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Research Article

A Proposed Ranking Method to Solve Transportation Problem by Pentagonal Fuzzy Numbers

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Abstract

Fuzzy numbers figuring indispensable roles in problems in decision making, analysis of data, and socioeconomics arrangement. Finding the Ranking of any fuzzy numbers is an inevitable step in many mathematical models. Many of the methods proposed, which produced the best solution to the transportation problems. This paper introduces a Proposed Ranking method applying the same we transform the fuzzy transportation problem to an exquisite valued one, subsequently into a new proposed process to uncover the fuzzy realistic solution. The numerical illustration demonstrates that the new projected method tender an awesome means for managing the transportation problems on fuzzy algorithms.

Keywords: *Fuzzy set, Fuzzy Number, Pentagonal Fuzzy Numbers , Ranking of Pentagonal Fuzzy Numbers, Fuzzy Transportation Problem, Centroid Method.*
AMS Mathematics Subject Classification (2010): 90C08, 90C90

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Introduction

The transportation problem is found globally in solving certain real-world problems. A transportation problem plays an essential role in the production industry and many other purposes. The transportation problem may be a special case of applied mathematics problems in LPP, which allow us to control the optimum distributing patterns between sources and end terminals. The solution to the setback will give a positive approach to find out the total counts of elements that will be carried from a precise origin to a definite destination. As a result, it shows a feasible cost on all factors which includes the time spending on this is minimum and profit acquired is maximum. The major gap that we felt by referring to several research papers and articles is to bring the best optimal solution to the transportation problems. The problem that needs to resolve is, to reach cost-effective production in various production companies. This manuscript might be one of the novel methodologies that bring down the optimal solution value. Here we compared with existing methods named NWCM, LCM, and VAM technique.

Consider $\breve{a}_i$ as quantity of items that available at source $\acute{i}$ and $\breve{b}_j$ as quantity of items that necessary at destination $\breve{j}$. Consider $\tilde{a}_{ij}$ as the price of transferring one item from source $\acute{i}$ to end terminal $\breve{j}$ and $\tilde{x}_{ij}$ as the amount of item carried from source $\acute{i}$ to terminal end $\breve{j}$. A fuzzy transportation problem is a progressive method in that we can get the expenditure of the transportation, Demand and supply facts are fuzzy quantities. The first introduced fuzzy set concept by Zadeh [1]. Zimmerman [2] devised fuzzy linear programming. Panda and Pal [3] investigated exponent operation and arithmetic operations of Pentagonal Fuzzy numbers. Anitha and Parvathi [4] proposed a new method to find the expected crisp value of Pentagonal Fuzzy numbers. Helen and Uma [5] defending the parametric representation of Pentagonal Fuzzy numbers. Siji and Kumari [6] have explored arithmetic operation and find the Ranking of Pentagonal Fuzzy numbers. Annie Christi and Kasthuri [7] proposed a technique to crack the fuzzy transportation problem for PFN. Edward [8] introduces the simplex type method for solving the fuzzy transportation problem. Uma Maheswari [9] applied the Robust ranking technique to solve fully Fuzzy transportation problems using Pentagonal Fuzzy numbers. Sathya Geetha [10] explored the Range method to solve Fuzzy transportation problems using PFNs. R. Srinivasan and Karthikeyan, N [11] have explored a two-stage cost- minimizing fuzzy transportation problem where supply and demand are fuzzy numbers using a stricture approach to reach a fully fuzzy solution. The proposed Ranking algorithm is to unravel a strong solution by using fuzzy transportation problems taking an account of supply, demand, and item transportation price as pentagonal fuzzy numbers.

In this manuscript, an unsullied way is recommended for the Ranking of fuzzy pentagonal numbers in a simplified way. To demonstrate this proposed method and the case is conferred. As the suggested process is straight and effortless to understand and applying it is undemanding to make out the fuzzy most select viable outcome of fuzzy transportation troubles take place in the factual conditions.

This manuscript is sorted out as follows: In division 2 it is centered the crucial description of fuzzy figures. In section 3, a getting Ranking practice is initiated and show on a novel algorithm to resolve the transportation problem by fuzzy numbers. In section 4, is to reveal the projected method a numerical design is solved. In section 5, a conclusion element is also encompassed.

Preliminaries

Definition: Fuzzy Set

$\tilde{A}$ is a fuzzy set on R is defined as a set of ordered pairs

$$\tilde{A} = \{ x_0, \mu_A(x_0) / x_0 \in \tilde{A}, \mu_A(x_0) \to [0,1] \}$$

where $\mu_A(x_0)$ is said to be the membership function.

Definition: Fuzzy Number

$\tilde{A}$ is a fuzzy set on R, likely bounded to the stated conditions given beneath

i. $\mu_A(x_0)$ is part by part continuous

ii. There exist at least one $x_0 \in \Re$ with $\mu_A(x_0) = 1$

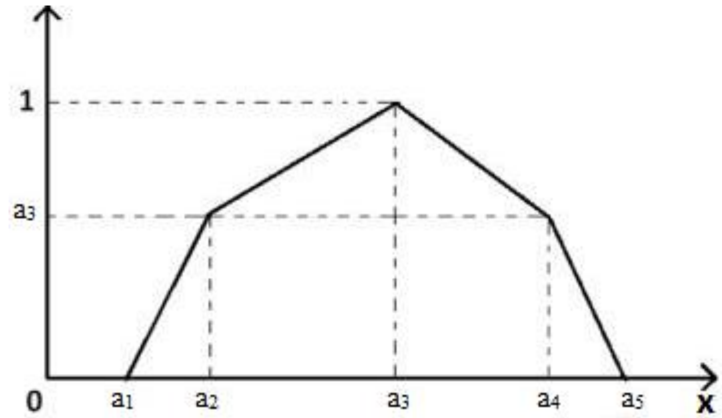
iii. $\tilde{A}$ is a regular and convex

Definition: Pentagonal Fuzzy Number (PFNs)

A fuzzy number $\tilde{A}$ on R is said to be the pentagonal fuzzy number (PFN) or linear fuzzy number which is named as $(\tilde{a}_1, \tilde{a}_2, \tilde{a}_3, \tilde{a}_4, \tilde{a}_5)$ if its membership function $\mu_A(x)$ has the following characteristic

$$\mu_A(x) = \begin{cases} 0, & x < \tilde{a}_1 \\ \tilde{u}_1 \dfrac{x-\tilde{a}_2}{\tilde{a}_3-\tilde{a}_2}, & \tilde{a}_1 \le x \le \tilde{a}_2 \\ \left(1-(1-u_1)\right)\dfrac{x-\tilde{a}_2}{\tilde{a}_3-\tilde{a}_2}, & \tilde{a}_2 \le x \le \tilde{a}_3 \\ 1, & x = \tilde{a}_3 \\ \left(1-(1-u_2)\right)\dfrac{\tilde{a}_4-x}{\tilde{a}_4-\tilde{a}_3}, & \tilde{a}_3 \le x \le \tilde{a}_4 \\ \tilde{u}_2 \dfrac{\tilde{a}_5-x}{\tilde{a}_5-\tilde{a}_4}, & \tilde{a}_4 \le x \le \tilde{a}_5 \\ 0, & x > \tilde{a}_5 \end{cases}$$

Here the midpoint $\tilde{a}_3$ has the grade of membership 1 and $\tilde{a}_4, \tilde{a}_2$ has the grades $\tilde{u}_1, \tilde{u}_2$ respectively. Note that every PFN is connected with two weights $\tilde{u}_1, \tilde{u}_2$.



Arithmetic Operations

Let $\tilde{a}_A = (\tilde{a}_1, \tilde{a}_2, \tilde{a}_3, \tilde{a}_4, \tilde{a}_5)$ and $\tilde{a}_B = (\tilde{b}_1, \tilde{b}_2, \tilde{b}_3, \tilde{b}_4, \tilde{b}_5)$ are two fuzzy numbers where $\tilde{a}_1 \le \tilde{a}_2 \le \tilde{a}_3 \le \tilde{a}_4 \le \tilde{a}_5$ and $\tilde{b}_1 \le \tilde{b}_2 \le \tilde{b}_3 \le \tilde{b}_4 \le \tilde{b}_5$. Then the arithmetic operations are defined as follows

Addition

$$\tilde{a}_A + \tilde{a}_B = (\tilde{a}_1 + \tilde{b}_1, \tilde{a}_2 + \tilde{b}_2, \tilde{a}_3 + \tilde{b}_3, \tilde{a}_4 + \tilde{b}_4, \tilde{a}_5 + \tilde{b}_5)$$

Subtraction

$$\tilde{a}_A - \tilde{a}_B = (\tilde{a}_1 - \tilde{b}_5, \tilde{a}_2 - \tilde{b}_4, \tilde{a}_3 - \tilde{b}_3, \tilde{a}_4 - \tilde{b}_2, \tilde{a}_5 - \tilde{b}_1)$$

Multiplication

$$\tilde{a}_A * \tilde{a}_B = \left(\frac{\tilde{a}_1}{5}\tilde{\gamma}_B, \frac{\tilde{a}_2}{5}\tilde{\gamma}_B, \frac{\tilde{a}_3}{5}\tilde{\gamma}_B, \frac{\tilde{a}_4}{5}\tilde{\gamma}_B, \frac{\tilde{a}_5}{5}\tilde{\gamma}_B\right) \text{ where } \tilde{\gamma}_B = (\tilde{b}_1 + \tilde{b}_2 + \tilde{b}_3 + \tilde{b}_4 + \tilde{b}_5)$$

Division

$$\tilde{a}_A \div \tilde{a}_B = \left(\frac{\tilde{5a_1}}{\tilde{\gamma}_B}, \frac{\tilde{5a_2}}{\tilde{\gamma}_B}, \frac{\tilde{5a_3}}{\tilde{\gamma}_B}, \frac{\tilde{5a_4}}{\tilde{\gamma}_B}, \frac{\tilde{5a_5}}{\tilde{\gamma}_B} \right)$$ if $\tilde{\gamma}_B \neq 0$ where $\tilde{\gamma}_B = \left(\tilde{b_1} + \tilde{b_2} + \tilde{b_3} + \tilde{b_4} + \tilde{b_5} \right)$

Scalar Multiplication

$$\tilde{k a}_A = \begin{cases} \tilde{k a_1}, \tilde{k a_2}, \tilde{k a_3}, \tilde{k a_4}, \tilde{k a_5} & if\ k > 0 \\ \tilde{k a_5}, \tilde{k a_4}, \tilde{k a_3}, \tilde{k a_2}, \tilde{k a_1} & if\ k < 0 \end{cases}$$

Fuzzy transportation problem by means of Mathematical formulation

The mathematical formulation of the pentagonal fuzzy numbers under the case that the total supply is equivalent to the total demand is given as follows

Min $$Z = \sum_{i=1}^{s} \sum_{j=1}^{t} \tilde{a}_{ij} \tilde{x}_{ij}$$

Subject to the constraints

$$\sum_{j=1}^{t} \tilde{x}_{ij} = \tilde{a}_i \quad j = 1, 2, \ldots t$$

$$\sum_{i=1}^{s} \tilde{x}_{ij} = \tilde{b}_j \quad i = 1, 2, \ldots s$$

$$\sum_{i=1}^{s} \tilde{a}_i = \sum_{j=1}^{t} \tilde{b}_j; \quad i = 1, 2, \ldots s, \quad j = 1, 2, \ldots t$$ and

$$\tilde{x}_{ij} \geq 0, \ i = 1, 2, \ldots s, \quad j = 1, 2, \ldots t$$

The fuzzy transportation problem is explicitly represented by the fuzzy transportation table:

	1	...	**t**	Supply
1	$\tilde{a}_{11}$	...	$\tilde{a}_{1t}$	$\tilde{a}_1$
⋮	⋮	...	⋮	⋮
S	$\tilde{a}_{s1}$	...	$\tilde{a}_{st}$	$\tilde{a}_s$
Demand	$\tilde{b}_1$	...	$\tilde{b}_t$	

Ranking Function

In this manuscript, we proposed a Centroid ranking technique. Let $\tilde{a}_A = \left(\tilde{a}_1, \tilde{a}_2, \tilde{a}_3, \tilde{a}_4, \tilde{a}_5 \right)$ be Pentagonal fuzzy numbers by using Centroid Ranking technique [12] for PFNs here the ranking was introduced.

$$R(\tilde{a}_A) = \left(\frac{\tilde{a}_5^2 + \tilde{a}_4^2 + \tilde{a}_5 \tilde{a}_4 - \tilde{a}_2^2 - \tilde{a}_1^2 - \tilde{a}_2 \tilde{a}_1}{3.(\tilde{a}_5 + \tilde{a}_4 - \tilde{a}_2 - \tilde{a}_1)} \right)$$

Proposed Method algorithm

Step – 1: Verify given problem is stabled or not.

(i.e) $\sum_{i=1}^{s} \tilde{a}_i = \sum_{j=1}^{t} \tilde{b}_j$.

If unstable, change into a stabled one by introducing a model source or model destination utilizing zero fuzzy item transportation expenses.

Step – 2: The Ranking value is imparted to transform both demand and supply.

Step – 3: The row–wise multiple between the greatest and least values of each row, and is divided by multiple of the rows and columns of the cost matrix.

Step – 4: The column–wise multiple between the greatest and least values of each column, and is divided by multiple of the rows and columns of the cost matrix.

Step – 5: We find the maximum of the resultant value and do the allocation of that particular cell of the given matrix, suppose we have more than one maximum consequent value. We can select anyone.

Step – 6: Follow the Third, fourth, and fifth steps, till $(s+t-1)$ groups are allocated. Suppose allocated cell not achieved apply Modi method to find optimality.

Result and Discussion

Numerical example

A resolution that we affirm to fuzzy transportation problem which involves transportation cost, customer needs and demands and existence of products using pentagonal Fuzzy figures. Observe the following transportation problem by Sathya Geetha [10]

	R_a	R_b	R_c	R_d	Inventory
I_a	(2, 4, 6, 8, 9)	(3, 5, 7, 8, 9)	(2, 4, 5, 6, 7)	(3, 4, 6, 7, 12)	30
I_b	(0, 2, 5, 6, 8)	(4, 5, 6, 8, 11)	(2, 3, 5, 7, 11)	(1, 5, 6, 9, 11)	27
I_c	(1, 2, 3, 4, 5)	(2, 3, 4, 6, 8)	(4, 5, 6, 8, 9)	(6, 7, 8, 9, 13)	40
I_d	(3, 5, 6, 7, 8)	(1, 5, 6, 7, 8)	(2, 7, 8, 9, 10)	(3, 3, 4, 5, 9)	50
Requirement	20	38	34	55	

Solution

Table 1

By using the Ranking Technique, we have to convert fuzzy Trapezoidal numbers into a crisp value

	R_a	R_b	R_c	R_d	Inventory
I_a	5.7272	6.2222	4.7143	6.6667	30
I_b	4.0000	7.0667	5.6970	6.4286	27
I_c	3.1111	4.7778	6.5000	8.8889	40
I_d	5.7143	5.1111	6.8000	5.1667	50
Requirement	20	38	34	55	

The given problem is balanced. Then choose the maximum of the penalties values and find the corresponding minimum cost value and allocate the particular cost cell of the given problem. If we have more than one maximum resultant value, we can choose anyone.

Table 2

	R_a	R_b	R_c	R_d	Inventory	$\frac{\min \times \max}{\text{row} \times \text{column}}$
I_a	5.7272	6.2222	4.7143	6.6667	30	1.964
I_b	4.0000	7.0667	5.6970	6.4286	27	1.766
I_c	3.1111	4.7778	6.5000	8.8889	40	1.728
I_d	5.7143	5.1111	6.8000	**50** 5.1667	50	2.172
Requirement	20	38	34	55		
$\frac{\min \times \max}{\text{row} \times \text{column}}$	1.1135	2.110	2.003	**2.871**		

Again, we choose the maximum of the penalties values and find the corresponding minimum cost value and allocate the particular cost cell of the given problem. If we have more than one maximum resultant value, we can choose anyone.

Table 3

	R_a	R_b	R_c	R_d	Inventory	$\frac{\min \times \max}{row \times column}$
I_a	5.7272	6.2222	4.7143	6.6667	30	2.619
I_b	4.0000	7.0667	5.6970	**5** 6.4286	27	2.355
I_c	3.1111	4.7778	6.5000	8.8889	40	2.305
I_d	5.7143	5.1111	6.8000	**50** 5.1667	50	2.172
Requirement	20	38	34	55		
$\frac{\min \times \max}{row \times column}$	1.480	2.813	2.553	**4.7619**		

The same procedure will be followed again and again until we reach the final allocation. Finally, using the new proposed ranking algorithm obtained gives the best possible resolutions are as follows.

Table 4

	R_a	R_b	R_c	R_d	Inventory
I_a	5.7272	6.2222	**30** 4.7143	6.6667	30
I_b	**18** 4.0000	7.0667	**4** 5.6970	**5** 6.4286	27
I_c	**2** 3.1111	**38** 4.7778	6.5000	8.8889	40
I_d	5.7143	5.1111	6.8000	**50** 5.1667	50
Requirement	20	38	34	55	

Result

Here (4+4-1) = 7 cells are allocated. Next we can get the optimal solution by means proposed Ranking algorithm.

Min $Z = 18(4.0000) + 2(3.1111) + 4(5.6970) + 50(5.1667) + 5(6.4286) + 38(4.7778) + 30(4.7143)$

Min $Z = 714.4736$

Discussion

The Comparison of the new Proposed Ranking Technique with NWCM, the LCM, Russell's Approximation Method, Row Minima Method, Column Minima Method, and VAM is listed below, it's clearly understood that the new proposed Ranking Technique affords the optimal results.

Methods	**Optimal solutions**
NWCM	896.12
LCM	727.19
Russell's Approximation Method	727.19
Row Minima Method	721.17
Column Minima Method	727.19
VAM Method	717.86
New Proposed Ranking Method	**714.47**

Conclusion

The main contribution of this manuscript is to derive the best possible viability of a fuzzy transportation problem for Pentagonal fuzzy numbers using the newly proposed Ranking algorithm method. This practice can use for all types of fuzzy transportation problems. The recently proposed Ranking technique is a regularized practice, simple to relate to, and able to be operated for the entire types of transportation problems either to capitalize on or play down an intended function. This approach could be broadening to resolve transportation problems by way of an additional fuzzy algorithm.

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