SOLVING FUZZY TRANSPORTATION PROBLEM BY VARIOUS METHODS AND THEIR COMPARISON IN FUZZY ENVIRONMENT

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Abstract:
In this study, we solve a heptagonal number issue utilizing some current approaches, including current zero point, zero suffix and increased zero suffix. These standard methods have been discussed in order to determine which the best method is. Initially, we use the range ranking function to transform the supplied fuzzy problem into a crisp value, and then we use and compare this procedure to obtain the best minimal answer. In the context of this research, the current zero-point method generates an optimal result that is better than that obtained by other methods.

Keywords: Fuzzy Transportation Problem, Heptagonal Fuzzy Number, Range Ranking Function, Current Zero Point, Zero Suffix, and the Increased Zero Suffix method.

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1 INTRODUCTION:

Transportation issue which illustrates the linear programming problem which is proposed by Hitchcock in 1941. In which the emergence of randomness and imprecision in the job is unavoidable due to certain unanticipated occurrences.

In actual word circumstance occasionally the decision maker cannot offer their response either yes or no, then the new term arrives is called hazy. The word fuzzy which is invented by Lotfi Zade (1965) at University of California in Berkley. In other phrase we may state that anything which is not clear of a picture containing forms that do not have any distinct edge. By Lotfi Zade was the originator to construct the fuzzy sets in order to mathematically portray imprecision or vagueness in everyday life.

According to study conducted by M. K. Purushothkumar, M. Ananthanarayanan and S. Dhanasekar [5] presented a technique of Fuzzy zero suffix algorithms to tackle totally fuzzy transportation issues. Roy etal [8] worked on fuzzy transportation issue utilizing zero point approach with ranking of trapezoidal fuzzy number. They identify the best solution for the transportation system by taking into account the closed, bounded, and non-empty feasible region of the transportation problem using fuzzy trapezoidal numbers. The problem is solved in two stages: in the first stage, a fuzzy transportation problem is made into a clear system through the application of a ranking of trapezoidal numbers. In the second step, the zero-point method is utilized to deal with the crisp transportation issue, and the North-West Corner method is examined for comparison. Based on the findings of a study by Nagastiti et al. [6] that compared the theories of the zero point method and the zero suffix method in determining the optimal solution, it is possible to draw the conclusion that the process of using the zero suffix method is more efficient in determining an optimal solution in 6 steps than the process of using the zero point method in 9 steps. A. Edward Samuel [2] proposed an improved zero pint method for the transportation problems. A. Edward Samuel and M. Venkatachalapathy [1] investigate a technique for enhancing the modified zero point approach for imbalanced fuzzy transportation issues. T. Karthy and K, Ganesan [10] suggested a new approach named by increased zero point method for the trapezoidal fuzzy transportation issues. P. Jayaraman and R. Jahairhussian [3] solve a fuzzy optimum transportation issues by increased zero suffix using Robust ranking approach. When the inventory and the interest of hubs, as well as the limit and cost edges, are addressing fuzzy numbers, the authors of this study proposed a positioning procedure for the purpose of solving the fuzzy transportation problem. This procedure assumes that the fuzzy interest and supply are in the form of triangular and trapezoidal fuzzy numbers. The authors' goal was to determine the least expensive method of transporting specific goods through a capacitated network. L. Kane et al. [4] proposed a two-step strategy for defining a fuzzy transportation problem that used polyhedral and hexagonal fuzzy numbers. Rubeelamary S. and Sivaranjani S. [9] find a fuzzified ranking of incident fuzzy numbers that can be utilized to predict a fuzzy min-max transportation problem. In order to find the best options, they executed their similar assessments of the proposed system with computation, such as Russell's Method, the Northern Parts Approach, the Least Cost Technique, and Vogel's Estimation Techniques. This allowed them to determine which algorithms provided the most accurate results.

In this article, three different approaches that have been shown to be effective in the past for resolving hazy transportation issues are discussed. A mathematical model of a transportation issue is addressed, and the findings are contrasted with those obtained by the other two approaches that are already in use. This is done to explain the suggested method and evaluate its great implications.

1.1 Heptagonal Fuzzy Number: In the event that A is a generalized heptagonal fuzzy number of the form A= (a_1, a_2, a_3, a_4, a_5, a_6, a_7), then the effectiveness of membership $\mu_A(x)$ of a heptagonal fuzzy number has the following feature:

$$\mu_A(x) = \begin{cases} 0, & x < a_1, \\ \frac{1}{2}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \le x \le a_2 \\ \frac{1}{2}, & a_2 \le x \le a_3 \\ \frac{1}{2}+\frac{1}{2}\left(\frac{x-a_3}{a_4-a_3}\right), & a_3 \le x \le a_4 \\ \frac{1}{2}+\frac{1}{2}\left(\frac{a_5-x}{a_5-a_4}\right), & a_4 \le x \le a_5 \\ \frac{1}{2}, & a_5 \le x \le a_6 \\ \frac{1}{2}\left(\frac{a_7-x}{a_7-a_6}\right), & a_6 \le x \le a_7 \\ 0, & x > a_7 \end{cases}$$

1.2 Range Ranking Function: In a setting marked by uncertainty, when it comes to the process of making decisions, the fuzzy ranking number has an important effect. In order to rank fuzzy numbers, it is necessary to locate the greatest and the smallest fuzzy numbers. Within the scope of this study, we will be using heptagonal fuzzy numbers. Or In other terms, we may state that if the number is a fuzzy heptagonal or octagonal number, then the function is represented by range. This function is also useful for obtaining the crisp value of fuzzy numbers that have been given.

Range = Max-Min

2 Methodology:

1. Current Zero point Method
2. Zero Suffix Method
3. Increased Zero Suffix

2.1 Current Zero Point Method:

The zero-point approach is a brand new algorithm that was developed with the goal of finding a fuzzy optimal result for a triangular fuzzy number.

Step 1: We use the range function to turn the fuzzy transportation table we were given into a clear value.

Step 2: Check to see if the fuzzy transportation table is balanced after you've changed the crisp values. If it is, go on to the next step; if not, add a fake row or column in accordance with supply and demand.

Step 3: Subtract the smallest element of the row from the element of the row if a fake row and column are inserted.

Step 4: After completing Step 3, at which point the fuzzy navigation table was established, go to step 4 by deducting the column element from the smallest element of the column.

Step 5: Check to see if the total of the fuzzy source when costs of reduction are fuzzy zero. is less than or equal to the total of the fuzzy demand in each column. Check to see whether the total of the fuzzy demands in each row is smaller than the sum of the fuzzy requests in each column whose decrease costs in those rows are fuzzy nil. In such case, go to step 7, Go to step 5 if it is not.

Step 6: Draw the fewest possible Both vertical as well as horizontal lines were drawn to contain every one of the fuzzy noughts in the modified fuzzy transportation table in such a way that certain rows and columns' entries do not meet step 4's requirement (which is not covered by any lines).

Step 7: Create the reduction table for transporting things that are fuzzy as described below. 1. Identify the lowest item in the fuzzy cost matrix that has no lines covering it. 2. Subtract this item from all of the entries that were left unfilled, and then add the smallest element of the reduction fuzzy transportation table at the intersection of the two lines. 3. Decide which cell in the fuzzy transportation issue reduction form a decreased has cost that is greater than all other costs. Choose anybody if there are more than one.

Step 8: Choose the rows and columns of the table displaying decreased costs for transportation, but instead select the cell that has the sole fuzzy zero value for cost reduction. Next, give that cell the largest amount of resources. Find the next maximum such that the cell happens if the one in question doesn't have the maximum value.

Step 9: After removing the fuzzy supply point that was totally used up and the fuzzy demand point that had been fully received, finish the table that minimizes the usage of fuzzy transportation. In addition to this, the table has to be edited so that it includes both the partly used fuzzy source element and the partially obtained fuzzy desire point.

Step 10: Repetition of steps 7 through 9 until all fuzzy needs and supply points have been satisfied.

2.2 Zero Suffix Method:

Step 1: Create an elaborate transportation problem.

Step 2: Use the range ranking function to transform the vagueness of the transportation issue into crispness.

Step 3: After converting the fuzzy transportation issue into crisp values, check to verify that the table on fuzzy transportation is in a balanced state. Go to the following stage if this is the case: If not, add the necessary dummy rows or columns (columns or supplies).

Step 4: Remove each row element from the minimum element of the row minimum, followed by the minimum element of each column's value.

Step 5: At the very least one zero may be expected in every column and row of the minimize fuzzy transportation table.

Step 6: Find the sum of all the zero suffix values in step six. S stands for it.

$$S = \frac{\text{Sum of non zero Costs in near adjacent sides}}{\text{Number of fuzzy value added}}$$

Step 7: Choose the highest value from S. If it has only one maximum value, put that value in that cell. If it has more than one equal value, pick (a, b) and give that requirement the highest value you can.

Step 8: After carrying out step 7, the resultant fuzzy matrix has to have at least one fuzzy zero in each row and column; otherwise, step 7 needs to be carried out once again. It is carried out in order to reduce either depleted fuzzy demand or fuzzy supply as much as possible.

Step 9: If the optimal solution has not yet been found, repeat Steps 3 through 5 once again.

2.3 Increased Zero Suffix:

Step 1: In order to develop the convoluted transportation issue

Step 2: When the nature of the problem has been established, check to see whether it is balanced. If it is, you may go on to the following stages; if not, you will need to add the dummy element in order to fulfil the requirements.

Step 3: Use the range function to make the question about transportation more clear. **Step 4:** Subtract the smallest element of the relevant row and column value from each element of that row and column.

Step 5: There will be at least one zero in each column and row of the reduced fuzzy transportation table.

Step 6: Determine the improved value of the zero suffix for all zeros as the sixth step's objective. It is indicated by the letter S.

$$S = \frac{\text{Sum of non zero Costs in } i^{th} \text{ row and } j^{th} \text{ Column}}{\text{Sum of No of zeros in } i^{th} \text{ row and } j^{th} \text{ Column}}$$

Step 7: Select the maximum value of S. If it only has one maximum value, assign that value. If it has several maximum values, choose (a, b), and provide to that demand the maximum value that is possible.

Step 8: After the allocation is complete, if we can ensure that there are fewer than m+n-1 cells, start the procedure again from step 2.

Step 9: Continue the procedure until the entire rim needs have been satisfied.

3 Numerical Example:

Assuming that S. Chandrasekaran, G. Kokila, and Junu Saju [13] describe an unbalanced fuzzy transportation issue, which is provided below in Table 1, in which the fuzzy demand, fuzzy availability, and fuzzy cost are all heptagonal fuzzy numbers.

Table1-Heptagonal Fuzzy transportation table

	A	**B**	**B**	**Supply**
D	(3, 6, 2, 1, 5, 0, 4)	(2, 3, 1, 4, 3, 6, 5)	(2 ,4, 3, 1, 6, 5, 2)	(2, 2, 1, 2, 1, 1, 0)
E	(2, 7, 7, 6, 3, 2, 1)	(1, 3, 5, 7, 9, 11, 13)	(0, 1, 2, 4, 6, 0, 5)	(3, 2, 1, 4, 5, 0, 1)
F	(3, 6, 3, 2, 1,8, 7)	(3, 4, 3, 2, 1, 1, 0)	(2, 4, 6, 8, 10, 12, 14)	(2, 4, 3, 1, 6, 5, 2)
Demand	(0, 1, 2, 4, 6, 0, 5)	(0, 4, 6, 4, 6, 2, 0)	(2, 7, 7, 6, 3, 2, 1)	

Solution: Using ranking as a method, convert the heptagonal fuzzy number that has been provided into a crisp value.

Range = Max-min

Range (3,6,2,1,5,0,4) = 6, Range (2,3,1,4,3,6,5) = 5, Range (2,4,3,1,6,5,2) = 5, Range (2,7,7,6,3,2, 1) = 6, Range (1,3,5,7,9,11,13) = 12, Range (0,1,2,4,6,0,5) = 6.

Range (3,6,3,2,1,87) = 7, Range (3,4,3,2,1,1,0) = 4, Range (2,4,6,8,10,12,14) =12

Range of all supply and demand is Range (2,2,1,2,1,1,0) = 2, Range (3,2,1,4,5,0,1) = 5, Range (2,4,3,1,6,5,2) = 5, Range (2,4,3,1,6,5,2) =

6, Range (0,4,6,4,6,2,0) = 6, Range (2,7,7,6,3,2,1) = 6.

Table 2- Deffuzzified fuzzy transportation problem

	A	B	C	Supply
D	6	5	5	2
E	6	12	6	5
F	7	4	12	5
Demand	6	6	6	

Total Supply =12, Total Demand= 18

Here, $\sum_{i=1}^{m} a_i \neq \sum_{j=1}^{n} b_j$, then the problem was not balanced Instead of an unstable fuzzy navigation issue that requires adding the dummy row in multiple ways, we now have a symmetric fuzzy transportation problem.

Table 3-Add the row for balance the crisp value table

	A	B	C	Supply
D	6	5	5	2
E	6	12	6	5
F	7	4	12	5
G	0	0	0	6
Demand	6	6	6	

Table 4-Row reduction of crisp value using table3

	A	B	C	Supply
D	1	0	0	2
E	0	6	0	5
F	3	0	8	5
G	0	0	0	6
Demand	6	6	6	

Now using current zero point method allocate table is given below

Table 5- allocate the value of current zero point method is

	A	B	C	Supply
D	6	**[1]** 5	**[1]** 5	2
E	**[5]** 6	12	6	5
F	7	**[5]** 4	12	5
G	**[1]** 0	0	**[5]** 5	6
Demand	6	6	6	

Optimum Value of Current zero point is =1*5+1*5+5*6+5*4+1*0+0*5=**60**

Now this problem solves using zero suffix and increased zero suffix, after reduce the column and row

Table 6- Row and Column reduction of defused fuzzy number is

	A	B	C	Supply
D	1	0	0	2
E	0	6	0	5
F	3	0	8	5
G	0	0	0	6
Demand	6	6	6	

Now find the suffix value of all zero using zero suffix method. The suffix value is S_1, S_2, S3, S4, S5 ,S_6 ,S_7 & S_8

$S_1 = \frac{7}{2} = 3.5, S_2 = 0\ S_3 = 3.3,\ S_4 = 7, S_5 = 5.6, S_6 = 3,\ S_7 = 0, S_8 = 8$

Maximum value is 8 allocate the value of supply or demand according

Table 7-Allocate of zero suffix method

	A	B	C	Supply
D	**[1]** 6	**[1]** 5	5	2
E	**[5]** 6	12	6	5
F	7	**[5]** 4	12	5
G	0	0	**[6]** 0	6
Demand	6	6	6	

Optimum Value of zero suffix =1*6+1*5+5*6+5*4+0*6=**61**

Now again we solve using Increased zero suffix is, the allocation table of method is .

Table 8-Allocate the fully fuzzy table using increased zero suffix method

	A	B	C	Supply
D	6	**[1]** 5	**[1]** 5	2
E	6	12	**[5]** 6	5
F	7	**[5]** 4	12	5
G	**[6]** 0	0	0	6
Demand	6	6	6	

Optimum solution of increased zero point is =1*5+1*5+5*6+5*4+6*0=60

4 RESULT, DISCUSSION AND COMPARISON:

The comparison of various approaches can be seen in table 9, which can be found below.

Table 9- Comparison between Existing methods

S. No	Techniques	Optimum Solution	Iteration	Allocation Value
1.	Current Zero Point	60	0	X_{12}=1, X_{13}=1, X_{21}=5, X_{32}=5 X_{41}=1, X_{43}=5

2.	Zero Suffix	61	3	X_{11}=3, X_{12}=1, X_{21}=5, X_{32}=5. X_{43}=6
3.	Increased Zero Suffix	60	3	X_{12}=1, X_{13}=1, X_{23}=5, X_{32}=5 X_{41}=6

5 CONCLUSION:

In order to solve the fuzzy transportation issue, an existing algorithm that makes use of the current zero point, zero suffix and increased zero suffix has been developed. In this case, the range ranking function has turned a fuzzy transportation issue into a clear value. Based on the findings of the comparison, the current zero point is superior to both the increased zero suffix and the zero suffix. The optimal solution of current zero point and increased zero suffix is 60, but whereas optimum value of zero suffix is 61. Nevertheless, the number of iterations that take place is three in both the increased zero suffix and the zero suffix, but in the current zero point there is no iteration at all for the purpose of addressing fuzzy problems.

REFERENCE:

1. Edward Samuel, M, Venkatachalapathy (2014): Improving IZPM for unbalanced fuzzy transportation problems; International Journal of Pure and Applied Mathematics, Vol. 94, No. 3, PP 419-424.
2. Edward Samuel (2012): Improved zero point method for the transportation problems; Applied Mathematical Sciences, Vol. 6, No. 109, PP 5421-5426.
3. Jayaraman, P. and Jahirhussian, R. (2013): Fuzzy optimal transportation problem by improved zero suffix method via Robust ranking techniques; International Journal of Fuzzy Mathematics and Systems, Vol. 3, No. 4 PP 303-311.
4. L. Kane, M. Diakite, S. Kane, H. Bado & Diawara, D.(2021): Fully fuzzy transportation problems with pentagonal and Hexagonal fuzzy numbers; Journal of Applied Research on Industrial Engineering, Vol, 8, No. 3, PP 251-269.
5. M. K. Purushothkumar, M. Ananthanarayanan and S. Dhanasekar (2018): Fuzzy zero suffix algorithm to solve fully fuzzy transportation problems; International Journal of Pure and Applied Mathematics, Vol. 119, No. 9, PP 79-88.
6. Pukky T. B. Nagastiti, Bayu Surarso and Sutimin (2020): Comparison between zeropoint method and zero suffix method in fuzzy transportation problems; Journal Mathematics MANTIK, Vol.6, No.1, PP 38-46.
7. P. Ngastiti, B. Surarso, B. Sutimin (2018): Zero point and zero suffix methods with robust ranking for solving fully fuzzy transportation problems; Journal of Physics: Conference Series, Vol. 10, No. 22, PP 1-10.
8. Roy, Haridas, Pathak, Govind and Kumar, Rakesh (2020): A study of fuzzy transportation problem using zero point method with ranking of trapezoidal fuzzy number; BULLETIN MONUMENTAL, Vol. 21, Issue.8, PP 24-29.
9. Rubeelamary S and Sivaranjani S.(2020): Ranking of Heptagonal fuzzy number to solve fuzzy Min-Max transportation problems; International Journal of analytical and experimental modal analysis, Vol. 12, No. 1, PP 39-44.
10. T. Karthy and G. Ganesan (2019): Revised Improved zero point method for the Trapezoidal fuzzy transportation problem; The 11th National Conference on Mathematical technique and application, AIP Conference, PP 020063-1 to 020063-7.
11. V. Traneva, S. Tranev (2020): An Intuitionistic fuzzy zero suffix method for solving the transportation problem, In: Dimov I., Fidanova S. (eds) Advances in High Performance Computing. HPC 2019, Studies in Computational Intelligence, Springer, Cham, Vol. 902, http://dx.doi.org/10.1007/978-3-030-55347-0_7.