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# Fuzzy Transportation Problem through Monalisha's Approximation Method

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*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## Abstract

Transportation Problem (TP) is based on supply and demand of commodities transported from several sources to the different destinations. Usual methods for calculating initial basic feasible solution are North-West corner method, least cost method, row minima method/ column minima method, Russell's method, Vogel's approximation method etc. The transportation costs are considered as imprecise numbers described by fuzzy numbers which are more realistic and general in nature. Since the objective is to minimize the total cost or to maximize the total profit, subject to some fuzzy constraints, the objective function is also considered as a fuzzy number. The method is to rank the fuzzy objective values of the objective function by some ranking method to find the best alternative. On the basis of this idea method of magnitude ranking technique has been adopted to transform the fuzzy transportation problem and the initial basic feasible solution is found by Monalisha's Approximation Method (MAM'S).
An numerical illustration is also discussed.

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**AMS subject classification:** 90C08, 90C90, 90C29, 90C70, 90B06.

# 1 Introduction

Transportation problem is associated with routine activities in our real life and mainly deals with logistics. Transportation algorithm is one of the powerful frame works to supply the commodities to the customer in efficient manner. Transportation problems deal with the transportation of a single/multi product manufactured at different plants (origins) to number of different warehouses (destinations). The main objective of Transportation problems satisfies the demand at destinations from the supply constraints at the minimum possible transportation cost. Very first basic transportation problem was developed by Hitchcock [1]. Kishore N. and Anurag Jayswal [2] Prioritized goal programming formulation of an unbalanced transportation problem with budgetary constraints. K. R. Sobha [3] proposed a new method for solving unbalanced transportation problems. Monalisha Pattnaik [4] proposed MAM's method for solving transportation problems. All the parameters of the transportation problems may not be known precisely due to uncontrollable factors in real world applications. The parameters of the transportation problem are not always exactly known and stable. This imprecision may follow from the lack of exact information, uncertainty in judgment etc. In 1965, Zadeh [5] introduced the notion of fuzziness that was reinforced by Bellman and Zadeh [6]. Zimmermann [7,8] has discussed about the effective solutions of Fuzzy set theory, Fuzzy linear programming with several objective functions. Bit A.K., Biswal M.P., Alam S.S [9] have introduced the Fuzzy programming approach to multi criteria decision making transportation problem. Charnas S, Delgado M, Verdegy J.L., Vila M.A, [10] have explained in detail about the Interval and fuzzy extension of classical transportation problems. Defuzzification is a process that converts a fuzzy set or fuzzy number into a crisp value or number. Hajjari T, Abbasbandy, S [11] has proposed the concept of Promoter Operator for Defuzzification Methods. Chanas and Kuchta [12] proposed the concept of optimal solution for the transportation problem with fuzzy coefficients expressed as fuzzy numbers. Saad O.M. and Abbas S.A. [13] had made a parametric study on transportation problem under fuzzy environment. Kadhirvel K, Balamurugan K," [14] Method for Solving Transportation Problems Using Trapezoidal Fuzzy Numbers", Pandian & Natrajan [15,16,17] proposed a new algorithm, namely fuzzy zero point method. Gani A and Razak K.A [18] have given the procedure to solve two stage fuzzy transportation problems. Charnes A., Cooper W. W. and Henderson A [19] have given an introduction to Linear Programming. Danzig G.B [20] have explained about the extensions of Linear Programming. Fuzzy Mathematical Programming methods and linear programming Application were proposed by Lai Y.J., Hwang C.L. [21], Nagoor Gani A and Stephan Dinagar D, [22]. A new method on ranking generalized trapezoidal fuzzy numbers based on centroid point and standard deviations by Chen and Chen [23]was derived. F. Azman, L. Abdullah [24], N. Ravi Shankar and P. Phani Bushan Rao [25,26], have given a review on Ranking Fuzzy Numbers Using the Centroid Point Method. Ranking functions and their applications to fuzzy linear programming have been developed by Maleki H.R. [27].

S. Krishna Prabha, S. Vimala [28,29], have given some methods for solving balanced/unbalanced fuzzy transportation problems with various ranking techniques. S. Narayanamoorthy, S. Saranya, S. Maheswari and S. Kalyani [30,31], have given a new method for finding solution to fuzzy transportation problems. Ringuset J.L. Rinks, D.B [32] obtained the Interactive solutions for the linear multi objective transportation problem. Waiel F, Abd El. Wahed [33], given a detailed description of q Multi objective transportation problem under fuzziness.

Preliminaries of basic concepts, operations of fuzzy set theory and Method of magnitude, for ranking fuzzy numbers have been reviewed in section 2. In section 3, Monalisha's Approximation Method (MAM'S) has been proposed for Fuzzy Transportation Problem. A numerical example is illustrated and compared with exisisting methods in section 4.

# 2 Preliminaries

## 2.1 Trapezoidal and triangular fuzzy numbers

If the membership function $f_{\tilde{A}}(x)$ is piecewise linear, Then $\tilde{A}$ is said to be a trapezoidal fuzzy number. The membership function of a trapezoidal fuzzy number is given by

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{w(x-a)}{b-a} if\ a \le x \le b \\ w\ if\ b \le x \le c \\ \dfrac{w(x-d)}{(c-d)} if\ c \le x \le d \\ 0 \quad otherwise \end{cases}$$

If $w = 1$, then $\tilde{A} = (a, b, c, d; 1)$ is a normalized trapezoidal fuzzy number and $\tilde{A}$ is a generalized or non normal trapezoidal fuzzy number if $0 < w < 1$.The image of $\tilde{A} = (a, b, c, d; w)$ is given by $-\tilde{A} = (-d, -c, -b, -a; w)$.

In particular case if $b = c$, the trapezoidal fuzzy number reduces to a triangular fuzzy number given by $\tilde{A} = (a, b, d; w)$. The value of "$b$" corresponds with the mode or core and $[a, d]$ with the support. If $w = 1$, then $\tilde{A} = (a, b, d)$ is a normalized triangular fuzzy number $\tilde{A}$ is a generalized or non normal triangular fuzzy number if $0 < w < 1$.

## 2.2 Properties of trapezoidal fuzzy number

Let $\breve{A} = (a_1, b_1, c_1, d_1)$ and $\breve{B} = (a_2, b_2, c_2, d_2)$ be two trapezoidal fuzzy numbers, then the fuzzy numbers addition and fuzzy numbers subtraction are defined as follows:

(i) Fuzzy numbers addition of $\breve{A}$ and $\breve{B}$ is denoted by $\breve{A} \oplus \breve{B}$ and is given by
$\breve{A} \oplus \breve{B} = (a_1,b_1, c_1, d_1) \oplus (a_2,b_2, c_2, d_2) = (a_1 + a_2, b_1 + b_2, c_1 + c_2, d_1 + d_2)$

(ii) Fuzzy numbers subtraction of $\breve{A}$ and $\breve{B}$ is denoted $\breve{A} \ominus \breve{B}$ and is given by
$\breve{A} \ominus \breve{B} = (a_1,b_1, c_1, d_1) \ominus (a_2,b_2, c_2, d_2) = (a_1 - d_2, b_1 - c_2, c_1 - b_2, d_1 - a_2)$

## 2.3 New approach for ranking of trapezoidal fuzzy numbers

### 2.3.1 Method of magnitude

If $\tilde{\alpha} = (a_1, a_2, a_3, a_4)$ is a trapezoidal fuzzy number, then the defuzzified value or the ordinary (crisp) number of, a is given below, a = $\frac{a_1+2a_2+2a_3+a_4}{6}$.We need the following definitions of ordering on the set of the fuzzy numbers based on the magnitude of a fuzzy number.

The magnitude of the trapezoidal fuzzy number, $\tilde{u} = (x_o - \sigma, x_o, y_o, y_o + \beta)$ with parametric form

$\tilde{u} = (\underline{u}(r), \overline{u}(r))$ where $\underline{u}(r) = x_0 - \sigma + \sigma r$ and $\overline{u}(r) = y_o + \beta - \beta r$ is defined as

$$\text{Mag}(u) = \frac{1}{2}(\int_0^1 (\underline{u}(r) + \overline{u}(r) + x_0 + y_0) f(r) dr , \tag{1}$$

where the function f(r) is a non-negative and increasing function on [0,1],with f(0) = 0 ,f(1) = 1 and $\int_0^1 f(r)dr = \frac{1}{2}$.

Obviously function f(r) can be considered as a weighting function. In actual applications, function f(r) can be chosen according to the actual situation. The magnitude of a trapezoidal fuzzy number u which is defined by (1), synthetically reflects the information on every membership degree, and meaning of this magnitude is visual and natural. The resulting scalar value is used to rank the fuzzy numbers. In the other words Mag(u) is used to rank fuzzy numbers. The larger Mag(u) the larger fuzzy number.

The magnitude of the trapezoidal fuzzy number $\tilde{u}$ = (a, b, c, d) is given by $Mag(\overline{u}) = \frac{a+5b+5c+d}{12}$ or $Mag(u) = \frac{5}{12}(b+c) + \frac{1}{12}(a+d)$.

Let $\tilde{u}$ and $\tilde{v}$ be two trapezoidal fuzzy numbers. The ranking of $\tilde{u}$ and $\tilde{v}$ by the Mag(u) on E, the set of trapezoidal fuzzy numbers is defined as follows:

(i) $Mag(\tilde{u}) > Mag(\tilde{v})$ if and only if $\tilde{u} > \tilde{v}$;
(ii) $Mag(\tilde{u}) < Mag(\tilde{v})$ if and only if $\tilde{u} < \tilde{v}$ and
(iii) $Mag(\tilde{u}) = Mag(\tilde{v})$ if and only if $\tilde{u} = \tilde{v}$;

The ordering ≥ and ≤ between any two trapezoidal fuzzy numbers $\tilde{u}$ and $\tilde{v}$ are defined as follows:

(i) if $\tilde{u} \geq \tilde{v}$;if and only if $\tilde{u} > \tilde{v}$ or $\tilde{u} = \tilde{v}$ and
(ii) if $\tilde{u} \leq \tilde{v}$;if and only if $\tilde{u} < \tilde{v}$ or $\tilde{u} = \tilde{v}$.

The magnitude approach for ranking fuzzy numbers has some mathematical properties. It does not imply much computational effort and does not require a priori knowledge of the set of all alternatives. We also used comparative examples to illustrate the advantages of the proposed method.

## 2.4 Problem formulation

The balanced fuzzy transportation problem, in which a decision maker is uncertain about the precise values of transportation cost, availability and demand, may be formulated as follows:

$$minimize \sum_{i=1}^{p} \sum_{j=1}^{q} c_{ij} * x_{ij}$$

Subject to $\sum_{j=1}^{q} x_{ij} = \tilde{a}_i$, i = 1, 2, 3,………,p
$\sum_{i=1}^{p} x_{ij} = b_j$, j = 1,2,3,………,q
$\sum_{i=1}^{p} a_i = \sum_{j=1}^{q} b_j$

$X_{ij}$ is a non- negative trapezoidal fuzzy number,

Where

p = total number of sources
Q = total number of destinations
$a_i$ = the fuzzy availability of the product at $i^{th}$ source
$b_j$ = the fuzzy demand of the product at $j^{th}$ destination
$c_{ij}$ = the fuzzy transportation cost for unit quantity of the product from $i^{th}$ source to $j^{th}$ destination
$x_{ij}$ = the fuzzy quantity of the product that should be transported from $i^{th}$ source to $j^{th}$ destination to minimize the total fuzzy transportation cost.
$\sum_{i=1}^{p} a_i = 1$, total fuzzy availability of the product,
$\sum_{j=1}^{q} b_j = 1$,total fuzzy demand of the product
$\sum_{i=1}^{p} \sum_{j=1}^{q} c_{ij} * x_{ij} = 1$ total fuzzy transportation cost

If $\sum_{i=1}^{p} a_i = \sum_{j=1}^{q} b_j$ then the fuzzy transportation problem is said to be balanced fuzzy transportation problem, otherwise it is called unbalanced fuzzy transportation problem. Consider transportation with m fuzzy origin s (rows) and n fuzzy destinations (Columns) Let $C_{ij}$=[$C_{ij}^{(1)}$,$C_{ij}^{(2)}$,$C_{ij}^{(3)}$] be the cost of transporting one unit of the product from $i^{th}$ fuzzy origin to $j^{th}$ fuzzy destination $a_i$=[$a_i^{(1)}$,$a_i^{(2)}$,$a_i^{(3)}$] be the quantity of commodity available at fuzzy origin i $b_j$=[$b_j^{(1)}$,$b_j^{(2)}$,$b_j^{(3)}$] be the quantity of commodity requirement at fuzzy destination j. $X_{ij}$=[$X_{ij}^{1}$,$X_{ij}^{2}$,$X_{ij}^{3}$] is quantity transported from $i^{th}$ fuzzy origin to $j^{th}$ fuzzy destination.

# 3 Main Results

For finding the optimal solution in fuzzy environment for fuzzy transportation problem a new algorithm is proposed.

## 3.1 Algorithm for solving transportation problem by Monalisha's Approximation Method (MAM'S)

**Step 1.** Determine the cost table from the given problem.

(i) Examine whether total demand equals total demand/supply. If yes, go to step 2.
(ii) If not , introduce dummy row/column having all its cost elements as zero and supply/ demand as the (+ve) difference of supply and demand.

**Step 2.** Locate the smallest element in each row of the given cost matrix and then subtract the same from each element of that row.

**Step 3.** In the reduced matrix obtained in step 2, locate the smallest element of each column and then subtract the same from each element of that column.

**Step 4.** For each row of the transportation table identify the smallest and the next - to - smallest costs. Determine the difference between them for each row. Display them alongside the transportation table by enclosing them in parenthesis against the respective rows. Similarly compute the differences for each column.

**Step 5.** Identify the row or column with the largest difference among all the rows and columns. If a tie occurs, use any arbitrary tie breaking choice. Let the greatest difference correspond to $i^{th}$ row and let 0 be in the $i^{th}$ row. Allocate the maximum feasible amount $x_{ij}=\min(a_i,b_j)$ in the $(i, j)^{th}$ cell and cross off either the $i^{th}$ row or the $j^{th}$ column in the usual manner.

**Step 6.** Recompute the column and row differences for the reduced transportation table and go to step 5. Repeat the procedure until all the rim requirements (the various origin capacities and destination requirements are listed in the right most outer column and the bottom outer row respectively) are satisfied.

# 4 Numerical Example

Consider the fuzzy transportation problem.

The following table shows all the necessary information on the availability of supply to each warehouse, the requirement of each market and unit transportation cost (in Rs) from each warehouse to each market. Here cost value, supplies and demands are trapezoidal fuzzy numbers. Here FOi and FDi are Fuzzy Supply and Fuzzy Demand. The given problem is balanced transportation problem. There exists fuzzy initial basic feasible solution.

## 4.1 Example: 1

Let us solve the balanced fuzzy transportation problem for maximizing the profit,

| | $FD1$ | $FD2$ | $FD3$ | $FD4$ | Fuzzy available |
|---|---|---|---|---|---|
| $F01$ | (1,2,3,4) | (1,3,4,6) | (9,11,12,14) | (5,7,8,11) | (1,6,7,12) |
| $F02$ | (0,1,2,4) | (-1,0,1,2) | (5,6,7,8) | (0,1,2,3) | (0,1,2,3) |
| $FO3$ | (3,5,6,8) | (5,8,9,12) | (12,15,16,19) | (7,9,10,12) | (5,10,12,15) |
| Fuzzy requirement | (5,7,8,10) | (-1,5,6,10) | (1,3,4,6) | (1,2,3,4) | (6,17,21,30) |

By using method of magnitude for defuzzyfing the trapezoidal fuzzy numbers,

Mag(u) = $\frac{5}{12}(b+c)+\frac{1}{12}(a+d)$
R(1,2,3,4) = 2.5, R(1,3,4,6) =3.5 , R(9,11,12,14) =11.5,
R(5,7,8,11) = 7.5 R(1,6,7,12) = 6.5
R(0,1,2,4)= 1.5, R (-1,0,1,2)= 0.5, R (5,6,7,8)= 6.5,
R(0,1,2,3)= 1.5, R (0,1,2,3)= 1.5
R(3,5,6,8)=5.5,R(5,8,9,12)=8.5,R (12,15,16,19)= 16.5,
R(7,9,10,12)=9.5, R(5,10,12,15)=10.8
R(5,7,8,10)= 7.5 ,R (-1,5,6,10)=5.3 ,R (1,3,4,6) =3.5,
R (1,2,3,4)= 2.5,R (6,17,21,30)=18.8

We get the following

| | $FD1$ | $FD2$ | $FD3$ | $FD4$ | Fuzzy available |
|---|---|---|---|---|---|
| $F01$ | 2.5 | 3.5 | 11.5 | 7.5 | 6.5 |
| $F02$ | 1.5 | 0.5 | 6.5 | 1.5 | 1.5 |
| $FO3$ | 5.5 | 8.5 | 15.5 | 9.5 | 10.8 |
| Fuzzy requirement | 7.5 | 5.3 | 3.5 | 2.5 | 18.8 |

By using the above new algorithm for solving the transportation problem we get the following allocations.

**Step 1.** Determine the cost table from the given problem. Here total demand equals total demand, go to step 2.

| | $FD1$ | $FD2$ | $FD3$ | $FD4$ | Fuzzy available |
|---|---|---|---|---|---|
| $F01$ | 2.5 | 3.5 | 11.5 | 7.5 | 6.5 |
| $F02$ | 1.5 | 0.5 | 6.5 | 1.5 | 1.5 |
| $FO3$ | 5.5 | 8.5 | 15.5 | 9.5 | 10.8 |
| Fuzzy requirement | 7.5 | 5.3 | 3.5 | 2.5 | 18.8 |

**Step 2.** Locating the smallest element in each row of the given cost matrix and then Subtracting the same from each element of that row.

| | $FD1$ | $FD2$ | $FD3$ | $FD4$ | Fuzzy available |
|---|---|---|---|---|---|
| $F01$ | 0 | 1 | 9 | 5 | 6.5 |
| $F02$ | 1 | 0 | 6 | 1 | 1.5 |
| $FO3$ | 0 | 3 | 10 | 4 | 10.8 |
| Fuzzy requirement | 7.5 | 5.3 | 3.5 | 2.5 | 18.8 |

**Step 3.** In the reduced matrix obtained in step 2, locating the smallest element of each column and then subtracting the same from each element of that column.

| | $FD1$ | $FD2$ | $FD3$ | $FD4$ | Fuzzy available |
|---|---|---|---|---|---|
| $F01$ | 0 | 1 | 3 | 4 | 6.5 |
| $F02$ | 1 | 0 | 0 | 0 | 1.5 |
| $FO3$ | 0 | 3 | 4 | 3 | 10.8 |
| Fuzzy requirement | 7.5 | 5.3 | 3.5 | 2.5 | 18.8 |

**Step 4.** For each row of the transportation table identifying the smallest and the next - to -smallest costs. Determining the difference between them for each row in the transportation table. Displaying them alongside the transportation table by enclosing them in parenthesis against the respective rows of the transportation table. Similarly computing the differences for each column of the transportation table.

| | $FD1$ | $FD2$ | $FD3$ | $FD4$ | Fuzzy available | Penalty |
|---|---|---|---|---|---|---|
| $F01$ | 0 | 1 | 3 | 4 | 6.5 | (1) |
| $F02$ | 1 | 0 | 0 [1.5] | 0 | 1.5 | (0) |
| $FO3$ | 0 | 3 | 4 | 3 | 10.8 | (3) |
| Fuzzy requirement | 7.5 | 5.3 | 3.5 | 2.5 | 18.8 | |
| Penalty | (0) | (1) | (3) | (3) | | |

**Step 5.** Identifying the row or column with the largest difference among all the rows and columns. If a tie occurs, use any arbitrary tiebreaking choice. Let the greatest difference correspond to i$^{th}$ row and let 0 be in the i$^{th}$ row. Allocating the maximum feasible amount $x_{ij}$ = min $(a_i,b_j)$ in the (i, j)$^{th}$ cell and cross off either the i$^{th}$ row or the j$^{th}$ column in the usual manner.

| | $FD1$ | $FD2$ | $FD3$ | $FD4$ | Fuzzy available | Penalty |
|---|---|---|---|---|---|---|
| $F01$ | 0 | 0 [5.3] | 0 | 1 | 6.5 | (0) |
| $FO3$ | 0 | 2 | 1 | 0 | 10.8 | (0) |
| Fuzzy requirement | 7.5 | 5.3 | 2 | 2.5 | 18.8 | |
| penalty | (0) | (2) | (1) | (1) | | |

**Step 6.** Recomputing the column and row differences for the reduced transportation table and go to step 5. Repeating the procedure until all the rim requirements (the various origin capacities and destination requirements are listed in the right most outer column and the bottom outer row respectively) are satisfied.

| | $FD1$ | $FD3$ | $FD4$ | Fuzzy available | Penalty |
|---|---|---|---|---|---|
| $FO1$ | 0 | 0 [1.2] | 1 | 1.2 | (0) |
| $FO3$ | 0 | 1 | 0 | 10.8 | (0) |
| Fuzzy requirement | 7.5 | 2 | 2.5 | 18.8 | |
| Penalty | (0) | (1) | (1) | | |

| | $FD1$ | $FD3$ | $FD4$ | Fuzzy available | penalty |
|---|---|---|---|---|---|
| $FO3$ | 0 [7.5] | 1 [0.8] | 0 [2.5] | 10.8 | (1) |
| Fuzzy requirement | 7.5 | 0.8 | 2.5 | 18.8 | |

## 4.2 Optimal solution

| | $FD1$ | $FD2$ | $FD3$ | $FD4$ | **Fuzzy Available** |
|---|---|---|---|---|---|
| $F01$ | 2.5 | 3.5 [5.3] | 11.5 [1.2] | 7.5 | 6.5 |
| $F02$ | 1.5 | 0.5 | 6.5 [1.5] | 1.5 | 1.5 |
| $FO3$ | 5.5 [7.5] | 8.5 | 15.5 [0.8] | 9.5 [2.5] | 10.8 |
| Fuzzy requirement | 7.5 | 5.3 | 3.5 | 2.5 | 18.8 |

The above table satisfies the rim conditions with (m+n-1) non negative allocations at independent positions.

Thus the optimal allocation is: $x_{12}$ = 5.5, $x_{13}$ =1.2, $x_{31}$ = 7.5 ,$x_{23}$= 1.5, $x_{33}$ =0.8 and $x_{34}$ =2.5.

The transportation cost according to the MAM's method is:

Total Cost = (3.5x5.5)+(11.5 x1.2)+(6.5 x1.5)+(5.5 x7.5)+(15.5 x0.8)+(9.5 x 2.5)=119.5

The result obtained from MAM's method with magnitude of ranking is compared with the exisisting results namely (i) Fuzzy Zero Method (ii) Russell's Method,(iii) Fuzzy VAM and,(iv)MODI Method.

Comparison Table is given bellow.

| **Example reference** | **Fuzzy zero method [22]** | **Russell's [21]** | **Fuzzy VAM [21]** | **Optimum solution (MODI) [21]** | **Monalisha's Approximation Method (MAM'S)** |
|---|---|---|---|---|---|
| 1 | 132.17 | 183 | 122.5 | 121 | 119.5 |

**Example: 2**

| | $FD1$ | $FD2$ | $FD3$ | $FD4$ | **Fuzzy available** |
|---|---|---|---|---|---|
| $F01$ | (-4,0,4,16) | (-4,0,4,16) | (-4,0,4,16) | (--2,0,2,8) | (0,4,8,12) |
| $F02$ | (8,16,24,32) | (8,14,18,24) | (4,8,12,16) | (2,6,10,14) | (4,8,18,26) |
| $FO3$ | (4,8,18,26) | (0,12,16,20) | (0,12,16,20) | (8,14,18,24) | (4,8,12,16) |
| Fuzzy requirement | (2,6,10,14) | (2,2,8,12) | (2,6,10,14) | (2,6,10,14) | **(8,20,38,54)** |

Determine the cost table from the given problem. Here total demand equals total demand.

| | $FD1$ | $FD2$ | $FD3$ | $FD4$ | **Fuzzy available** |
|---|---|---|---|---|---|
| $F01$ | 2.6 | 2.6 | 2.6 | 1.3 | 6 |
| $F02$ | 20 | 16 | 10 | 8 | 13.3 |
| $FO3$ | 13.3 | 13.3 | 13.3 | 16 | 10 |
| Fuzzy requirement | 8 | 5.3 | 8 | 8 | **29.3** |

By proceeding above the optimal solution is given by

| | $FD1$ | $FD2$ | $FD3$ | $FD4$ | **Fuzzy available** |
|---|---|---|---|---|---|
| $F01$ | 2.6 [6] | 2.6 | 2.6 | 1.3 | 6 |
| $F02$ | 20 | 16 | 10 [5.3] | 8 [8] | 13.3 |
| $FO3$ | 13.3 [2] | 13.3 [5.3] | 13.3 [2.7] | 16 | 10 |
| Fuzzy requirement | 8 | 5.3 | 8 | 8 | **29.3** |

The above table satisfies the rim conditions with (m+n-1) non negative allocations at independent positions.

Thus the optimal allocation is: $x_{11} = 6$, $x_{23} = 5.3$, $x_{24} = 8$, $x_{31} = 2$, $x_{32} = 5.3$ and $x_{33} = 2.7$.

The transportation cost according to the MAM's method is:

Total Cost = (8x8)+(10x5.3)+(13.3x2.7)+(13.3x5.3)+(13.3x2)+(2.6x6)=265.6

The result obtained from MAM's method with magnitude of ranking is compared with the exisisting results namely (i) Fuzzy Zero Method (ii) Fuzzy U-V distribution Method,(iii) Fuzzy VAM and,(iv)MODI Method. Comparison Table is given bellow.

| Example | New Fuzzy method [20] | Fuzzy U-V distribution method [12] | Fuzzy VAM [21] | Optimum solution (MODI) [21] | Monalisha's Approximation Method (MAM'S) |
|---|---|---|---|---|---|
| 2 | 270.2 | 269.5 | 272 | 267.2 | 265.6 |

## 5 Conclusion

This technique can be tried for solving problems like balanced and unbalanced assignment problems, transshipment, project scheduling problems, network flow problems etc. This research work can be extended for pentagonal, hexagonal and octagonal fuzzy numbers. Mat Lab Coding can be generated and implemented in real life time problems.

## Competing Interests

Authors have declared that no competing interests exist.

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