilde{\theta}}{a(P-1)}(nq)\left\{e^{\tilde{\theta}(T_2)}+1\right\}\right\} - \widetilde{h_1}\left\{\frac{a(P-1)}{b+\tilde{\theta}}\left\{\frac{(e^{bT_1}-1)}{b} + \frac{(e^{-\tilde{\theta}T_1}-1)}{\tilde{\theta}}\right\} + nq\frac{(e^{\tilde{\theta}(T_2-T_1)}-1)}{\tilde{\theta}} + \frac{qT_3\, n(n-1)}{2}\right\}\right\} + \left\{\frac{Pae^{bt}}{b+\tilde{\theta}}\log\left\{\frac{q(b+\tilde{\theta})}{a}+1\right\} - n(A + C_T) - nq(C_t + v) - \widetilde{h_2}\left\{\frac{a}{b+\tilde{\theta}}\left\{\frac{(1-e^{bT_3})}{b} + \frac{(e^{(b+\tilde{\theta})T_3} - e^{bT_3})}{\tilde{\theta}}\right\}\right\}\right\}\right) \quad (20)$$

Solution procedure

The Joined total fuzzy profit is a concave function of T_2, for fixed q, implying that there must be an optimal n=n* that meets the following criteria:

$$\widetilde{JTP}(T_2, q, n) \geq \widetilde{JTP}(T_2, q, n^* + 1)$$

$$\widetilde{JTP}(T_2, q, n) \geq \widetilde{JTP}(T_2, q, n^* - 1)$$

Lemma 1: For specified value q and n, $\widetilde{JTP}(T_2, q, n)$ is concave with respect to T_2 and the best possible of T_2 must satisfy $\frac{\partial^2 \widetilde{JTP}}{\partial {T_2}^2} < 0$.

Proof: Assume partial derivatives of the first and second order $\widetilde{JTP}(T_2, q, n)$ with respect to T_2 we get

$$\frac{\partial \widetilde{JTP}}{\partial T_2} = \left(\frac{1}{T_2+T_3}\right)\left(\left\{-\frac{\tilde{C}P\, e^{\tilde{\theta}(T_2)}}{(b+\tilde{\theta})\left[e^{\tilde{\theta}(T_2)}+1\right]} + -\widetilde{h_1}\left\{nq\, e^{\tilde{\theta}(T_2-T_1)}\right\}\right\}\right)$$
$$+\left(\frac{-1}{(T_2+T_3)^2}\right)\left(\left\{vnq - \tilde{S} - \frac{\tilde{C}P}{b+\tilde{\theta}}\log\left\{\frac{b+\tilde{\theta}}{a(P-1)}(nq)\left\{e^{\tilde{\theta}(T_2)}+1\right\}\right\}\right.\right.$$
$$\left.\left.-\widetilde{h_1}\left\{\frac{a(P-1)}{b+\tilde{\theta}}\left\{\frac{(e^{bT_1}-1)}{b}+\frac{(e^{-\tilde{\theta}T_1}-1)}{\tilde{\theta}}\right\}+nq\,\frac{(e^{\tilde{\theta}(T_2-T_1)}-1)}{\tilde{\theta}}+\frac{qT_3\,n(n-1)}{2}\right\}\right\}\right)$$
$$= 0 \tag{21}$$

$$\frac{\partial^2 \widetilde{JTP}}{\partial {T_2}^2} = \left(\frac{-2}{(T_2+T_3)^2}\right)\left(\left\{-\frac{\tilde{C}P\, e^{\tilde{\theta}(T_2)}}{(b+\tilde{\theta})\left[e^{\tilde{\theta}(T_2)}+1\right]} - \widetilde{h_1}\left\{nq\, e^{\tilde{\theta}(T_2-T_1)}\right\}\right\}\right)$$
$$+\left(\frac{1}{T_2+T_3}\right)\left(\left\{-\frac{\tilde{C}P\,\tilde{\theta}\,\log\{e^{-\tilde{\theta}(T_2)}+1\}}{(b+\tilde{\theta})} - \widetilde{h_1}\left\{nq\, e^{\tilde{\theta}(T_2-T_1)}\right\}\right\}\right)$$
$$+\left(\frac{2}{(T_2+T_3)^3}\right)\left(\left\{vnq - \tilde{S} - \frac{\tilde{C}P}{b+\tilde{\theta}}\log\left\{\frac{b+\tilde{\theta}}{a(P-1)}(nq)\left\{e^{\tilde{\theta}(T_2)}+1\right\}\right\}\right.\right.$$
$$\left.\left.-\widetilde{h_1}\left\{\frac{a(P-1)}{b+\tilde{\theta}}\left\{\frac{(e^{bT_1}-1)}{b}+\frac{(e^{-\tilde{\theta}T_1}-1)}{\tilde{\theta}}\right\}+nq\,\frac{(e^{\tilde{\theta}(T_2-T_1)}-1)}{\tilde{\theta}}+\frac{qT_3\,n(n-1)}{2}\right\}\right\}\right)$$
$$< 0 \tag{22}$$

3. Numerical example

The following input variable of numerical example:

$a = 1 \;\; b = 2 \;\; C_T = Rs.25/unit, \;\; p = Rs.15/unit \;\; c = Rs.12/unit \;\; v = Rs.5/unit \;\; T_3 = 0.5 \;\; year \;\; T_1 = 0.15 \;\; \mathrm{t_k} = 0.4 \;\; year \; C_t = Rs.15/unit, P = Rs.18/unit$

$\widetilde{h_1} = (2,4,6)$, $\widetilde{h_2} = (5,7,9)$, $\tilde{C} = (15,20,22)$, $\tilde{S} = (12,14,16)$, $\tilde{\theta} = (0.001,0.006,0.010)$

Using the MATEMATICA software, we obtain the optimum solution for $q, {T_3}^*$ and $\widetilde{JTP}$ are: ${T_3}^* =$ 0.985 year and $\widetilde{JTP}$ = Rs. 7255 the corresponding optimal order quantity q^*= 193.49 unit.

The optimal cost varies with the change in the form parameter once more. The related changes in the cycle time and the joined total profit are shown in table 1 below by changing the values of a parameter while keeping the remaining parameters at their original values.

4. Sensitivity analysis:

A sensitivity study to look at the consequences of fixing the fuzzy parameters $\widetilde{h_1}, \widetilde{h_2}, \tilde{C}, \tilde{S}$ and $\tilde{\theta}$ on the optimal solution using the values of defuzzification that this variable are often used (Figures 4-8). The results are shown in tables.

Table 1

		${T_2}^*$	q^*	$\widetilde{JTP}$
a	+50	0.809	251.15	7245
	+20	0.841	247.62	7017
	-20	0.865	242.01	6920
	−50	0.887	236.13	6135
b	+50	0.886	275.45	6508
	+20	0.911	286.35	6835
	-20	0.971	292.06	7015
	−50	0.987	298.49	7150
$\tilde{\theta}$	+50	0.901	238.49	7155
	+20	0.936	235.31	6815
	-20	0.945	227.28	6720
	−50	0.952	222.20	6245
T_1	+50	0.856	270.89	8385
	+20	0.866	274.10	8460
	-20	0.896	276.54	8596
	−50	0.925	295.50	8605
T_3	+50	0.898	267.75	8561
	+20	0.856	278.59	8613
	-20	0.916	288.72	8987
	−50	0.962	292.10	9166
$\widetilde{h_1}$	+50	0.881	234.52	7623
	+20	0.894	233.43	7475
	-20	0.963	232.77	6890
	−50	0.980	230.15	5807
$\widetilde{h_2}$	+50	0.899	236.13	7469
	+20	0.884	231.56	7241
	-20	0.871	230.39	7144
	−50	0.864	228.46	6732
$\tilde{C}$	+50	0.954	250.97	7059
	+20	0.924	272.30	7239
	-20	0.921	289.92	7374
	−50	0.912	304.63	7659
$\tilde{S}$	+50	0.934	331.24	6469
	+20	0.931	318.42	6944
	-20	0.925	309.04	7379
	−50	0.912	295.41	8085

The sensitivity of the optimal solution to changes in the values of the parameters associated with this model. Change the value of only one parameter at a time (+ 50%, + 20%, 20%, 50%). The following points are observed.

Optimal joined total fuzzy profit $(\widetilde{JTP})$ reacts very sensitively to the effects of changes in fuzzy parameters $\widetilde{h_1}, \widetilde{h_2}$,and $\tilde{\theta}$. It is moderately sensitive to the effects of changes in fuzzy parameters $\tilde{C}$ and $\tilde{S}$

- $q*$ is extremely sensitive to the effects of changes fuzzy parameter $\widetilde{h_1}, \widetilde{h_2}$,and $\tilde{\theta}$. It is observed that q* is slightly observant of the impacts of change in of the fuzzy parameters $\widetilde{C}$ and $\tilde{S}$.
- $T_2{}^*$is moderately observant of the impacts of change of $\widetilde{h_1}, \widetilde{h_2}$, and $\tilde{\theta}$ while very sensitive to the impact of changes in cycle time of fuzzy parameters $\tilde{C}$ and $\tilde{S}$.

Figure : 4 Outcome of deteriorating rate parameter $\tilde{\theta}$ on joined total fuzzy profit.

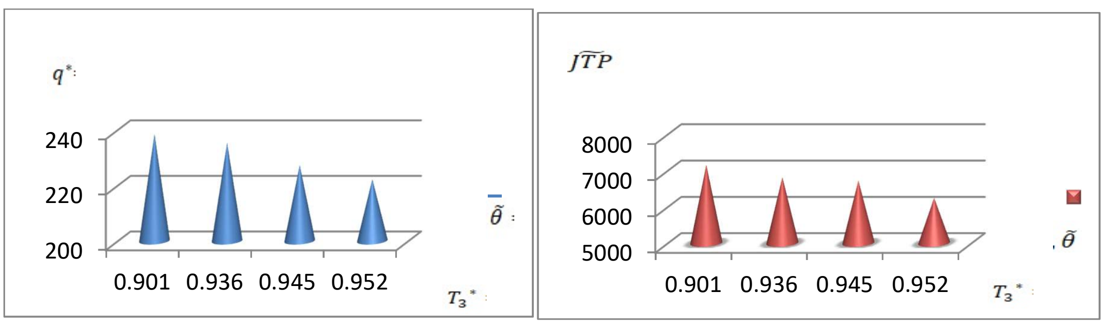


Figure : 5 Outcome of Pharmaceutical company holding cost parameters $\widetilde{h_1}$ on joined total fuzzy profit.

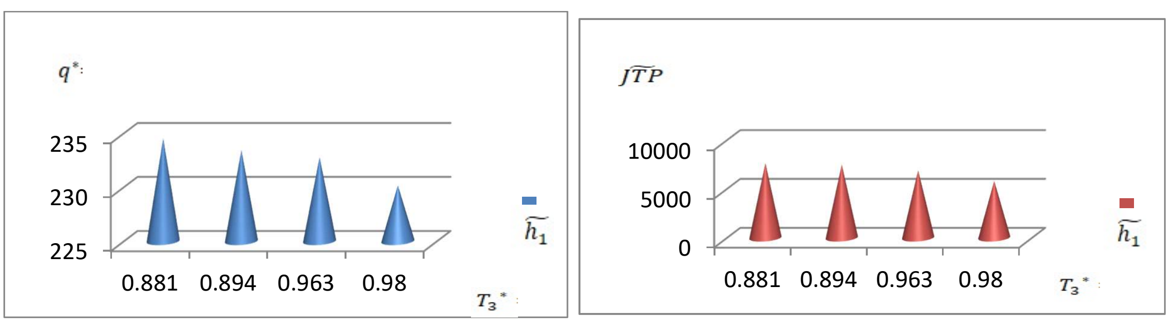


Figure : 6 Outcome of Hospital pharmacy's holding cost parameters $\widetilde{h_2}$ on joined total fuzzy profit.

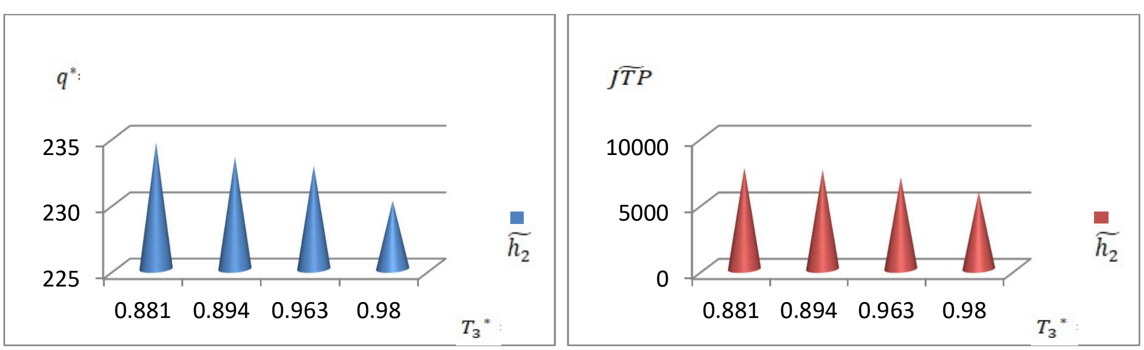


Figure : 7 Outcome of Hospital pharmacy's ordering cost parameter $\widetilde{C}$ on joined total fuzzy profit.

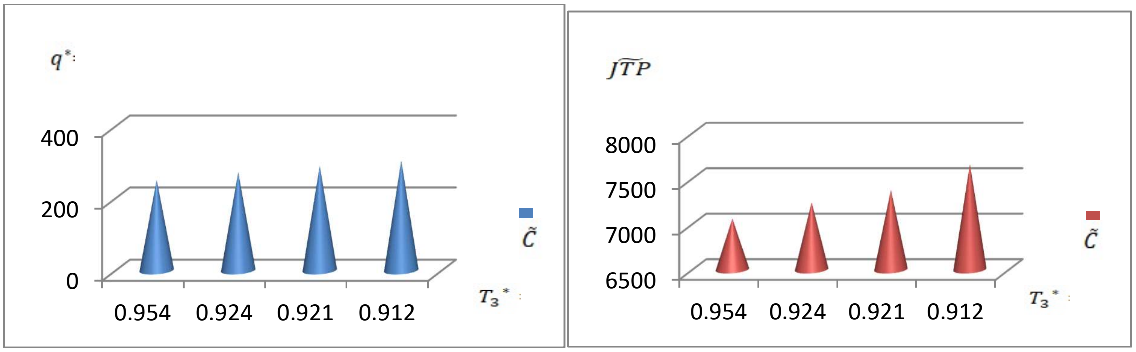
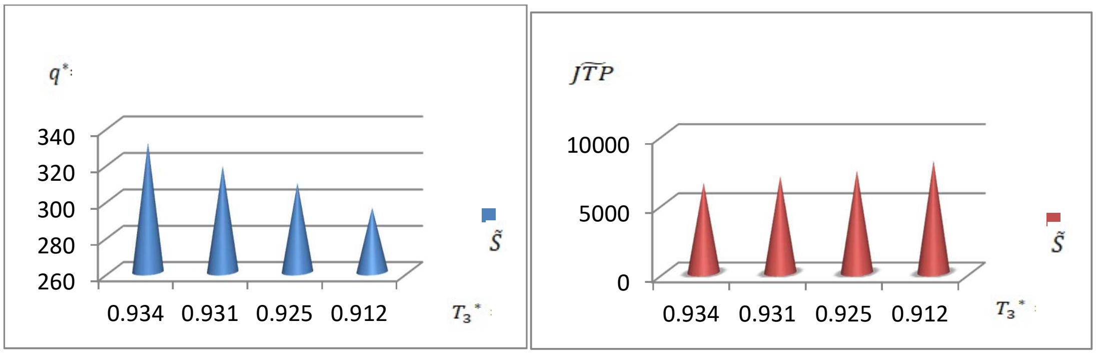


Figure : 8 Outcome of Pharmaceutical company setup cost $\widetilde{S}$ on total joined fuzzy profit.



5. Conclusion:

Managing the pharmacy inventory and profit cycle can effectively organizations to growth of Economic performance, meets managerial requirements, and decrease patient safety risks. Moderate access of inventory, hospitals can reduce the chance of theft, make sure that only the right personnel can conduct inventory transactions, and demonstrate compliance with government regulations. Developed this model for fuzzy inventory pharmaceutical products with two-echelon supply chain in healthcare industries. Setup cost, production cost, holding cost for pharmaceutical company and hospital pharmacy, deteriorating rate cost represented by triangular fuzzy numbers. For defuzzification, we use the graded mean method to find the optimal period of optimistic maximization of the stock. The numerical example shows that the step-mean method maximizes joined total cost of profit. The proposed model can be enlarging to multi -items supply chains, System types include single-buyer multi-vendor, multi-buyer single-vendor, and multi-buyer multi-vendor.

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