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Research Article

New ranking and new algorithm for tackling pentagonal neutrosophic transportation issue with applications

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ABSTRACT

The cost of transportation is one of the most important expenses for any organization with a supply chain. Over the last few decades, fuzzy decision-making has received a lot of interest in the fields of science, technology, economics, and business, among others. The neutrosophic set concept introduces a new tool for managing uncertainty. The primary aim of this work is to develop a new technique for solving the Pentagonal Neutrosophic Fuzzy Transportation Problem. In particular, we focus on a transportation issue with single-valued pentagonal neutrosophic numbers in which demand, stock, and expenses for transportation are all uncertain. The objective of this study is to reduce the total transportation expenses. For this, first developed a novel ranking technique for transforming single valued pentagonal neutrosophic figures into crisp quantities. The average deviation technique is then applied to the transportation problem using the Excel solver to find an initial basic feasible solution (IBFS). Furthermore, the modified distribution (MODI) method is employed to find the optimal solution. The recommended strategy is explained using numerical models, and it is compared to the existing approach.

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INTRODUCTION

In the highly competitive market, many transport system concepts exist in a variety of formats, and all stakeholders are keen to make the best use of available resources to maximize profit while minimizing cost [1]. Transporting items from numerous sources, industries, or depots to exotic destinations, retailers, or garages to fulfill the accessibility of the product in line with the needs has become a critical component of a company. Hitchcock incorporated it first, and Koopman's separately produced it later [2]. The Distribution System constitutes one of the most significant and active uses of statistical analysis to address management complications about the actual distribution of goods [3]. To meet the needs of each arrival region and maintain each shipping location's finite capacity, it is necessary to reduce the transportation costs associated with moving commodities from one place to another [4]. The classic transportation problem (TP) is an essential, useful, and well-known

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optimization problem in decision science that only takes origin and departure point constraints into account [5].

Although a great deal of work has been put into creating an intelligent transportation paradigm, creating these networks is extremely difficult due to the complicated working atmosphere of modern real-world applications, such as city development applications [6]. To address the TP, which attempts to move commodities from diverse supply sites to various demand areas while preserving the minimizing of overall shipping costs, a transportation framework is therefore highly needed. Logistics networks, supply chain administration, personnel planning, stock control, production scheduling, etc. were just a few examples of legitimate applications for the TP model. Real-world issues now have unclear, uncontrollable aspects like transportation charges, availability, and demand are in fuzzification [7].

Using a set with its fitness function or membership grade, Zadeh [8] initially created the conceptual definition of a fuzzy set (FS). Frequently, the fuzzy set's criterion was inadequate to capture the uncertainty of a situation. Several transportation-related research studies, some of which are completely fuzzy while others are only slightly fuzzy, were solved during that time [9,10]. Atanassov [11] suspected affiliation and non-belongingness in the fuzzy system and presented its expansions as an intuitionistic theory of fuzzy sets (IFS), which incorporates the affiliation level and grade of non-membership component of every aspect in the set. This was after the emergence of the fuzzy set concept in diverse fields of uncertainty. The issues with considerable uncertainty can be resolved by this theory, but the transportation model's ambiguous and inconsistent facts cannot. Smarandache [12] created the neutrosophic set (NS), a further outgrowth of the crisp set, FS, and IFS, to address difficulties involving inconsistent data or indeterminate that could not be solved by any type of fuzzy set. The truth, indeterminacy, and falsity membership levels are three useful NS elements that can be used to express indeterminacy and inconsistent data. The single-valued neutrosophic concept (SVNS) was first proposed by Wang et al. [13]. Several difficulties in practical life can be solved more effectively and appropriately using the concept of SVNS. Figure 1 illustrates this.

By combining the fuzzy zero suffix approach as well as a scalar split with a triangle sorting strategy, Geetha and Selvakumari [14] created the Neutrosophic fuzzy transportation issue. Rizk-Allah et al. [7] developed a neutrosophic optimization model based on the neutrosophic judgment set and the neutrosophic compromise programming framework to find the optimal compromise solution. Goal programming was utilized by Singh et al. [15] to expand the idea of the bilevel transportation dilemma with neutrosophic figures. The KKM technique was employed by Khalifa et al. [16] for reverse capacitated transportation issues in the neutrosophic setting. The mean of the provided expenses was calculated by Sikkannan and Shanmugavel [17] for the best solution to the neutrosophic imprecise transportation issue that originated.

A novel process for the optimization of real-world transportation problems in the neutrosophic context was put forth by Thamaraiselvi and Santhi [18]. A single-valued neutrosophic mobility model's effective cost was dropped by Kanagajothi and Kumar [19]. A brand-new critical transportation dilemma constructed using the single-valued neutrosophic set was recommended by Lu and Luo [20]. The octagonal neutrosophic quantity and its application in the context of transportation problems applying russell's approximation method were developed by Anandhi and Arthi [21]. The incorporation of single-valued trapezoidal neutrosophic integers in transportation issues was explored by Saini et al. [22]. Furthermore, Singh et al. [23] combined various weights in various attribute functions with the decision-option makers. They handled a Chabots-related online marketing TODIM-based MCDM scenario in the PNN system. A new element of a networking-based

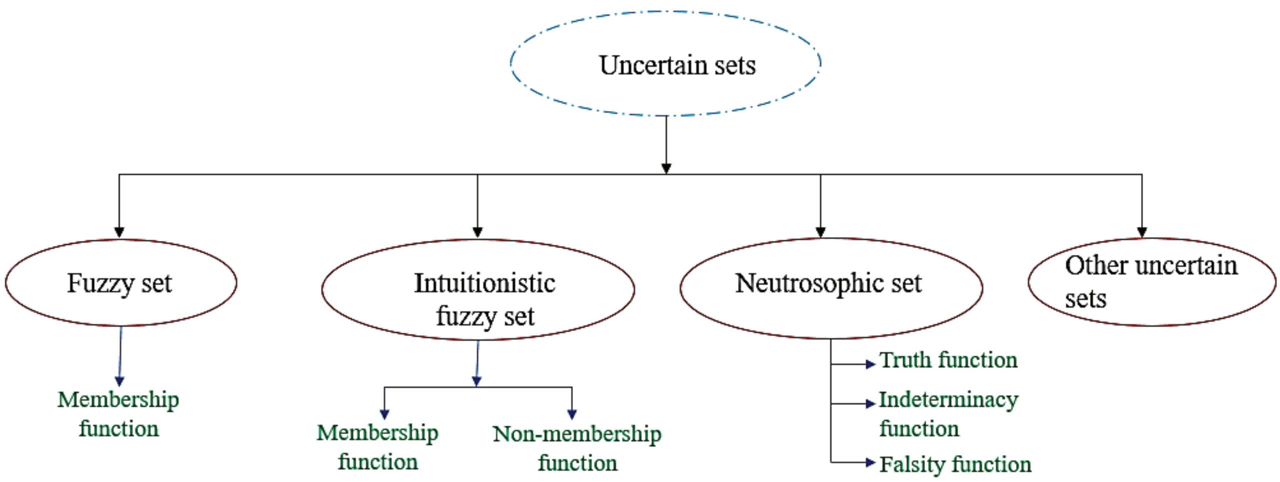

Figure 1. Types of uncertain sets.

PERT situation with pentagonal neutrosophic values was examined by Chakraborty [24].

Habiba and Quddoos [25] introduced a novel version of the uncertain classical transportation problem called the interval pentagonal neutrosophic transportation problem, in which the uncertain cost of transportation is represented by an estimated range, and the uncertainty of the source and destination parameters are described by pentagonal neutrosophic numbers. Using the ideas of expected value and interval number uncertainty, the interval cost goal has been divided into two equal crisp objectives. Using membership functions, Kalaivani and Kaliyaperumal [26] suggested a unique ranking method for the transportation dilemma utilizing single-valued trapezoidal neutrosophic numbers. Hosseinzadeh and Tayyebi [27] introduced an innovative approach for finding a compromise optimal solution to the neutrosophic fuzzy multi-objective linear programming challenge, and they applied it to a transportation problem to demonstrate its usefulness and efficacy. Dhouib [28] used a new algorithm called double-matrix to solve the travelling salesman problem in a pentagonal uncertain neutrosophic context. Joseph Robinson et al. [29] modeled the neutrosophic transportation issue as a parametric linear programming issue and employed weighted possibilistic mean values for the membership functions.

According to the preceding discussion, there is no statistical approach for determining an IBFS of a single-valued pentagonal neutrosophic transportation problem. The authors were prompted by this research gap. The objective of this study is to minimize the overall transportation cost. The research makes a significant contribution by first creating a novel ranking function for crisping up pentagonal neutrosophic uncertain values. Second, creating a unique algorithm for determining IBFS. Third, validating the proposed methodologies using existing and random numerical instances.

The rest of this study is structured as follows: Preliminaries are presented in Section 2 before mathematical expressions are presented in Section 3, a proposed algorithm is laid out in Section 4, mathematical instances are provided in Section 5, findings and comments are presented in Section 6, and finally conclusions are presented in Section 7.

PRELIMINARIES

This section describes a few definitions that are relevant to this study.

Fuzzy Set 2.1. [22]

A non-empty collection of a fuzzy set $\tilde{z}$ is stated as $\acute{Z}=\{[\tilde{x},\mu_{\tilde{z}}(\tilde{x})]|\tilde{x}\epsilon\tilde{z}\}$, where $\mu_{\tilde{z}}(\tilde{x}): \tilde{z} \rightarrow [0,1]$ the membership level of that specific set.

Intuitionistic Fuzzy Set 2.2. [24]

An IFS $\bar{I}_F$ is stated as $\acute{Z} = \{\langle\tilde{x};\ [\sigma_{\bar{z}}(\tilde{x}),\ \delta_{\bar{z}}(\tilde{x})]\ \rangle|\ \tilde{x}\in\bar{z}\}$

Here, $\sigma_{\bar{z}}(\tilde{x})$: $\tilde{z} \rightarrow[0, 1]$ indicates the level of truthfulness, $\delta_{\bar{z}}(\tilde{x})$: $\widetilde{z} \rightarrow[0, 1]$ indicates the level of falsehood. $\sigma_{\bar{z}}(\tilde{x}), \delta_{\bar{z}}(\tilde{x})$ should meet the following condition:

$$0\leq\sigma_{\bar{z}}(\tilde{x}) + \delta_{\bar{z}}(\tilde{x})\leq1.$$

Neutrosophic Set 2.3. [15,23]

A set $A_{\overline{N_s}}$ is a neutrosophic collection of Ũ and is defined as

$$A_{\overline{N_s}} = \left\{\langle\dot{x}; \left[\theta_{A_{\overline{N_s}}}(\dot{x}), \varphi_{A_{\overline{N_s}}}(\dot{x}), \sigma_{A_{\overline{N_s}}}(\dot{x})\right] : \dot{x} \in \tilde{U}\rangle\right\},$$

where $\theta_{A_{\overline{N_s}}}(\dot{x}): \widetilde{U} \rightarrow]0^-,1^+[$ signifies the function of the truth, $\varphi_{A_{\overline{N_s}}}(\dot{x}): \widetilde{U} \rightarrow]0^-,1^+[$ signifies the function of the indeterminacy and $\sigma_{A_{\overline{N_s}}}(\dot{x}): \widetilde{U} \rightarrow]0^-,1^+[$ signifies the function of the falsity then the relation of them as follows:

$$0^- \leq \theta_{A_{\overline{N_s}}}(\dot{x}) + \varphi_{A_{\overline{N_s}}}(\dot{x}) + \sigma_{A_{\overline{N_s}}}(\dot{x}) \leq 3^+$$

Single-Valued Neutrosophic Set 2.4. [25]

A set $A_{\overline{SvN}}$ is a single-valued neutrosophic set that is specified as

$A_{\overline{SvN}} = \{\langle\dot{x}; [\theta_{A_{\overline{SvN}}}(\dot{x}), \varphi_{A_{\overline{SvN}}}(\dot{x}), \sigma_{A_{\overline{SvN}}}(\dot{x})]: \dot{x}\epsilon\ \tilde{U}\rangle$ and $\theta_{A_{\overline{SvN}}}(\dot{x}), \varphi_{A_{\overline{SvN}}}(\dot{x}), \sigma_{A_{\overline{SvN}}}(\dot{x})\epsilon[0,1]\}$,

where $\theta_{A_{\overline{SvN}}}(\dot{x}), \varphi_{A_{\overline{SvN}}}(\dot{x}), \sigma_{A_{\overline{SvN}}}(\dot{x})$ are the membership criteria used for truthfulness, indeterminacy, and falsehood, and each membership are independent of one another under the following conditions:

$$0 \leq \theta_{A_{\overline{SvN}}}(\dot{x}) + \varphi_{A_{\overline{SvN}}}(\dot{x}) + \sigma_{A_{\overline{SvN}}}(\dot{x}) \leq 3$$

Single-Valued Pentagonal Neutrosophic Number 2.5. [15,23]

A pentagonal neutrosophic integer with single-valued $s_{\overline{NP}}$ is characterized as

$s_{\overline{NP}} = \{[(p_1,p_2,p_3,p_4,p_5);\zeta], \quad [(p_1,p_2,p_3,p_4,p_5);\xi], [(p_1,p_2,p_3,p_4,p_5);\gamma]\}$, such that $\zeta,\xi,\gamma \in [0,1]$. Furthermore, truth functionality $\theta_{\overline{NP}} : \widetilde{U} \rightarrow [0,\zeta]$, indeterminacy functionality $\varphi_{\overline{NP}} : \widetilde{U} \rightarrow [\xi,1]$, and falsehood functionality $\sigma_{\overline{NP}}: \widetilde{U} \rightarrow [\gamma,1]$ are defined by:

$$\theta_{\overline{NP}}(\dot{x}) = \begin{cases} \dfrac{\zeta(\dot{x}-p_1)}{(p_2-p_1)} & p_1 \leq \dot{x} \leq p_2 \\ \dfrac{\zeta(\dot{x}-p_2)}{(p_3-p_2)} & p_2 \leq \dot{x} < p_3 \\ \zeta & \dot{x} = p_3 \\ \dfrac{\zeta(p_4-\dot{x})}{(p_4-p_3)} & p_3 < \dot{x} \leq p_4 \\ \dfrac{\zeta(p_5-\dot{x})}{(p_5-p_4)} & p_4 \leq \dot{x} \leq p_5 \\ 0 & \text{otherwise} \end{cases}$$

$$\varphi_{\overline{N_P}}(\dot{x}) = \begin{cases} \dfrac{p_2 - \dot{x} + \xi(\dot{x} - p_1)}{(p_2 - p_1)} & p_1 \le \dot{x} \le p_2 \\ \dfrac{p_3 - \dot{x} + \xi(\dot{x} - p_2)}{(p_3 - p_2)} & p_2 \le \dot{x} < p_3 \\ \xi & \dot{x} = p_3 \\ \dfrac{\dot{x} - p_3 + \xi(p_4 - \dot{x})}{(p_4 - p_3)} & p_3 < \dot{x} \le p_4 \\ \dfrac{\dot{x} - p_4 + \xi(p_5 - \dot{x})}{(p_5 - p_4)} & p_4 \le \dot{x} \le p_5 \\ 1 & \text{otherwise} \end{cases}$$

$$\sigma_{\overline{N_P}}(\dot{x}) = \begin{cases} \dfrac{p_2 - \dot{x} + \gamma(\dot{x} - p_1)}{(p_2 - p_1)} & p_1 \le \dot{x} \le p_2 \\ \dfrac{p_3 - \dot{x} + \gamma(\dot{x} - p_2)}{(p_3 - p_2)} & p_2 \le \dot{x} < p_3 \\ \gamma & \dot{x} = p_3 \\ \dfrac{\dot{x} - p_3 + \gamma(p_4 - \dot{x})}{(p_4 - p_3)} & p_3 < \dot{x} \le p_4 \\ \dfrac{\dot{x} - p_4 + \gamma(p_5 - \dot{x})}{(p_5 - p_4)} & p_4 \le \dot{x} \le p_5 \\ 1 & \text{otherwise} \end{cases}$$

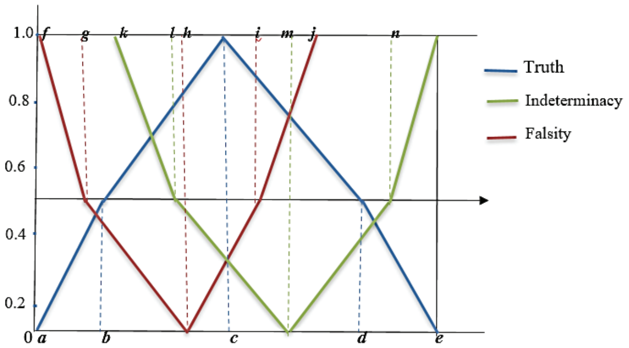

Figure 1. Graphical representation of single-valued pentagonal neutrosophic numbers.

Average Deviation 2.6. [30]

Average deviation is defined as

$$\frac{1}{n}\sum_{i=1}^{n} |p_i - \mu(P)| \quad (1)$$

Here $\mu(P)$ = average of the data collection, n = quantity of data elements, p_i = data numbers in the collection

Proposed Score Function 2.7.

This section describes a novel rank function in a pentagonal neutrosophic setting that employs membership functions. The ranking function is a defuzzification tool of pentagonal neutrosophic numbers to crisp numbers. Let $N_{\overline{SF}} = [(p_1, p_2, p_3, p_4, p_5);\ \zeta, \xi, \gamma]$ be a single valued pentagonal neutrosophic numbers. The degree of truth, indeterminacy, and falsehood has an entire impact on the rank function. The score formula for any single-typed pentagonal neutrosophic quantity is described as follows in equation (2):

$$N_{\overline{SF}} = \left[\frac{l_1 + l_2 + l_3}{3}\right]\left[\frac{2 + \zeta - \xi - \gamma}{3}\right] \quad (2)$$

where $l_1 = \frac{p_1 + p_2}{2}, l_2 = l_3 + p_3 - (l_1 + p_3), l_3 = \frac{p_4 + p_5}{2}$

Also, ζ indicates the status of truthfulness, ξ indicates the status of indeterminacy, and γ indicates the status of falsehood.

NEUTROSOPHIC TRANSPORTATION ISSUE EXPRESSED MATHEMATICALLY [31]

This section develops a numerical model for the stated transportation issue in a neutrosophic setting, as seen in Table 1. Let there be m providers and n destinations where all the desire, availability, and expense are expressed in equations (3-5) as single-valued neutrosophic quantities:

$$\text{Minimize } \bar{z}^{N_s} = \sum_{i=1}^{m}\sum_{j=1}^{n} \bar{c}_{ij}^{N_s} x_{ij} \quad (3)$$

subject to

$$\sum_{j=1}^{n} x_{ij} = \bar{a}_i^{N_s}, i = 1 \text{ to } m \quad (4)$$

$$\sum_{i=1}^{m} x_{ij} = \bar{b}_j^{N_s}, j = 1 \text{ to } n; \quad (5)$$

$$x_{ij} \ge 0\ (i = 1,2,\dots,m;\ j = 1,2,\dots,n)$$

Here,

x_{ij} is the quantity of good units shifted from the i^{th} origin to the j^{th} the desired location,

$\bar{c}_{ij}^{N_s}$ is the neutrosophic expense of transporting single unit measure from i^{th} original to j^{th} the point of departure,

$\bar{a}_i^{N_s}$ is the goods complete availability at the point of origin i,

$\bar{b}_j^{N_s}$ is the overall demand for a particular good at the location j.

ALGORITHM FOR SOLVING PENTAGONAL NEUTROSOPHIC TRANSPORTATION PROBLEM (PNTP)

The stages for the suggested algorithm are listed below, and a flowchart is illustrated in Figure 2:

Step 1: Select an issue with transportation where the supply of goods, requirements, and expenses are all expressed in terms of pentagonal neutrosophic variables.

Step 2: Utilizing the score function given in equation (2), which converts pentagonal neutrosophic integers into crisp figures.

Step 3: Verify whether the issue is balanced, indicating that the combined demand and supply are supposed to be equal.

(a) Move on to step 5 if the issue is balanced.

(b) Move on to step 4 if the issue is unbalanced.

Table 1. Neutrosophic transportation problem

Sources	Destinations					
		D_1	D_2	….	D_n	Supply
	S_1	$c_{11}^{N_s}$	$c_{12}^{N_s}$	….	$c_{1n}^{N_s}$	$a_1^{N_s}$
	S_2	$c_{21}^{N_s}$	$c_{22}^{N_s}$	….	$c_{2n}^{N_s}$	$a_2^{N_s}$
	……	……	……	….	….	….
	S_m	$c_{m1}^{N_s}$	$c_{m2}^{N_s}$	….	$c_{mn}^{N_s}$	$a_m^{N_s}$
	Demand	$b_1^{N_s}$	$b_2^{N_s}$	….	$b_n^{N_s}$	

Step 4: To obtain the balanced one, create a fake row or column with no transit costs.

Step 5: To find the penalty, use an Excel solver to compute the average deviation for each row and column. Equation (1) yields the formula for average deviation.

Step 6: Determine which column or row has the highest penalty.

Step 7: The selection of the highest penalty can be chosen arbitrarily if there is a tie.

Step 8: Choose the lowest cost value in the row or column that has the highest penalty and allocate as much demand or supply as possible.

Step 9: The entire row or column whose availability or demand is met should be removed.

Step 10: Proceed with steps 4 to 9 until all supply and demand are met completely.

Step 11: To obtain an optimal result, first calculate the IBFS of the overall expense of transportation. Following that, apply the MODI approach.

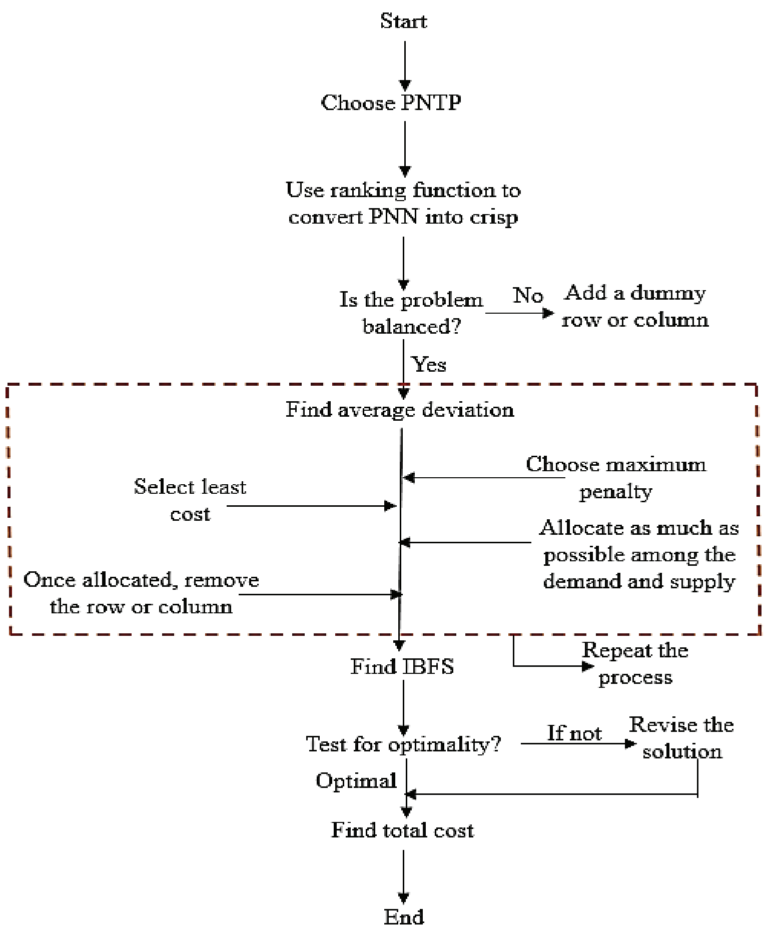

Figure 2. Flowchart.

NUMERICAL EXAMPLES

In this section, the pentagonal neutrosophic transportation issue is used to demonstrate the applicability and effectiveness of the proposed strategy.

Example 5.1. [32] A washing machine manufacturer company has three warehouses and three destinations. To find minimal transportation for shipping their products to different terminal points with neutrosophic membership values (0.9,0.1,0.1) to all the cost, demand, and supply which is shown in Table 2[32]:

Step 1: Select an issue with transportation where the supply of goods, requirements, and expenses are all expressed in terms of pentagonal neutrosophic variables.

Step 2: Utilizing the score function given in equation (2), which converts pentagonal neutrosophic integers into crisp figures. Here, the pentagonal neutrosophic number [(5,10,13,14,18); 0.9,0.1,0.1] has both neutrosophic membership functions and pentagonal fuzzy numbers. After using the suggested ranking function in equation (2), the crisp value comes out to be 9.60. For each of the remaining entries in Table 2, we proceeded in the same manner.

Table 3 is not balanced after defuzzification, indicating that supplies and needs are not equivalent.

Step 3: Verify whether the issue is balanced, indicating that the combined demand and supply are supposed to be equal.

(a) Move on to step 5 if the issue is balanced.

(b) Move on to step 4 if the issue is unbalanced.

Step 4: To obtain the balanced one, create a fake row or column with no transit costs.

Step 5: To find the penalty, use an Excel solver to compute the average deviation for each row and column. Equation (1) yields the formula for average deviation. In Table 5, the penalties of row and column are shown.

Step 6: Determine which column or row has the highest penalty. In Table 5, column 3 has the maximum penalty.

Step 7: The selection of the highest penalty can be chosen arbitrarily if there is a tie. There is no tie for the highest penalty in Table 5.

Step 8: Choose the lowest cost value in the row or column that has the highest penalty and allocate as much demand or supply as possible. The allocations are shown as superscripts in every table.

Step 9: The entire row or column whose availability or demand is met should be removed.

Step 10: Proceed with steps 4 to 9 until all supply and demand are met completely.

Table 2. Input values of PNTP

Warehouse	W_1	W_2	W_3	Availability
R_1	(5,10,13,14,18;0.9,0.1,0.1)	(1,2,3,4,5;0.9,0.1,0.1)	(2,6,8,10,14;0.9,0.1,0.1)	(2,11,23,34,45;0.9,0.1,0.1)
R_2	(3,4,5,6,7;0.9,0.1,0.1)	(1,5,6,7,11;0.9,0.1,0.1)	(1,4,5,9,16;0.9,0.1,0.1)	(10,47,52,65,76;0.9,0.1,0.1)
R_3	(3,6,9,12,15;0.9,0.1,0.1)	(2,5,7,8,8;0.9,0.1,0.1)	(1,1,1,1,1;0.9,0.1,0.1)	(11,16,51,67,75;0.9,0.1,0.1)
Requirement	(20,40,60,80,100;0.9,0.1,0.1)	(15,30,45,75,110;0.9,0.1,0.1)	(3,18,56,76,87;0.9,0.1,0.1)	

Table 3. Defuzzified values

Warehouse	W_1	W_2	W_3	Availability
R_1	9.60	2.7	7.2	23.69
R_2	3.89	5.4	7.49	42.3
R_3	8.1	4.79	0	48.89
Requirement	42.59	54	76.5	

Table 4. Balanced PNTP

Warehouse	W_1	W_2	W_3	Availability
R_1	9.60	2.7	7.2	23.69
R_2	3.89	5.4	7.49	42.3
R_3	8.1	4.79	0	48.89
R_4	0	0	0	58.21
Requirement	42.59	54	76.5	

Table 5. First allocation

Warehouse	W_1	W_2	W_3	Availability	Row Penalty
R_1	9.60	2.7	7.2	23.69	2.53
R_2	3.89	5.4	7.49	42.3	1.26
R_3	8.1	4.79	0	48.89	2.86
R_4	0	0	$0^{58.21}$	58.21	0
Requirement	42.59	54	76.5		
Column Penalty	3.45	1.87	3.67		

Table 6. Second allocation

Warehouse	W_1	W_2	W_3	Availability	Row Penalty
R_1	9.60	2.7	7.2	23.69	2.53
R_2	3.89	5.4	7.49	42.3	1.26
R_3	8.1	4.79	$0^{18.29}$	48.89	2.86
Requirement	42.59	54	18.29		
Column Penalty	2.20	1.06	3.26		

Table 7. Third allocation

Warehouse	W_1	W_2	Availability	Row Penalty
R_1	9.60	$2.7^{23.69}$	23.69	3.45
R_2	3.89	5.4	42.3	0.76
R_3	8.1	4.79	30.6	1.66
Requirement	42.59	54		
Column Penalty	2.20	1.06		

Table 8. Fourth allocation

Warehouse	W_1	W_2	Availability	Row Penalty
R_2	$3.89^{42.3}$	5.4	42.3	0.76
R_3	8.1	4.79	30.6	1.66
Requirement	42.59	30.31		
Column Penalty	2.11	0.31		

Table 9. Final allocations

Warehouse	W_1	W_2	Availability
R_3	$8.1^{0.29}$	$4.79^{30.31}$	30.6
Requirement	0.29	30.31	

Step 11: To obtain an optimal result, first calculate the IBFS of the overall expense of transportation. Following that, apply the MODI approach.

The suggested algorithm's allocation is shown in Tables 5-9. After determining the IBFS for the overall transport expense, we moved on to the MODI method, and the ideal minimal expense of transportation is 228.51.

Example 5.2. [32] Consider the following PNTP with neutrosophic membership values (1,0,0) to all transportation expenses, demand, and supply. For table 10, need to find the total minimal transportation cost [32].

Check whether the defuzzified values of demand and supply are balanced if not add a dummy row or column with zero cost. By using the proposed algorithm, calculated IBFS of the total transportation cost to the above table 10 then proceeded to MODI technique, and the optimal transportation cost is 0.075.

Example 5.3. Consider the following neutrosophic transportation problem involving pentagonal numbers. Determine a minimum amount of transportation expenses for Table 11.

Using the suggested ranking technique and algorithm, determined IBFS for the above table and thereafter proceeded to MODI strategy, and the minimal optimum solution is 666.19.

Example 5.4. Three branches at a warehouse each have a different delivery route for grocery items to different spots (L1, L2, and L3). Consider the following branches that are responsible for supplying tea, coffee, and seasonings, accordingly. For Table 12, figure out the lowest transportation expenses.

Employed a defuzzified technique in equation (2) to convert ambiguous values to precise values. The recommended algorithm was utilized to calculate the IBFS of the overall transportation cost to the aforementioned Table 12, and the MODI procedure was then used to calculate the best possible transportation expense., which is 1033.87.

Example 5.5. With three origins and four delivery points, consider the following balanced PNTP. Discover the lowest transportation expense for Table 13 below.

Using the defuzzified technique in equation (2) and the recommended algorithm, the IBFS of the entire transportation cost to the aforementioned table 13 was determined, and thereafter the MODI procedure to determine the best least expense for transportation, which is 1727.56.

Table 10. Input data of PNTP

Factories	K	L	Availability
F_1	(0.2,0.4,0.5,0.6,0.7;1,0,0)	(0.3,0.2,0.6,0.5,0.1;1,0,0)	(0.1,0.2,0.5,0.4,0.3;1,0,0)
F_2	(0.7,0.8,0.6,0.9,0.1;1,0,0)	(0.2,0.3,0.5,0.7,0.1;1,0,0)	(0.2,0.3,0.5,0.8,0.9;1,0,0)
Requirement	(0.8,0.7,0.5,0.3,0.2;1,0,0)	(0.2,0.3,0.4,0.1,0.2;1,0,0)	

Table 11. Input data of PNTP

Warehouse	A	B	Availability
P	(41,43,45,47,49;0.6,0.3,0.5)	(61,63,65,67,69;0.8,0.4,0.6)	(151,153,155,157,159;0.7,0,0.55)
Q	(81,83,85,87,89;0.5,0.4,0.1)	(101,103,105,107,109;0.8,0.45,0.3)	(271,273,275,277,279;0.4,0.25,0.5)
Requirement	(11,13,15,17,19;0.6,0.3,0.2)	(31,33,35,37,39;0.7,0.1,0.4)	

Table 12. Input values of PNTP

Warehouse	Location 1	Location 2	Location3	Availability
Tea	(1,4,8,9,10;0.7,0.5,0.3)	(36,39,40,41,42;0.6,0.4,0.2)	(36,37,38,40,42;0.8,0.1,0.5)	(100,121,129,132,140;0.6,0.4,0.3)
Coffee	(23,25,31,33,35;0.9,0.6,0.1)	(11,13,14,17,18;0.8,0.5,0.3)	(8,9,11,12,13;0.6,0.5,0.3)	(21,25,35,42,55;0.7,0.5,0.2)
Spices	(57,59,61,63,68;0.5,0.2,0.1)	(71,72,74,75,78;0.5,0.2,0.3)	(22,23,25,26,27;0.8,0.6,0.7)	(2,8,16,25,40;0.8,0.6,0.2)
Requirement	(10,15,20,25,30;0.7,0.4,0.3)	(40,50,60,70,80;0.9,0.2,0.5)	(30,47,51,68,92;0.6,0.1,0.3)	

Table 13. Input data for PNTP

Warehouse	1	2	3	4	Availability
W_1	(8,9,11,13,16; 0.5,0.1,0.2)	(15,18,21,25,27; 0.8,0.4,0.2)	(2,5,9,14,18; 0.9,0.5,0.3)	(11,14,19,25,28; 0.9,0.2,0.1)	30
W_2	(15,19,23,29,32; 0.6,0.3,0.3)	(20,26,30,34,37; 0.7,0.4,0.3)	(1,7,9,12,17; 0.4,0.1,0.1)	(7,8,11,16,20; 0.7,0.2,0.2)	42
W_3	(22,23,25,26,28; 0.6,0.1,0.3)	(36,37,38,40,42; 0.6,0.2,0.2)	(30,34,39,43,47; 0.8,0.3,0.1)	(37,41,46,49,54; 0.9,0.4,0.1)	69
Requirement	22	50	35	34	

Table 14. Comparative study

Examples	Proposed method	Existing method
5.1	228.51	414
5.2	0.075	0.39
5.3	666.19	1284.63
5.4	1033.87	1671.55
5.5	1727.56	2348.24

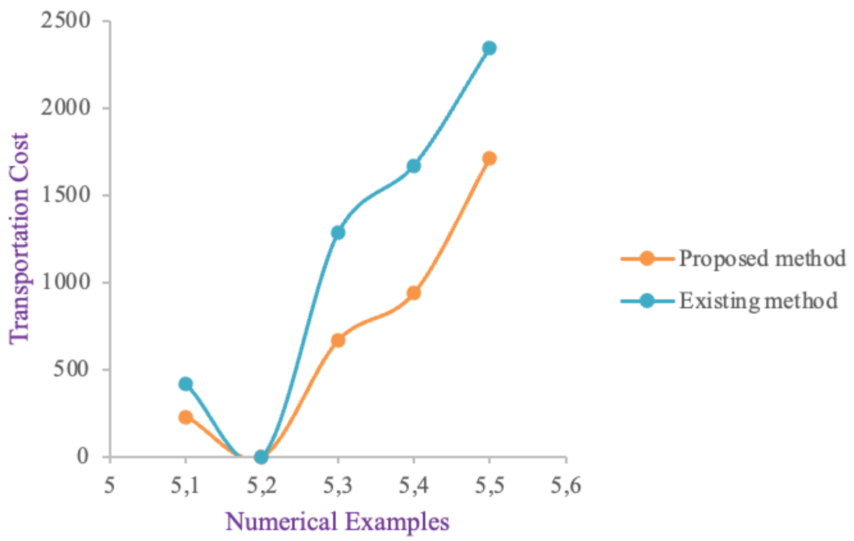

Figure 3. Comparison chart.

RESULTS AND DISCUSSION

The proposed PNTP is evaluated in this work utilizing balanced and unbalanced numerical examples. First, a new score function of neutrosophic pentagonal numbers was put forward for converting them to crisp. Second, for determining IBFS, the statistical approach known as the average deviation strategy has been used. Average deviation is a handy tool for determining a parameter's distance from a data set's mean. The transportation charges are used as a data set to calculate the average deviation in this case. Furthermore, the data for the first three problems existed, and the remaining two problems were chosen at random. More importantly, the existing data incorporates linear programming for profit maximization. In this case, we used the structure of an existing problem to reduce transportation costs. Because transportation is a specific example of linear programming, the current method in the literature to address pentagonal neutrosophic transportation concerns was Vogel's Approximation. When compared to other existing solutions, the proposed two techniques reduced transportation costs. The fundamental purpose of this study is to establish the lowest possible price of transport to suppliers and consumers. Finally, it is obvious from Table 14 and Figure 3 that the suggested strategy yields better results.

CONCLUSION

This paper investigates and solves a pentagonal neutrosophic issue with transportation. The pentagonal neutrosophic number concept is intriguing and effective, with several potential applications in a wide range of academic disciplines. Using membership functions, we first presented a novel ranking technique for neutrosophic fuzzy sets in this article, which is simpler to use than the existing ranking procedure. Second, we created a novel algorithm that tackles the transportation issue in a pentagonal neutrosophic setting. The execution of the proposed strategy to numerical instances revealed no flaws in the approach and satisfied the study's objectives. In addition, the proposed technique is faster and involves fewer computing challenges. The recommended algorithm provides a fresh approach to dealing with uncertainty. The ranking function also contributes significantly to lowering overall transportation expenses. As a result, the proposed ranking approach can be used to handle the pentagonal neutrosophic assignment and transshipment issues. Neutrosophic bipolar fuzzy sets cannot be solved with the suggested study, which we will work on in the future.

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