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A naive algorithm to solve pentagonal fuzzy transportation problem

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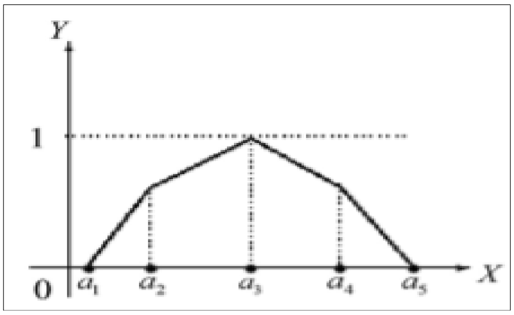
Abstract
This paper presented a new ranking method and a new algorithm to solve pentagonal FTP. We compared this algorithm with the North-West corner method, LCM, Zero Suffix method, VAM, and Best Candidate method and we got the optimum solution. Here we transform FTP into a crisp problem and using the proposed ranking technique we solve a numerical example using a new algorithm.

Keywords: Ranking function, fuzzy transportation problem, optimum solution, pentagonal fuzzy numbers

Introduction
The purpose of the fuzzy transportation problem is to decide the transportation schedule that reduces the entire fuzzy transportation cost and time. An FTP is a problem in which all the quantities are fuzzy quantities such as transportation cost, supply, and demand. These quantities are unknown due to many unmanageable factors. To manage exact details in building decisions Zadeh 1978 [10] established the concept of fuzziness.
[1] Suggested a method to solve FTP working on PFN. In [2] the best optimality condition has been checked. Also [3] proposed octagonal FTP using a different ranking method. A simple algorithm is given to check the feasibility of FTP by [4]. [5] Solved TP with fuzzy numbers by the ranking method [6, 7]. Solved FTP using the Best Candidate method. Balanced and unbalanced FTP by using Octagonal Fuzzy Numbers introduced by [8]. The [9] proposed solution of FTP uses robust rank techniques and an improved method.
A new algorithm is suggested to discover an optimum solution for FTP in which PFN is involved. We obtain the least value for the optimum solution by applying the ranking technique and proposed algorithm.

Preliminaries
Definition (PFN) [1]
A fuzzy number A is said a PFN, which is named as (s_1, s_2, s_3, s_4, s_5) whose membership function μA (x) is given by

$$\mu_A(x) = \begin{cases} 0, \text{ if } x < s_1 \\ u_1\left(\frac{x-s1}{s2-s1}\right), \quad \text{if } s_1 \le x < s_2 \\ 1-(1-u_1)\left(\frac{x-s2}{s3-s2}\right), \text{ if } s_2 \le x < a_3 \\ 1, \text{ if } \quad x = s_3 \\ 1-(1-u_2)\left(\frac{s4-x}{s4-s3}\right), \text{ if } s_3 \le x < s_4 \\ u_2 \ \frac{s5-x}{s5-s4,}, \text{ if } s_4 \le x < s_5 \\ 0, \text{ if } x > s_5 \end{cases}$$



Proposed ranking technique

To calculate the interquartile range, we need to follow the following steps:

1. Arrange the numbers in increasing order.
2. Find the Median.
3. Calculate the median of both upper (Q_3) and lower (Q_1) data.
4. Observe the difference between Q_3 and Q_1.
5. The inter-quartile range = Q3 – Q1

Proposed ranking method

1. Set up the transportation problem table and examine whether it is balanced or not. If it is not balanced, then add a dummy row/column.
2. We convert the FTP into crisp values using the proposed ranking method.
3. For each row we take the sum of the row maximum and just less than the maximum and divide it by several columns.
4. For each column we take the sum of the column maximum and just less than the maximum and divide it by several rows.
5. We choose the greatest of the resultant value. After that, we choose the least value of the cost and make the allocation. If we get multiple greatest values, we can choose any value.
6. Repeat steps 3 to 5 to complete the allocations and the optimal solution.

Numerical examples

1. Consider a balanced FTP

Table 1: Balanced FTP

	d_1	d_2	d_3	d_4	Supply
s_1	(1,3,5,7,9)	(0,1,2,3,4)	(2,4,7,8,9)	(0,3,4,5,8)	50
s_2	(2,4,5,6,8)	(0,3,4,6,7)	(3,5,6,8,9)	(0,2,3,4,5)	40
s_3	(2,4,5,6,9)	(0,2,4,6,8)	(1,2,5,7,10)	(2,3,4,5,6)	60
s_4	(0,13,5,6)	(1,2,4,5,6)	(0,1,2,3,5)	(2,3,5,7,9)	30
Demand	40	45	45	50	

Solution

By using the proposed ranking technique, we transform given PFN into crisp values.

Table 2: Balanced FTP transform

	d_1	d_2	d_3	d_4	Supply
s_1	6	3	5.5	5	50
s_2	4	5	4.5	3.5	40
s_3	4.5	6	7	3	60
s_4	5	4	3.5	5.5	30
Demand	40	45	45	50	

Now we must find the greatest value from the result and notice the least value of the cost and make the allocation.

Table 3: least value of the cost and make the allocation

	d_1	d_2	d_3	d_4	Supply	
s_1	6	3	5.5	5	50	$\frac{11.5}{4}$
s_2	4	5	4.5	3.5	40	$\frac{9.5}{4}$
s_3	4.5	6	7	3 50	60	$\frac{13}{4}$
s_4	5	4	3.5	5.5	30	$\frac{10.5}{4}$
Demand	40	45	45	50		
	$\frac{11}{4}$	$\frac{11}{4}$	$\frac{12.5}{4}$	$\frac{10.5}{4}$		

Now again we must find the greatest value from the result and notice the least value of the cost and make the allocation.

Table 4: greatest value of the cost and make the allocation

	d_1	d_2	d_3	d_4	Supply	
s_1	6	3	5.5	5	50	$\frac{11.5}{3}$
s_2	4	5	4.5	3.5	40	$\frac{9.5}{3}$
s_3	4.5	6	7	3	60	$\frac{13}{3}$
s_4	5	4	3.5	5.5	30	$\frac{9}{3}$
Demand	40	45	45	50		
	$\frac{11}{4}$	$\frac{11}{4}$	$\frac{12.5}{4}$	$\frac{10.5}{4}$		

The same technique is followed repeatedly until we get the final allocation.

Table 5: The Final allocation

	d_1	d_2	d_3	d_4	Supply
s_1	6 5	3 45	5.5	5	50
s_2	4 25	5	4.5 15	3.5	40
s_3	4.5 10	6	7	3 50	60
s_4	5	4	3.5 30	5.5	30
Demand	40	45	45	50	

The transportation cost Z = 3 *50 + 4.5 * 10 + 3 * 45 + 6 * 5 + 4 * 25 + 4.5 * 15 + 3.5 * 30

Z = 632.5

Comparison with other techniques

In the below table the analogy of the proposed technique along with the other techniques are given. It is evidence presented that the proposed technique gives the optimum solution.

Table 6: Comparison with other techniques

Techniques	Optimum Solution
North-west corner method	972.5
VAM method	635
LCM method	647.5
Zero suffix method	635
Best Candidate method	647.5
Proposed Technique	632.5

Example 2) Consider an unbalanced FTP.

Table 7: Unbalanced FTP

	d_1	d_2	d_3	d_4	Supply
s_1	(1,3,5,7,9)	(0,1,2,3,4)	(2,4,7,8,9)	(0,3,4,5,8)	50
s_2	(2,4,5,6,8)	(0,3,4,6,7)	(3,5,6,8,9)	(0,2,3,4,5)	40
s_3	(2,4,5,6,9)	(0,2,4,6,8)	(1,2,5,7,10)	(2,3,4,5,6)	60
s_4	(0,1,3,5,6)	(1,2,4,5,6)	(0,1,2,3,5)	(2,3,5,7,9)	30
Demand	40	25	35	45	

Solution

By using the proposed ranking technique, we transform given PFN into crisp values.

Table 8: Unbalanced FTP to crisp values

	d_1	d_2	d_3	d_4	Supply
s_1	6	3	5.5	5	50
s_2	4	5	4.5	3.5	40
s_3	4.5	6	7	3	60
s_4	5	4	3.5	5.5	30
Demand	40	25	35	45	

The stated Problem is unbalanced so we add 0 columns to make it balance.

Table 9: Unbalanced FTP to balance values

	d_1	d_2	d_3	d_4	d_5	Supply
s_1	6	3	5.5	5	0	50
s_2	4	5	4.5	3.5	0	40
s_3	4.5	6	7	3	0	60
s_4	5	4	3.5	5.5	0	30
Demand	40	25	35	45	35	

Now we must find the greatest value from the result and notice the least value of the cost and make the allocation.

Table 10: Least value of the cost and make the allocation.

	d_1	d_2	d_3	d_4	d_5	Supply	
s_1	6	3	5.5	5	0	50	11.5 5
s_2	4	5	4.5	3.5	0	40	9.5 5
s_3	4.5	6	7	3	0	60	13 5
s_4	5	4	3.5	5.5	0	30	10.5 5
Demand	40	25	35	45	35		
	11 4	11 4	12.5 4	10.5 4	0 4		

Again, we must find the greatest value from the result and notice the least value of the cost and make the allocation.

Table 11: Greatest value of the cost and make the allocation

	d_1	d_2	d_3	d_4	d_5	Supply	
s_1	6	3	5.5	5	0	50	11.5 5
s_2	4	5	4.5	3.5	0	40	9.5 5
s_3	4.5	6	7	3	0	60	13 5
s_4	5	4	3.5 30	5.5	0	30	10.5 5
Demand	40	25	35	45	35		
	10.5 3	11 3	12.5 3	8.5 3	0 3		

The same technique is followed repeatedly until we get the final allocation.

Table 12: Final allocation

	d_1	d_2	d_3	d_4	d_5	Supply
s_1	6	3 25	5.5	5	0 25	50
s_2	4 35	5	4.5 5	3.5	0	40
s_3	4.5 5	6	7	3 45	0 10	60
s_4	5	4	3.5 30	5.5	0	30
Demand	40	25	35	45	35	

The transportation cost Z = 3*25 +0*25 + 4*35 + 4.5*5 +4.5*5 + 3*45 + 0*10 + 3.5*30
Z = 500

Comparison with other techniques

In below table the analogy of the proposed technique along with the other techniques are given. It is presented that the proposed technique gives the optimum solution.

Table 13: Comparison with other techniques

Techniques	Optimum Solution
North-West Corner Method	662.5
VAM Method	560
LCM Method	540
Zero Suffix Method	500
Best Candidate Method	510
Proposed Technique	500

Conclusion

A new range technique i.e., the interquartile range is proposed to get a crisp value which is very easy, and a new algorithm is applied to solve FTP. We get an optimal solution using this method as compared to other known techniques.

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