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An Enumeration Technique for Transshipment Problem in Neutrosophic Environment

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Abstract. Neutrosophic sets, which are the generalization of fuzzy, and intuitionistic fuzzy sets, have been introduced to express uncertain, incomplete, and indeterminacy knowledge regarding a real-world problem. This paper is intended for the first time to introduce a transshipment problem mathematically in a neutrosophic environment. The neutrosophic transshipment problem is a special type of neutrosophic transportation problem in which available commodities regularly travel from one origin to other origins/destinations before arriving at their final destination. This article provides a technique for solving transshipment problems in a neutrosophic environment. A fully neutrosophic transshipment problem is considered in this article and the parameters (transshipment cost, supply and demand) are expressed in trapezoidal neutrosophic numbers. The possibility mean ranking function is used in the proposed technique. The proposed technique gives a direct optimal solution. The proposed technique is simple to implement and can be used to find the neutrosophic optimal solution to real-world transshipment problems. A numerical example is provided to demonstrate the efficacy of the proposed technique in the neutrosophic environment.

Keywords: Decision-Making Problem, Transshipment Problem, Neutrosophic Transshipment Problem, Single-Valued Trapezoidal Neutrosophic Number

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When a particular product needs to be transported from source to sink in a network, transportation is one of the most important engineering challenges. A common transportation problem arises when a certain bulk of commodity needs to shipped from their origins to their destinations through multiple intermediate points (transshipment points). This classic form of transporters problem is called a transshipment problem. This problem was first proposed by

Orden [1]. The concept of the transshipment problem can also be applied to determining the shortest path between two nodes in a network. As an application of transshipment problem, King and Logan [2] established a mathematical method for simultaneously identifying threads in a network linking to product processor market points, while Rhody [3] suggested a method based on a reduced matrix. Judges et al. [4] proposed a general linear model extension of the transshipment problem to a multi-plant, multi-product, and multiregional problem. The alternative formulations of transshipment problems under the transport model was discussed by Hurt and Tramel [5] , which would allow for answers to common difficulties that King and Logan articulated without the requirement for artificial variables to be subtracted. "The time-minimizing transshipment problem" was investigated by Garg and Prakash [6]. Subsequently, Herer and Tzur [7] examined the dynamic transshipment problem. Ozdemir et al. [8] then looked on the problem of multilocation transshipment with capacitated manufacturing and lost sales.

Transshipment problem formulation requires the understanding of parameters such as demand, supply, associated cost, time, stock space, budget, etc. Traditional methods can be used to solve the transshipment problem when the decision parameters are known. However, in real-world scenarios, numerous types of uncertainty arise mathematically when designing transshipment due to factors such as a lack of precise information, information that cannot be obtained, rapid changes in the fuel rate or traffic jam, or whether conditions. Therefore, the transshipment problem with impricise information cannot be solved by traditional mathematical techniques. Zadeh [9] introduced the idea of fuzzy sets to deal with uncertainties. In order to handle unsure information, Zadeh effectively applied the theory of fuzzy set (FS) in various fields. The applications of this theory are rapidly growing in the field of optimization after the foremost work by Bellman and Zadeh [10]. Zimmermann [11] demonstrated that the solutions generated by fuzzy linear programming are always optimal and efficient. Fuzzy transshipment problem is the name given to the transshipment problem that is explored in fuzzy theory, which has been discussed by many researchers ([12]- [16]). Only the membership degrees are insufficient to indicate the element's marginal attainment in the fuzzy decision set, as was shown later on in the research. The intuitionistic fuzzy set (IFS), which incorporates both a membership and a non-membership function, was developed by Atanassov [17]. It is recommended that the sum of an element's membership and non-membership degrees does not exceed 1 in an intuitionistic fuzzy set. The transportation problem discussed in IFS is known as intuitionistic fuzzy transportation problem. Paramanik and Roy [18–20] discussed transportation and goal programming in IFS. Later, the transshipment problem in IFS has been discussed by many researchers ([21], [22]).

As a result of the presence of neutral ideas in the decision-making process, the extension of FS and IFS were required. Smarandache [23] introduced the neutrosophic set (NS) as a way to deal with the degree of indeterminacy and neutrality. Truth (degree of belongingness), indeterminacy (degree of belongingness up to a certain extant), and falsity (degree of non-belongingness) are three different membership functions for the element into a feasible solution set that the NS evaluates. But NS is difficult to implement without explicit detail in real-life problems. A single-valued neutrosophic set (SVNS) has been proposed for NS extension by Wang et al. [24]. By combining trapezoidal fuzzy numbers with a single-valued neutrosophic set, Ye [25] introduced single-valued trapezoidal neutrosophic (SVTrN) numbers. Many researchers such as Ahmad et al. [26], Garai et al. [27], Ahmad [28], Touqeer et al. [29], have recently used the concept of NS in decision-making problems. The effects of ignoring the values of propositions between the truth and falsity degrees are indeterminacy/neutral thoughts. As a result, when dealing with transshipment problems, it is important to consider the degree of indeterminacy.

Despite the fact that many researchers ([30]- [33]) applied the concept of neutrosophic theories to transportation problems. Neuosophic logic has not been applied to existing supply chain theories of transshipment models, to the best of our knowledge. This article aims to provide a simple yet effective method for solving neutrosophic transshipment problems in a day-to-day situation. There are a number of advantages to using the technique:

- All parameters are represented as trapezoidal neutrosophic numbers in a fully neutrosophic transshipment problem.
- The proposed technique is based on the possiblility mean ranking function.
- The technique proposed produces an optimal solution directly.
- The proposed method is simple to comprehend and can be used to solve real-life transshipment issues.

The following is how this article is organised. The neutrosophic set and neutrosophic numbers are introduced in Section 2. In the Section 3 formulates the airthmetic operations on single valued neutrosophic numbers, while the Section 4 presents the possilibity mean and ranking function on SVTrN-numbers. The mathematical structure of the transshipment problem in a neutrosophic environment was formulated in Section 5. The proposed technique's steps were addressed in Section 6. In Section 7, an example is given to show the effectiveness of the proposed solution strategy. The paper comes to a close with the conclusion.

1. **Mathematical Preliminaries**

This section provides an overview of key conceptions and definitions related to neutrosophic sets.

Definition 1. *[23] Let M be a universe and y in M. The neutrosophic set N over M is defined by $N = \langle y, T_N(y), I_N(y), F_N(y) : y \in M\rangle$, where the functions $T_N, I_N, F_N : P \rightarrow]^-0, 1^+[$ represent the truth-membership, indeterminate-membership, falsity-membership respectively such that $^-0 \leq T_N(y) + I_N(y) + F_N(y) \leq 3^+$*

Definition 2. *[23] Let M be a universe and y in M. Then a single valued neutrosophic set N is characterized by truth-membership T_N, indeterminacy-membership function I_N, falsity-membership function F_N, where $T_N, I_N, F_N : M \rightarrow [0,1]$ are functions such that $0 \leq T_N(y) + I_N(y) + F_N(y) \leq 3$.*

Definition 3. *[27] A single valued trapezoidal neutrosophic number is defined by $\tilde{m} = \langle (m_1, m_2, m_3, m_4); t_{\tilde{m}}, i_{\tilde{m}}, f_{\tilde{m}}\rangle$, where $t_{\tilde{m}}, i_{\tilde{m}}, f_{\tilde{m}} \in [0,1]$ and m_1, m_2, m_3, m_4 in $\mathbb{R}$ with condition that $m_1 \leq m_2 \leq m_3 \leq m_4$. The truth-membership, indeterminacy-membership, and falsity-membership functions of $\tilde{m}$ are given as follows:*

$$\mu_{\tilde{m}}(y) = \begin{cases} t_{\tilde{m}}(\frac{y-m_1}{m_2-m_1}); & m_1 \leq y \leq m_2 \\ t_{\tilde{m}}; & m_2 \leq y \leq m_3 \\ t_{\tilde{m}}(\frac{m_4-y}{m_4-m_3}); & m_3 \leq y \leq m_4 \\ 0; & otherwise, \end{cases}$$

$$\nu_{\tilde{m}}(y) = \begin{cases} \frac{m_2-y+i_{\tilde{m}}(y-m_1)}{m_2-m_1}; & m_1 \leq y \leq m_2 \\ i_{\tilde{m}}; & m_2 \leq y \leq m_3 \\ \frac{y-m_3+i_{\tilde{m}}(m_4-y)}{m_4-m_3}; & m_3 \leq y \leq m_4 \\ 1; & otherwise \end{cases}$$

$$\lambda_{\tilde{m}} = \begin{cases} \frac{m_2-y+f_{\tilde{m}}(y-m_1)}{m_2-m_1}; & m_1 \leq y \leq m_2 \\ f_{\tilde{m}}; & m_2 \leq y \leq m_3 \\ \frac{y-m_3+f_{\tilde{m}}(m_4-y)}{m_4-m_3}; & m_3 \leq y \leq m_4 \\ 1; & otherwise, \end{cases}$$

where $t_{\tilde{m}}$, $i_{\tilde{m}}$ and $f_{\tilde{m}}$ are represents the maximum truth-membership degree, minimum-indeterminacy membership degree, minimum falsity-membership degree respectively. The geometrical representation of SVTrNF-number is shown by Fig. 1.

Definition 4. *[34] Let $\tilde{m} = \langle (m_1, m_2, m_3, m_4); t_{\tilde{m}}, i_{\tilde{m}}, f_{\tilde{m}}\rangle$ and $\tilde{n} = \langle (n_1, n_2, n_3, n_4); t_{\tilde{n}}, i_{\tilde{n}}, f_{\tilde{n}}\rangle$ be two single valued trapezoidal neutrosophic numbers and $k \neq 0$ be any number and $\wedge = min$, $\vee = max$, then the operations on them are defined as follows :*

(1) $\tilde{m} \oplus \tilde{n} = \langle (m_1 + n_1, m_2 + n_2, m_3 + n_3, m_4 + n_4); t_{\tilde{m}} \wedge t_{\tilde{n}}, i_{\tilde{m}} \vee i_{\tilde{n}}, f_{\tilde{m}} \vee f_{\tilde{n}}\rangle$,

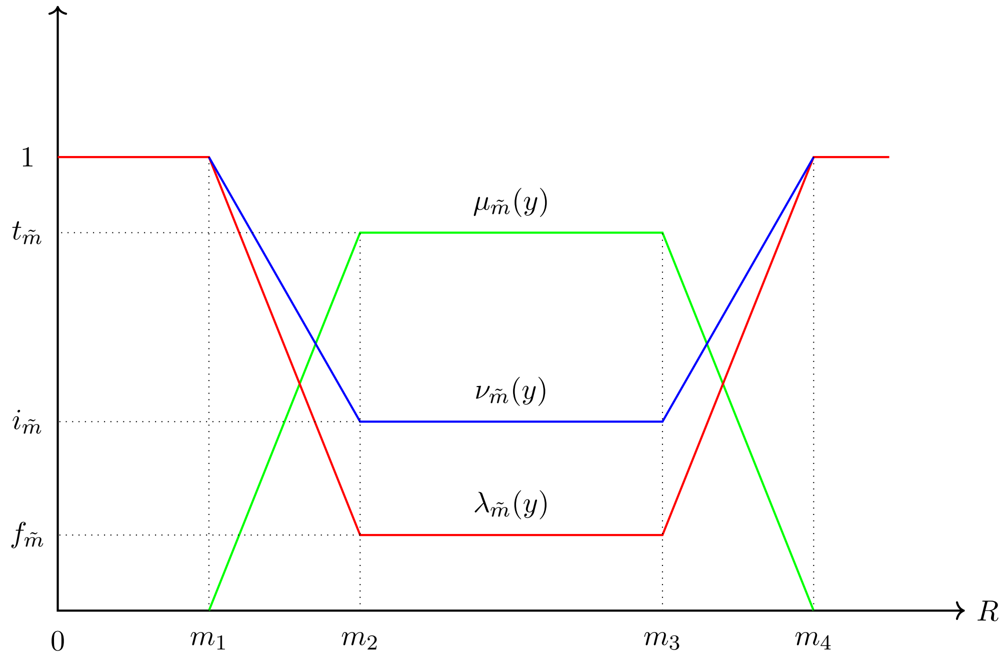

Figure 1. SVTrN-number

(2) $\tilde{m} \ominus \tilde{n} = \langle (m_1 - n_4, m_2 - n_3, m_3 - n_2, m_4 - n_1); t_{\tilde{m}} \wedge t_{\tilde{n}}, i_{\tilde{m}} \vee i_{\tilde{n}}, f_{\tilde{m}} \vee f_{\tilde{n}} \rangle,$

(3)

$$\tilde{m} \otimes \tilde{n} = \begin{cases} \langle (\frac{m_1}{n_4}, \frac{m_2}{n_3}, \frac{m_3}{n_2}, \frac{m_4}{n_1}); t_{\tilde{m}} \wedge t_{\tilde{n}}, i_{\tilde{m}} \vee i_{\tilde{n}}, f_{\tilde{m}} \vee f_{\tilde{n}} \rangle & \text{if } m_4 > 0, n_4 > 0 \\ \langle (\frac{m_4}{n_4}, \frac{m_3}{n_3}, \frac{m_2}{n_2}, \frac{m_1}{n_1}); t_{\tilde{m}} \wedge t_{\tilde{n}}, i_{\tilde{m}} \vee i_{\tilde{n}}, f_{\tilde{m}} \vee f_{\tilde{n}} \rangle & \text{if } m_4 < 0, n_4 > 0 \\ \langle (\frac{m_4}{n_1}, \frac{m_3}{n_2}, \frac{m_2}{n_3}, \frac{m_1}{n_4}); t_{\tilde{m}} \wedge t_{\tilde{n}}, i_{\tilde{m}} \vee i_{\tilde{n}}, f_{\tilde{m}} \vee \rangle & \text{if } m_4 < 0, n_4 < 0 \end{cases}$$

(4)

$$c\tilde{m} = \begin{cases} \langle (cm_1, cm_2, cm_3, cm_4); t_{\tilde{m}}, i_{\tilde{m}}, f_{\tilde{m}} \rangle & \text{if } c > 0 \\ \langle (cm_4, cm_3, cm_2, cm_1); t_{\tilde{m}}, i_{\tilde{m}}, f_{\tilde{m}} \rangle & \text{if } c < 0 \end{cases}$$

(5) $\tilde{m}^{-1} = \langle (\frac{1}{m_4}, \frac{1}{m_3}, \frac{1}{m_2}, \frac{1}{m_1}); t_{\tilde{m}}, i_{\tilde{m}}, f_{\tilde{m}} \rangle,$ *where* $\tilde{m} \neq 0.$

2. The Possibility Mean and The Ranking Function for SVTrN-numbers

Sometimes, decision information supplied by a decision maker in difficult decision-making situations is vague or inaccurate due to time restrictions, a lack of facts, or the restricted attention and information processing capacity of the decision maker. As a result, incorporating the possibility mean into the neutrosophic decision-making process in transshipment is critical for scientific study and real-world application. Therefore, in this section the possibilty mean and the ranking function based on the possiblity mean are defined.

2.1. *The Possibility Mean Functions for SVTrN-Number*

Let $\tilde{m} = \langle (m_1, m_2, m_3, m_4); t_{\tilde{m}}, i_{\tilde{m}}, f_{\tilde{m}} \rangle$ be any SVTrN-number. Then the possibilty mean functions are defined as follows: [27]

1. α-cut set of the SVTrN-number $\tilde{m}$ for truth-membership function is obtained as

$$\tilde{m}_\alpha = [M_L, M_R] = [m_1 + \tfrac{\alpha(m_2-m_1)}{t_{\tilde{m}}}, m_3 - \tfrac{\alpha(m_3-m_2)}{t_{\tilde{m}}}]$$

where $\alpha \in [0, t_{\tilde{m}}]$. The possibility mean of truth-membership function for SVTrN-number $\tilde{m}$ is given by

$$P_\mu(\tilde{m}) = \frac{m_1 + 2m_2 + 2m_3 + m_4}{6} t_{\tilde{m}}^2$$

2. β-cut set of the SVTrN-number $\tilde{m}$ for indeterminacy membership function is obtained as

$$\tilde{m}_\beta = [M_L, M_R] = [m_1 + \tfrac{(1-\beta)(m_2-m_1)}{1-i_{\tilde{m}}}, m_3 - \tfrac{(1-\beta)(m_3-m_1)}{1-i_{\tilde{m}}}]$$

where $\beta \in [\nu_{\tilde{m}}, 1]$. The possibility mean of indeterminacy-membership function for SVTrN-number $\tilde{m}$ is given by

$$P_\nu(\tilde{m}) = \frac{m_1 + 2m_2 + 2m_3 + m_4}{6}(1 - i_{\tilde{m}})^2$$

3. γ-cut set of the SVTrN-number $\tilde{m}$ for falsity-membership function is obtained as

$$\tilde{m}_\gamma = [M_L, M_R] = [m_1 + \tfrac{(1-\gamma)(m_2-m_1)}{1-i_{\tilde{m}}}, m_3 - \tfrac{(1-\gamma)(m_3-m_1)}{1-i_{\tilde{m}}}]$$

where $\gamma \in [f_{\tilde{m}}, 1]$. The possibility mean of falsity-membership function for SVTrN-number $\tilde{m}$ is given by

$$P_\lambda(\tilde{m}) = \frac{m_1 + 2m_2 + 2m_3 + m_4}{6}(1 - f_{\tilde{m}})^2$$

2.2. *The Ranking Function Based on The Possibility Mean Function*

The ranking fuction based on possiblity mean values for a SVTrN-number $\tilde{m} = \langle (m_1, m_2, m_3, m_4);\ t_{\tilde{m}}, i_{\tilde{m}}, f_{\tilde{m}} \rangle$ is given by

$$P_\theta(\tilde{m}) = \theta P_\mu(\tilde{m}) + (1-\theta) P_\nu(\tilde{m}) + (1-\theta) P_\lambda(\tilde{m})$$

Theorem 1. *Let $\tilde{m} = \langle (m_1, m_2, m_3, m_4); t_{\tilde{m}}, i_{\tilde{m}}, f_{\tilde{m}} \rangle$ and $\tilde{n} = \langle (n_1, n_2, n_3, n_4); t_{\tilde{n}}, i_{\tilde{n}}, f_{\tilde{n}} \rangle$ be two SVTrN-numbers and $\theta \in [0, 1]$. For the possibility mean values of the SVTrN-numbers $\tilde{m}$ and $\tilde{n}$, the following illustrantions hold true.*

(1) *If $P_\theta(\tilde{m}) > P_\theta(\tilde{n})$, than $\tilde{m} \succ \tilde{n}$.*
(2) *If $P_\theta(\tilde{m}) < P_\theta(\tilde{n})$, than $\tilde{m} \prec \tilde{n}$.*
(3) *If $P_\theta(\tilde{m}) = P_\theta(\tilde{n})$, than $\tilde{m} \approx \tilde{n}$.*

Proof. It is evident from the definition of ranking function. □

3. Mathematical Formulation of SVNTrP

We have mathematically formulated a transshipment problem in a neutrosophic environment in this section. The parameters of the problem under consideration are single-valued trapezoidal neutrosophic numbers. i.e., the decision maker is unsure about the cost of transshipment, supply and demand. The primary goal of the transshipment problem is to transport any item/product from one origin or destination to another origin or destination while minimising total transshipment costs. In a neutrosophic environment, the mathematical structure of the transshipment problem is as follows:

$$min \tilde{z}^N = \sum_{i=1}^{m+n} \sum_{j=1}^{m+n} \tilde{C}_{ij}^N \otimes \tilde{X}_{ij}^N$$

$$\text{Subject to } \sum_{j=1}^{m+n} \tilde{X}_{ij}^N - \sum_{j=1}^{m+n} \tilde{X}_{ji}^N = \tilde{a}_i^N, \; i = 1, 2, ..., m.$$

$$\sum_{i=1}^{m+n} \tilde{X}_{ij}^N - \sum_{i=1}^{m+n} \tilde{X}_{ji}^N = \tilde{b}_j^N, \; j = m+1, m+2, ..., m+n.$$

$$\tilde{X}_{ij}^N \geq 0, \; i, j = 1, 2, ..., m+n; \; i \neq j.$$

The problem is said to be balanced if $\sum_{i=1}^{m} \tilde{a}_i^N \approx \sum_{j=1}^{n} \tilde{b}_j^N$, otherwise it is know as unbalance problem. Where,

- m and n denote total number of supply sources and total number of demand points, respectively.
- a_i^N denotes available commodity at ith source.
- b_j^N denotes demand of the commodity at jth destination.
- $\tilde{C}_{ij}^N = (c_{ij,1}, c_{ij,2}, c_{ij,3}, c_{ij,4} \; ; w_{\tilde{a}}, u_{\tilde{a}}, y_{\tilde{a}})$ denotes the neutrosophic transshipment cost of a unit commodity from ith source to jth destination.
- The number of units of the commodity to be carried from the ith source to the jth destination is denoted by X_{ij}.

4. Methodology

In this section, a noval transshipment problem technique is presented, that uses the possibility mean ranking function to obtain the optimal solution. The technique is explained in detail below in a step-by-step manner.

Step 1 Construct a neutrosophic transshipment problem in Table form in which either all parameters are taken as SVTrNF-numbers.

Step 2 Put zeros where demand and supply are unknown.

Step 3 Assign zero values to each digonal cell and delete the rows/columns whose demand has been met.

Step 4 The transshipment cost is then converted to a crisp number using the possibility mean based ranking function that is discussed in Section 4.

Step 5 From the matrix obtained after Step 4, choose minimum element from each row then subtract it from each element of corresponding row.

Step 6 From the matrix obtained after Step 5, choose minimum element from each column then subtract it from each element of corresponding column.

Step 7 In this manner, each row and column will have at least one zero value. Then, for each cell having a zero value, use the following formula to determine the zero average value O_{ij}.

$$O_{ij} = \text{the average of the ith row's and jth column's minimum values.}$$

Step 8 Select the maximum zero average value and assign it to the appropriate cell with the minimum demand/supply, then delete the row/column whose supply/demand has reached its limit.

Step 9 Pick an allocation that assigns the highest feasible demand in the same rank case.

Step 10 Follow steps 7 to 9 until the total demands are not fulfilled.

Step 11 Add the product of the assigned demand/supply and the cost value for each cell to get the total transshipment cost. The neutrosophic optimal solution is provided by this total transshipment cost.

5. Numerical Example

We provide an example of our proposed solution methodology in this section. A neutrosophic transshipment problem with two origins (A,B) and two destinations (C,D) has been considered. Table 1 shows the availability at the origins, the requirements at the destinations, and the transshipment costs.

Table 1. SVTrN transshipment problem

Destination → Sources ↓	A	B	C	D	Supply
A	$(0,0,0,0)$	$(5,7,9,11\,;\,0.4,0.8,0.5)$	$(4,6,9,11\,;\,0.9,0.3,0.7)$	$(1,3,8,10;0.3,0.9,0.4)$	$(14,20,21,27\,;\,0.2,0.7,0.9)$
B	$(7,10,12,15\,;\,0.1,0.6,0.8)$	$(0,0,0,0)$	$(2,5,9,12\,;\,0.6,0.3,0.1)$	$(6,9,12,15\,;\,0.5,0.2,0.6)$	$(13,18,23,28\,;\,0.5,0.3,0.6)$
C	$(3,7,9,13\,;\,0.4,0.7,0.3)$	$(5,8,12,15\,;\,0.2,0.4,0.7)$	$(0,0,0,0)$	$(7,12,14,19\,;\,0.8,0.3,0.2)$	–
D	$(2,6,9,13\,;\,0.9,0.7,0.8)$	$(6,7,8,9\,;\,0.3,0.8,0.6)$	$(1,5,7,11\,;\,0.2,0.9,0.7)$	$(0,0,0,0)$	–
Demand	–	–	$(12,18,20,26\,;\,0.4,0.3,0.5)$	$(15,20,24,29\,;\,0.7,0.8,0.4)$	

For each column or row, write zero value for unknown demand/supply.

Table 2. Balance tansshipment problem

Destination → Sources ↓	A	B	C	D	Supply
A	$(0,0,0,0)$	$(5,7,9,11\ ;\ 0.4,0.8,0.5)$	$(4,6,9,11\ ;\ 0.9,0.3,0.7)$	$(1,3,8,10;0.3,0.9,0.4)$	$(14,20,21,27\ ;\ 0.2,0.7,0.9)$
B	$(7,10,12,15\ ;\ 0.1,0.6,0.8)$	$(0,0,0,0)$	$(2,5,9,12\ ;\ 0.6,0.3,0.1)$	$(6,9,12,15\ ;\ 0.5,0.2,0.6)$	$(13,18,23,28\ ;\ 0.5,0.3,0.6)$
C	$(3,7,9,13\ ;\ 0.4,0.7,0.3)$	$(5,8,12,15\ ;\ 0.2,0.4,0.7)$	$(0,0,0,0)$	$(7,12,14,19\ ;\ 0.8,0.3,0.2)$	$(0,0,0,0)$
D	$(2,6,9,13\ ;\ 0.9,0.7,0.8)$	$(6,7,8,9\ ;\ 0.3,0.8,0.6)$	$(1,5,7,11\ ;\ 0.2,0.9,0.7)$	$(0,0,0,0)$	$(0,0,0,0)$
Demand	$(0,0,0,0)$	$(0,0,0,0)$	$(12,18,20,26\ ;\ 0.4,0.3,0.5)$	$(15,20,24,29\ ;\ 0.7,0.8,0.4)$	

The lowest cost value in each row is zero. We discover that zero is the smallest unit cost in each row, so we place zero in the diagonal cell of the transshipment matrix. Table 2 illustrates this.

Table 3. Reduced tansshipment problem

Destination → Sources ↓	A	B	C	D	Supply
A	$(0,0,0,0)$ $(\mathbf{0},\mathbf{0},\mathbf{0},\mathbf{0})$	$(5,7,9,11\ ;\ 0.4,0.8,0.5)$	$(4,6,9,11\ ;\ 0.9,0.3,0.7)$	$(1,3,8,10;0.3,0.9,0.4)$	$(14,20,21,27\ ;\ 0.2,0.7,0.9)$
B	$(7,10,12,15\ ;\ 0.1,0.6,0.8)$	$(0,0,0,0)$ $(\mathbf{0},\mathbf{0},\mathbf{0},\mathbf{0})$	$(2,5,9,12\ ;\ 0.6,0.3,0.1)$	$(6,9,12,15\ ;\ 0.5,0.2,0.6)$	$(13,18,23,28\ ;\ 0.5,0.3,0.6)$
C	$(3,7,9,13\ ;\ 0.4,0.7,0.3)$	$(5,8,12,15\ ;\ 0.2,0.4,0.7)$	$(0,0,0,0)$ $(\mathbf{0},\mathbf{0},\mathbf{0},\mathbf{0})$	$(7,12,14,19\ ;\ 0.8,0.3,0.2)$	$(0,0,0,0)$
D	$(2,6,9,13\ ;\ 0.9,0.7,0.8)$	$(6,7,8,9\ ;\ 0.3,0.8,0.6)$	$(1,5,7,11\ ;\ 0.2,0.9,0.7)$	$(0,0,0,0)$ $(\mathbf{0},\mathbf{0},\mathbf{0},\mathbf{0})$	$(0,0,0,0)$
Demand	$(0,0,0,0)$	$(0,0,0,0)$	$(12,18,20,26\ ;\ 0.4,0.3,0.5)$	$(15,20,24,29\ ;\ 0.7,0.8,0.4)$	

Delete the rows or columns whose demands have been met.

Table 4. New tansshipment problem

Destination → Sources ↓	C	D	Supply
A	$(4,6,9,11\ ;\ 0.9,0.3,0.7)$	$(1,3,8,10;0.3,0.9,0.4)$	$(14,20,21,27\ ;\ 0.2,0.7,0.9)$
B	$(2,5,9,12\ ;\ 0.6,0.3,0.1)$	$(6,9,12,15\ ;\ 0.5,0.2,0.6)$	$(13,18,23,28\ ;\ 0.5,0.3,0.6)$
Demand	$(12,18,20,26\ ;\ 0.4,0.3,0.5)$	$(15,20,24,29\ ;\ 0.7,0.8,0.4)$	

Now, using the possibility mean-based ranking function discussed in the section 3, apply it to the cost of transshipment.

Table 5. De-neutrosophic transshipment problem

Destination → Sources ↓	C	D	Supply
A	5.21	1.26	$(14, 20, 21, 27\ ;\ 0.2, 0.7, 0.9)$
B	5.81	5051	$(13, 18, 23, 28\ ;\ 0.5, 0.3, 0.6)$
Demand	$(12, 18, 20, 26\ ;\ 0.4, 0.3, 0.5)$	$(15, 20, 24, 29\ ;\ 0.7, 0.8, 0.4)$	

We obtained the final optimal table (Table 6) by completing the remaining steps of the proposed technique .

Table 6. Final Optimal Table

Destination → Sources ↓	A	B	C	D
A	$(0, 0, 0, 0)$ $(\mathbf{0, 0, 0, 0})$	$(5, 7, 9, 11\ ;\ 0.4, 0.8, 0.5)$	$(4, 6, 9, 11\ ;\ 0.9, 0.3, 0.7)$	$(1, 3, 8, 10; 0.3, 0.9, 0.4)$ $(\mathbf{14, 20, 21, 27\ ;\ 0.2, 0.7, 0.9})$
B	$(7, 10, 12, 15\ ;\ 0.1, 0.6, 0.8)$	$(0, 0, 0, 0)$ $(\mathbf{0, 0, 0, 0})$	$(2, 5, 9, 12\ ;\ 0.6, 0.3, 0.1)$ $(\mathbf{12, 18, 20, 26\ ;\ 0.4, 0.2, 0.6})$	$(6, 9, 12, 15\ ;\ 0.5, 0.2, 0.6)$ $(\mathbf{-12, -1, 4, 15\ ;\ 0.2, 0.8, 0.9})$
C	$(3, 7, 9, 13\ ;\ 0.4, 0.7, 0.3)$	$(5, 8, 12, 15\ ;\ 0.2, 0.4, 0.7)$	$(0, 0, 0, 0)$ $(\mathbf{0, 0, 0, 0})$	$(7, 12, 14, 19\ ;\ 0.8, 0.3, 0.2)$
D	$(2, 6, 9, 13\ ;\ 0.9, 0.7, 0.8)$	$(6, 7, 8, 9\ ;\ 0.3, 0.8, 0.6)$	$(1, 5, 7, 11\ ;\ 0.2, 0.9, 0.7)$	$(0, 0, 0, 0)$ $(\mathbf{0, 0, 0, 0})$

The optimal solution of trapezoidal neutrosophic transshipment problem, given in Table 1, is $(1, 3, 8, 10; 0.3, 0.9, 0.4) \otimes (14, 20, 21, 27; 0.2, 0.7, 0.9) \oplus (2, 5, 9, 12; 0.6, 0.3, 0.1) \otimes (12, 18, 20, 26; 0.4, 0.2, 0.6) \oplus (6, 9, 12, 15; 0.5, 0.2, 0.6) \otimes (-12, -1, 4, 15; 0.2, 0.8, 0.9) = (-34, 141, 396, 807; 0.2, 0.9, 0.9)$.

6. Conclusion

Neutrosophic sets, a generalisation of intuitionistic fuzzy sets, can represent both indeterminacy and uncertainty. Though many decision-making problems have been studied with various forms of input data, this study looked at solutions to the transshipment problem in a neutrosophic environment. The proposed method has proven to be effective in solving transshipment problems involving single-valued trapezoidal neutrosophic numbers. The proposed technique has been based on the possibility mean ranking function. The technique is simple to implement in real-world transshipment problems. Further, the technique produces an optimal solution directly. While the proposed technique analyses the solutions to neutrosophic transshipment problem in concrete form, the prediction of qualitative and complex data solutions does have certain limitations. Genetic algorithm approaches can overcome computational complexity in the management of higher dimensional problems. The research can be further expanded to address multiobjective transshipment problems in neutrosophic environment.

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