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Inventory model with sensitivity analysis under uncertain environment

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Abstract

This paper considers an inventory model under a Neutrosophic environment. There are many inventory models available, such as the EOQ (Economic Order Quantity) models with and without shortage, price breaks, and more. In this paper, we have considered a model without considering the shortage. Our main objective is to find the optimal total cost under uncertainty. To achieve this objective, we use Trapezoidal Neutrosophic environments. Our proposed method aims to solve numerical challenges and new problem types. Finally, the comparative and sensitive analysis is also included in this manuscript. For that purpose, we consider some examples of uncertainty.

Subject Classification: *90B05, 90B10, 90C70, 62A86.*

Keywords: *Inventory management (IM), Neutrosophic inventory model (NIM), Fuzzy inventory model (FIM), Trapezoidal fuzzy number (TpFN).*

1. Introduction

An inventory model must essentially address the three main issues: support production, supporting activities, and customer service. According to Fred Hansman [1] defined inventory as an idle resource of any kind provided such a resource has economic value. The purpose of inventory management is to minimize inventory costs such as carrying

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costs, set-up costs, etc. There are many factors involved in inventory problem analysis i.e., demand and inventory cost for inventory items, replenishment lead time and constraint on inventory system. Therefore, inventory control plays a most important role in real-life applications. Initially, the contribution of some researchers in classical IM problems. R Susanto (2018) [2] aimed to analyze of raw material inventory control using EOQ method, a goal by Riza et al. (2018) [3] who sought to reduce inventory costs by using the same method. Meanwhile, Lin et al. [4] (2007) explained IM and net present value. Yung-Fu Huang [5] (2013) focused on the inventory policy for retailers within a supply chain model that incorporates two tiers of trade credit. Chung and Lin (2013) [6] to explained on the IM of a retailer under the partial trade credit policy of a supplier. The classical inventory management model faces many challenges when it comes to handling uncertainty. This is because the model relies on precise and deterministic parameters such as demand, holding cost, and set-up cost. However, uncertainty has a significant impact on all of these parameters, making it difficult for the classical model to predict the best solution. To address this issue, Lotfi A. Zadeh [7] introduced the fuzzy theory in 1965. The fuzzy inventory model allows for the representation of vague and ambiguous information, which is not possible with traditional inventory models.

In 2016 Kundu et al. [8] aimed optimize a production inventory model by using a hybrid algorithm that combines interval comparison and fuzzy demand, while Bera and Jana [9] proposed a mathematical model for single period multiproduct production IM The following year, Kalaiarasi and Gopinath [10] aimed optimize the FIM, EOQ. The year 2021 saw several advancement, with Vukasović et al. [11] aiming to increase business efficiency by using fuzzy MCDM model for IM. Yung et al. [12] discussing the inventory classification system by using the the multi-attribute fuzzy ABC method . Later on, in 1999, F. Smarandache [13] introduced the concept of a neutrosophic set. He highlighted some of the specific characteristics that make it superior to the classical model and fuzzy model.

The objective of considering the Neutrosophic and novelty.

Evolutionary methods using uncertainty theory are provided in this research, in view of above gaps. The paper also includes an analysis of the current methods and their validity. The main objectives of the research are to identify gaps in current methods and to provide new evolutionary methods using uncertainty theory. The present study aims to explore the IM with sensitivity analysis under uncertain environment**.**

The study aims to explore the inventory model with sensitivity analysis under an uncertain environment. To achieve this, the following objectives have been set:

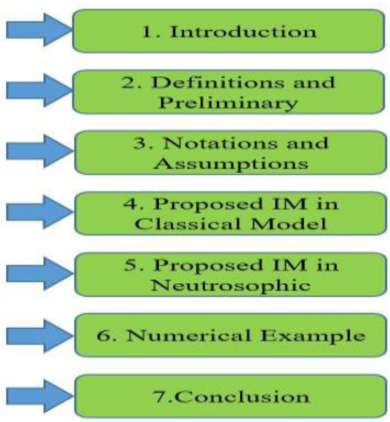
(1) Numerical solutions and their application of NIM without shortage, which are generally described through optimization theory, are studied.

(2) To predict the classical IM without shortage demand/cost underneath completely different uncertainty situations.

(3) Comparing the proposed method with existing approaches to establish its superiority.

(4) To develop the relationship between classical and neutrosophic solutions for testing the validity and accuracy of the suggested methods.

Structure of the Paper:



2. Definitions and Preliminaries

Definition 2.1 [14] [15]: Let $\alpha_{\tilde{k}}, \beta_{\tilde{k}}, \gamma_{\tilde{k}} \in [0,1]$, then a SVTpN number $\tilde{k} = \langle[\tilde{k}_m, \tilde{k}_a, \tilde{k}_n, \tilde{k}_k], (\alpha_{\tilde{k}}, \beta_{\tilde{k}}, \gamma_{\tilde{k}})\rangle$ on the real number R, whose MF of truth $\zeta_{\tilde{k}}(g)$, MF of indeterminacy $\psi_{\tilde{k}}(g)$, and MF of falsity $\xi_{\tilde{k}}(g)$ are given as follows:

$$\zeta_{\tilde{k}}(g)=\begin{cases}\frac{\alpha_{\tilde{k}}(g-\tilde{k}_m)}{(\tilde{k}_a-\tilde{k}_m)}, & \tilde{k}_m\le g\le\tilde{k}_a\\ \alpha_{\tilde{k}}, & \tilde{k}_a\le g\le\tilde{k}_n\\ \frac{\alpha_{\tilde{k}}(\tilde{k}_k-g)}{(\tilde{k}_k-\tilde{k}_n)}, & \tilde{k}_n\le g\le\tilde{k}_k\\ 0, & \text{otherwise}\end{cases},\ \psi_{\tilde{k}}(g)=\begin{cases}\frac{(\tilde{k}_a-g+\beta_{\tilde{k}}(g-\tilde{k}_m))}{(\tilde{k}_a-\tilde{k}_m)}, & \tilde{k}_m\le g\le\tilde{k}_a\\ \beta_{\tilde{k}}, & \tilde{k}_a\le g\le\tilde{k}_n\\ \frac{(g-\tilde{k}_n+\beta_{\tilde{k}}(\tilde{k}_k-g))}{(\tilde{k}_k-\tilde{k}_n)}, & \tilde{k}_n\le g\le\tilde{k}_k\\ 1, & \text{otherwise}\end{cases}$$

$$\xi_{\tilde{k}}(g)=\begin{cases}\frac{(\tilde{k}_a-g+\gamma_{\tilde{k}}(g-\tilde{k}_m))}{(\tilde{k}_a-\tilde{k}_m)}, & \tilde{k}_m\le g\le\tilde{k}_a\\ \gamma_{\tilde{k}}, & \tilde{k}_a\le g\le\tilde{k}_n\\ \frac{(g-\tilde{k}_n+\gamma_{\tilde{k}}(\tilde{k}_k-g))}{(\tilde{k}_k-\tilde{k}_n)}, & \tilde{k}_n\le g\le\tilde{k}_k\\ 1, & \text{otherwise}\end{cases}$$

Definition 2.2 [16]**:** Let $\tilde{U} = \langle[\tilde{u}_a^1, \tilde{u}_n^2, \tilde{u}_k^3, \tilde{u}_i^4]; (A_{\tilde{U}}, B_{\tilde{U}}, C_{\tilde{U}})\rangle$ and $\tilde{V} = \langle[\tilde{v}_a^1, \tilde{v}_n^2, \tilde{v}_k^3, \tilde{v}_i^4]; (A_{\tilde{V}}, B_{\tilde{V}}, C_{\tilde{V}})\rangle$ are two Trapezoidal Neutrosophic numbers, then

$$\tilde{U}\otimes\tilde{V}=\langle[\tilde{u}_a^1\tilde{v}_a^1,\tilde{u}_n^2\tilde{n}_n^2,\tilde{u}_k^3\tilde{n}_k^3,\tilde{u}_i^4\tilde{n}_i^4];(A_{\tilde{U}}\wedge A_{\tilde{V}},B_{\tilde{U}}\vee B_{\tilde{V}},C_{\tilde{U}}\vee C_{\tilde{V}})\rangle$$

$$\alpha\otimes\tilde{U}=\langle[\alpha\tilde{u}_a^1,\alpha\tilde{u}_n^2,\alpha\tilde{u}_k^3,\alpha\tilde{u}_i^4];(A_{\tilde{U}},B_{\tilde{U}},C_{\tilde{U}})\rangle,\alpha\ge 0$$

$$\alpha\otimes\tilde{U}=\langle[\alpha\tilde{u}_i^4,\alpha\tilde{u}_k^3,\alpha\tilde{u}_n^2,\alpha\tilde{u}_a^1];(A_{\tilde{U}},B_{\tilde{U}},C_{\tilde{U}})\rangle,\alpha< 0$$

$$\tilde{U}\oplus\tilde{V}=\langle[\tilde{u}_a^1+\tilde{v}_a^1,\tilde{u}_n^2+\tilde{n}_n^2,\tilde{u}_k^3+\tilde{n}_k^3,\tilde{u}_i^4+\tilde{n}_i^4];(A_{\tilde{U}}\wedge A_{\tilde{V}},B_{\tilde{U}}\vee B_{\tilde{V}},C_{\tilde{U}}\vee C_{\tilde{V}})\rangle$$

Definition 2.3 [16]**:** Let $\tilde{R}_k = \langle(r_1{}^a, r_2{}^n, r_3{}^k, r_4{}^i); (t_{\tilde{R}_k}, i_{\tilde{R}_k}, f_{\tilde{R}_k})\rangle$ be TpFN then the score function of $\tilde{R}_k$ is defined as $Sc(\tilde{R}_k) = \frac{1}{18}(r_1{}^a + 2r_2{}^n + 2r_3{}^k + r_4{}^i)(2 + t_{\tilde{R}_k} - i_{\tilde{R}_k} - f_{\tilde{R}_k})$ Let $\tilde{R}_k$ and $\tilde{A}_k$ be two SVTN-number. Where "Sc" denotes score function and "Ac" denotes Accuracy function. Then,

1. If $Sc(\tilde{R}_k) < Sc(\tilde{A}_k)$, then $\tilde{R}_k$ is smaller than $\tilde{A}_k$, denoted by $\tilde{R}_k < \tilde{A}_k$.
2. If $Sc(\tilde{R}_k) = Sc(\tilde{A}_k)$;
   (a) If $Ac(\tilde{R}_k) < Ac(\tilde{A}_k)$, then $\tilde{R}_k$ is smaller than $\tilde{A}_k$, denoted by $\tilde{R}_k < \tilde{A}_k$.
   (b) If $Ac(\tilde{R}_k) = Ac(\tilde{A}_k)$, then $\tilde{R}_k$ and $\tilde{A}_k$ are the same, denoted by $\tilde{R}_k = \tilde{A}_k$

Definition 2.4 [15]: Let $\hat{\underset{\sim}{\omega}} = [\underset{\sim}{\omega}^a, \underset{\sim}{\omega}^n, \underset{\sim}{\omega}^k, \underset{\sim}{\omega}^i]$ be a TpFN, and $\underset{\sim}{\omega}^a \le \underset{\sim}{\omega}^n \le \underset{\sim}{\omega}^k \le \underset{\sim}{\omega}^i$ then the centre of gravity (COG) of $\hat{\underset{\sim}{\omega}}$ is defined as

$$COG(\hat{\underset{\sim}{\omega}}) = \begin{cases} \underset{\sim}{\omega}, \text{ if } \underset{\sim}{\omega}^a = \underset{\sim}{\omega}^n = \underset{\sim}{\omega}^k = \underset{\sim}{\omega}^i \\ \frac{1}{3}\left[\underset{\sim}{\omega}^a + \underset{\sim}{\omega}^n + \underset{\sim}{\omega}^k + \underset{\sim}{\omega}^i - \frac{\underset{\sim}{\omega}^k \underset{\sim}{\omega}^i - \underset{\sim}{\omega}^a \underset{\sim}{\omega}^n}{\underset{\sim}{\omega}^k + \underset{\sim}{\omega}^i - \underset{\sim}{\omega}^a - \underset{\sim}{\omega}^n} \right], o.w \end{cases}$$

Definition 2.5 [17]: Let $\hat{\underline{p}} = (\hat{p}_1^j, \hat{p}_2^i, \hat{p}_3^t)$ & $\hat{\underline{q}} = (\hat{q}_1^j, \hat{q}_2^i, \hat{q}_3^t)$ are two TrFN then the grade mean integration of $\hat{\underline{p}}$ & $\hat{\underline{q}}$ can be obtained as follows:

$$g(\hat{\underline{p}}) = \frac{1}{6}(\hat{p}_1^j + 4\hat{p}_2^i + \hat{p}_3^t) \quad g(\hat{\underline{q}}) = \frac{1}{6}(\hat{q}_1^j + 4\hat{q}_2^i + \hat{q}_3^t)$$

Definition 2.6 [18]: Let $\hat{\underline{R}}^I = (\hat{r}_1, \hat{r}_2, \hat{r}_3, \hat{r}_1', \hat{r}_2', \hat{r}_3')$ be TrIFN then the score and accuracy of $\hat{\underline{R}}^I$ is defined as $S(\hat{\underline{R}}^{I\tau}) = \frac{1}{4}(\hat{r}_1 + 2\hat{r}_2 + \hat{r}_3)$, $S(\hat{\underline{R}}^{I\varsigma}) = \frac{1}{4}(\hat{r}_1' + 2\hat{r}_2' + \hat{r}_3')$

$$A(\hat{\underline{R}}^I) = \frac{1}{2}(S(\hat{\underline{R}}^{I\tau}) + S(\hat{\underline{R}}^{I\varsigma}))$$

3. Notations and Assumptions

3.1 *Notation*

h stands for "Length of the plan".	$\hat{k}^{neu}$ stands for "Neutrosophic carrying cost".
s stands for "set-up cost per order".	T stands for "Total cost for the period [0, k]"
m stands for "EOQ per cycle".	$\hat{s}^{neu}$ stands for "Neutrosophic ordering cost".
$\hat{m}^{neu}$ stands for "Neutrosophic EOQ".	k stands for "carrying cost per unit quantity per unit time".
a stands for "Length of the cycle".	D stands for "Total demand over the time period [0, k]"

3.2 *Assumptions*

In this manuscript, there are some assumptions are considered:

- Shortages are not allowed.
- Time of plan is constant.
- Only carrying cost and set-up cost are neutrosophic in nature.
- Total demand is considered as constant.

4. Classical Formulation in Inventory Model

An IM without shortage is considered in this manuscript. By the following model equation, the EOQ is obtained in this model.

$$m=\sqrt{\frac{2.s.D}{kh}} \tag{1}$$

The total cost,
$$T=\frac{khm}{2}+\frac{sD}{m} \tag{2}$$

Now differentiating equation (2) partially w.r.t T and equating zero, we have

Optimal order quantity

$$m^{*}=\sqrt{\frac{2.s.D}{kh}} \tag{3}$$

Minimum total cost

$$T^{*}=\sqrt{2skDh} \tag{4}$$

5. Proposed IM under Neutrosophic Environment

The model in neutrosophic environment is considered. the set up cost and carrying cost, which are neutrosophic in nature, are represented by trapezoidal neutrosophic number.

The demand and time of plan are considering as constant. The neutrosophic total cost, which is neutrosophified from the total cost given in equation (2), is given by

$$\hat{T}^{neu}=\frac{\hat{k}^{neu}hm}{2}+\frac{\hat{s}^{neu}D}{m} \tag{5}$$

Our aim is to find the neutrosophic total cost, and neutrosophic EOQ $(\hat{m}^{neu})$ by considering $\hat{k}^{neu}=\begin{pmatrix}\langle \hat{k}_1^{neu},\hat{k}_2^{neu},\hat{k}_3^{neu},\hat{k}_4^{neu}\rangle; \\ (\mu_{\hat{k}^{neu}},\sigma_{\hat{k}^{neu}},\omega_{\hat{k}^{neu}})\end{pmatrix}$ & $\hat{s}^{neu}=\begin{pmatrix}\langle \hat{s}_1^{neu},\hat{s}_2^{neu},\hat{s}_3^{neu},\hat{s}_4^{neu}\rangle; \\ (\mu_{\hat{s}^{neu}},\sigma_{\hat{s}^{neu}},\omega_{\hat{s}^{neu}})\end{pmatrix}$

are neutrosophic trapezoidal holding and setup cost numbers, where $0 < s <$ & $\hat{k}_1^{neu}$, $\hat{k}_2^{neu}$, $\hat{k}_3^{neu}$, $\hat{k}_4^{neu}$, $\hat{s}_1^{neu}$, $\hat{s}_2^{neu}$, $\hat{s}_3^{neu}$, $\hat{s}_4^{neu}$ are known positive number, from (5) we have

$$\hat{T}^{neu} = \hat{T}^{neu}(\hat{k}^{neu}, \hat{s}^{neu}) = \left[\hat{k}^{neu}.\frac{hm}{2}\right] + \left[\hat{s}^{neu}.\frac{D}{m}\right]$$

$$\hat{T}^{neu} = \left[\begin{array}{l}\left(\hat{k}_1^{neu}.\frac{hm}{2}+\hat{s}_1^{neu}.\frac{D}{m}, \hat{k}_2^{neu}.\frac{hm}{2}+\hat{s}_2^{neu}.\frac{D}{m}, \hat{k}_3^{neu}.\frac{hm}{2}+\hat{s}_3^{neu}.\frac{D}{m}, \hat{k}_4^{neu}.\frac{hm}{2}+\hat{s}_4^{neu}.\frac{D}{m}\right); \\ (\mu_{\hat{k}^{neu}} \wedge \mu_{\hat{s}^{neu}}, \sigma_{\hat{k}^{neu}} \vee \sigma_{\hat{s}^{neu}}, \omega_{\hat{k}^{neu}} \vee \omega_{\hat{s}^{neu}})\end{array}\right]$$

Now using definition 2.3, we have

$$\Rightarrow [\hat{T}^{neu}]^R = \frac{1}{6}\left[\left(\begin{array}{l}\hat{k}_1^{neu}.\frac{hm}{2}+\hat{s}_1^{neu}.\frac{D}{m}+2\hat{k}_2^{neu}.\frac{hm}{2}+2\hat{s}_2^{neu}.\frac{D}{m}+ \\ 2\hat{k}_3^{neu}.\frac{hm}{2}+2\hat{s}_3^{neu}.\frac{D}{m}+\hat{k}_4^{neu}.\frac{hm}{2}+\hat{s}_4^{neu}.\frac{D}{m}\end{array}\right)\right] \left[\frac{(2+(\mu_{\hat{k}^{neu}} \wedge \mu_{\hat{s}^{neu}})-(\sigma_{\hat{k}^{neu}} \vee \sigma_{\hat{s}^{neu}})-(\omega_{\hat{k}^{neu}} \vee \omega_{\hat{s}^{neu}}))}{3}\right]$$

$$\Rightarrow [\hat{T}^{neu}]^R = \frac{1}{6}\left[\left(\begin{array}{l}(\hat{k}_1^{neu}+2\hat{k}_2^{neu}+2\hat{k}_3^{neu}+\hat{k}_4^{neu}).\frac{hm}{2} \\ +(\hat{s}_1^{neu}+2\hat{s}_2^{neu}+2\hat{s}_3^{neu}+\hat{s}_4^{neu}).\frac{D}{m}\end{array}\right)\right] \times \left[\frac{(2+(\mu_{\hat{k}^{neu}} \wedge \mu_{\hat{s}^{neu}})-(\sigma_{\hat{k}^{neu}} \vee \sigma_{\hat{s}^{neu}})-(\omega_{\hat{k}^{neu}} \vee \omega_{\hat{s}^{neu}}))}{3}\right] = \phi(m) \quad (6)$$

$\phi(i)$ is minimum when $\frac{d\phi(m)}{dm} = 0$, & where $\frac{d^2\phi(m)}{dm^2} > 0$

Now, $\frac{d\phi(m)}{dm} = 0$ gives the economic order quantity as

$$\Rightarrow \frac{1}{6}\left[\left(\left(\begin{array}{l}\hat{k}_1^{neu}+2\hat{k}_2^{neu} \\ +2\hat{k}_3^{neu}+\hat{k}_4^{neu}\end{array}\right).\frac{h}{2}+\left(\begin{array}{l}\hat{s}_1^{neu}+2\hat{s}_2^{neu} \\ +2\hat{s}_3^{neu}+\hat{s}_4^{neu}\end{array}\right).\left(-\frac{D}{m^2}\right)\right)\right] \times \left[\frac{(2+(\mu_{\hat{k}^{neu}} \wedge \mu_{\hat{s}^{neu}})-(\sigma_{\hat{k}^{neu}} \vee \sigma_{\hat{s}^{neu}})-(\omega_{\hat{k}^{neu}} \vee \omega_{\hat{s}^{neu}}))}{3}\right] = 0$$

$$m^2 = \frac{2D}{h}\frac{(\hat{s}_1^{neu}+2\hat{s}_2^{neu}+2\hat{s}_3^{neu}+\hat{s}_4^{neu})}{(\hat{k}_1^{neu}+2\hat{k}_2^{neu}+2\hat{k}_3^{neu}+\hat{k}_4^{neu})}$$

Therefore, Neutrosophic optimal quantity is

$$\hat{m}^{neu} = \sqrt{\frac{2D}{h}\frac{(\hat{s}_1^{neu}+2\hat{s}_2^{neu}+2\hat{s}_3^{neu}+\hat{s}_4^{neu})}{(\hat{k}_1^{neu}+2\hat{k}_2^{neu}+2\hat{k}_3^{neu}+\hat{k}_4^{neu})}} \quad (7)$$

Also, at $m = \hat{m}^{neu}$, we have $\frac{d^2(m)}{dm^2} > 0$, This shows that $\phi(m)$ is minimum at $m = \hat{m}^{neu}$. And from equation (6), we find:

$$\Rightarrow [\phi(m)]^* = \frac{1}{6}\left[\begin{pmatrix} (\hat{k}_1^{neu} + 2\hat{k}_2^{neu} + 2\hat{k}_3^{neu} + \hat{k}_4^{neu}).\frac{hm}{2} \\ +(\hat{s}_1^{neu} + 2\hat{s}_2^{neu} + 2\hat{s}_3^{neu} + \hat{s}_4^{neu}).\frac{D}{m} \end{pmatrix}\right] \times \left[\frac{(2 + (\mu_{\hat{k}^{neu}} \wedge \mu_{\hat{s}^{neu}}) - (\sigma_{\hat{k}^{neu}} \vee \sigma_{\hat{s}^{neu}}) - (\omega_{\hat{k}^{neu}} \vee \omega_{\hat{s}^{neu}}))}{3}\right] \quad (8)$$

6. Numerical Example

In this section, we are going to discuss some real-life examples.

Example 6.1 [19] [20]: A farmer uses 500 units of rice in his storage house, which costs 1.2rs/unit. The inventory has carrying cost of 10% and order cost of 20rs/day. Find the EOQ and the cost for 6 days in both classical and Neutrosophic situation. We have observed that there is a lot of uncertainty in holding cost and set up cost, which is why we have transformed them into a Neutrosophic environment. Where holding cost $\hat{k}^{neu} = \langle[8,10,14,16];(1,0,0)\rangle$, $\hat{s}^{neu} = \langle[15,18,22,24];(1,0,0)\rangle$.

Solution: After considering the neutrosophic parameter the we find the below outcomes in Table 1.

Table 1

Sensitivity analysis while considering holding cost $(\hat{k}^{neu})$ and set up cost $(\hat{s}^{neu})$ under a neutrosophic environment.

Demand	Classical Environment	Kumar and Dutta [19]	Our Proposed Method	Demand	Classical Environment	Kumar and Dutta [19]	Proposed Method
500	1200	1194.99	1194.9	625	1341.64	1336.04	1336.0
525	1229.63	1224.5	1224.5	650	1368.21	1362.5	1362.5
550	1258.57	1253.32	1253.3	675	1394.27	1388.5	1388.5
575	1286.86	1281.48	1281.4	700	1419.86	1413.9	1413.9
600	1314.53	1309.04	1309.0	725	1444.99	1438.9	1438.9

In Table 1, we found that our proposed method is also solve the existing problem. Our method solves the existing problem more efficiently. The EOQ value is closer to the crisp EOQ, and the total cost is less than the crisp total cost.

Example 6.2: A farmer stores rice in his storage house. He uses 500-900 units of rice, which costs 1.2rs per unit. The inventory has a carrying cost of 10% and an order cost of 20 rs per day. We need to find the EOQ and the total inventory for 6 days in the neutrosophic sense. We have observed that there is a lot of uncertainty in holding cost and set-up cost, which is why we have transformed them into a neutrosophic environment. Table 2 shows the 1-6 cases.

Table 2

Let us consider the following data for solving our proposed model

Different Cases	Holding cost = $\hat{k}^{neu} = \begin{pmatrix} \langle \hat{k}_1^{neu}, \hat{k}_2^{neu}, \hat{k}_3^{neu}, \hat{k}_4^{neu} \rangle; \\ (\mu_{\hat{k}^{neu}}, \sigma_{\hat{k}^{neu}}, \omega_{\hat{k}^{neu}}) \end{pmatrix}$, setup cost = $\hat{s}^{neu} = \begin{pmatrix} \langle \hat{s}_1^{neu}, \hat{s}_2^{neu}, \hat{s}_3^{neu}, \hat{s}_4^{neu} \rangle; \\ (\mu_{\hat{s}^{neu}}, \sigma_{\hat{s}^{neu}}, \omega_{\hat{s}^{neu}}) \end{pmatrix}$, and Demand ($D$)	Different Cases	Holding cost = $\hat{k}^{neu} = \begin{pmatrix} \langle \hat{k}_1^{neu}, \hat{k}_2^{neu}, \hat{k}_3^{neu}, \hat{k}_4^{neu} \rangle; \\ (\mu_{\hat{k}^{neu}}, \sigma_{\hat{k}^{neu}}, \omega_{\hat{k}^{neu}}) \end{pmatrix}$, setup cost = $\hat{s}^{neu} = \begin{pmatrix} \langle \hat{s}_1^{neu}, \hat{s}_2^{neu}, \hat{s}_3^{neu}, \hat{s}_4^{neu} \rangle; \\ (\mu_{\hat{s}^{neu}}, \sigma_{\hat{s}^{neu}}, \omega_{\hat{s}^{neu}}) \end{pmatrix}$, and Demand ($D$)
Case (i):	[(8, 20, 28, 16); (0.96, 0.55, 0.33)], [(15, 36, 44, 24); (0.97, 0.5, 0.25)], and 500	**Case (iv):**	[(14, 46, 56, 34); (0.89, 0.33, 0.13)], [(21, 62, 72, 42); (0.91, 0.37, 0.17)], and 725
Case (ii):	[(10, 30, 36, 22); (0.94, 0.41, 0.25)], [(17, 46, 52, 30); (0.96, 0.45, 0.22)], and 575	**Case (v):**	[(16, 54, 66, 40); (0.87, 0.3, 0.11)], [(23, 70, 82, 48); (0.89, 0.33, 0.15)], and 800
Case (iii):	[(12, 38, 46, 28); (0.91, 0.39, 0.15)], [(19, 54, 62, 36); (0.92, 0.4, 0.2)], and 650	**Case (vi):**	[(18, 62, 76, 46); (0.75, 0.27, 0.1)], [(25, 78, 92, 54); (0.87, 0.29, 0.13)], and 875

Solution:

Table 3

Finding the total optimal cost under different cases

Different Cases	Proposed Method	Different Cases	Proposed Method	Different Cases	Proposed Method
Case (i)	828.5261	Case (iii)	2475.637	Case (v)	3865.993
Case (ii)	1848.368	Case (iv)	3139.966	Case (vi)	4462.155

In Table 3, we have presented the solution to example 6.2. Our proposed method is the only one that can solve this new problem, while

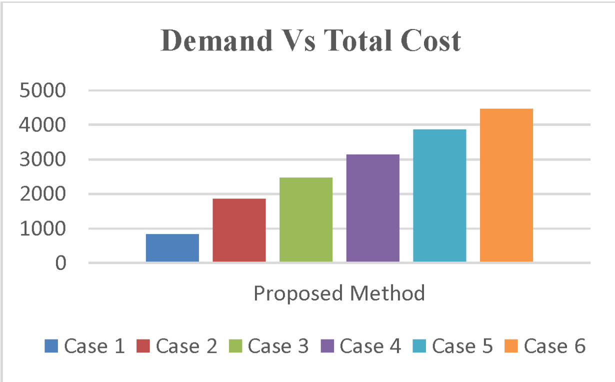


Figure 1

A pictorial comparison study with some of the existing methods [19] [20].

the methods of De and Rawat [20] and Kumar and Dutta [19] cannot. It was also observed that the EOQ is more sensitive towards demand. The total cost directly proportional to the demand.

In addition to tabular comparison, we also conducted a pictorial comparison study in Figure 1 with some of the existing methods such as De and Rawat [20], and Kumar and Dutta [19].

7. Conclusion

This manuscript presents an inventory model under a Neutrosophic environment. The proposed model aims to find the optimal total cost under uncertainty. The model does not consider shortage and uses Trapezoidal Neutrosophic environments to solve numerical challenges and new problem types. The manuscript also includes comparative and sensitive.

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