MID - WIDTH METOD FOR SOLVING FOR REAL INTERVAL INTEGER TRIANGULAR FUZZY TRANSPORTATON PROBLEM

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Abstract:

In this research paper, a new method is applied on mid-width value and triangular fuzzy transportation problem. this method was developed on two independent transportation problem. The method of a numerical examples are solved and applying Vogel;s approximation method, modi method and the obtained results are discussed.

Keywords:
Fuzzy transportation problem, mid – width value , triangular fuzzy number , optimal interval solution.

1. Introduction:

Transportation problem is one of the most best known triangular fuzzy transportation problem. The mid – width method is proposed to two sub problems namely, upper and lower level. Firstly , mid – value upper level problem is solved and secondly half width value lower level problem solved. So fully fuzzy integer transportation problem method is needed here. To solve the interval transportation problem is using two method is needed , one is Vogel;s approximation method and the another one is modi method.

We refer in this paper : - L.A . Zadeh , Fuzzy sets, information & control & Althada Ramesh Babu, B. Rama Bhupal reddy, Feasibility of fuzzy New method in finding initial Basic feasible solution for a fuzzy transportation problem . S. Solaiappan , Dr. K . Jeyaraman , A new optimal solution method for trapezoid fuzzy transportation problem. Solution of fuzzy transportation problem using improved VAM with Robust Ranking technique. Optimization of trapezoidal balanced transportation problem using zero – suffix and robust ranking methodology with fuzzy demand and fuzzy supply method.

Dr . K . Kalaiarasi , Dr. M . Arunadevi , S. Sindhu ,. Optimization of fuzzy assignment model with triangular fuzzy number using robust ranking techniques . Optimization of fuzzy EOQ model with unit time depended constant demand and shortages . A fuzzy transportation algorithum. Fuzzy sets sys. Mathur , N. Srivastara, P . K . Paul . A . Algorithum for solving fuzzy transportation .Bellman , R. E, Zadeh , L . A , Decision making in a fuzzy environment . Pandian , P. Nadarajan, G . A new algorithum for finding a fuzzy optimal solution for fuzzy transportation problem . Liu, S.T , Kao, C, solving fuzzy transportation problem based on extension principle. Eur. J. Oper res Chans. S , Kuchta , D . Fuzzy integer problem fuzzy sets sys Cuena mira . Ja. Miguel Garcia . F, On the parametric decomposition theorem in multi objective optimization . Chans. S , Kuchta , D . A concept of solution of the transportation problem with fuzzy cost coefficient , Fuzzy sets sys .

This paper is structure as follows ; In Section 2 recal some basic definitions and results were related to real interval Fuzzy numbers are presented . Section 3 a new method namely mid width method & Vogel's Approximation method , MODI method . Section 4 a new method namely mid width method is used for solving fully interval integer transportation problem proposed and a numerical example is given for understanding the solution procedure of the proposed method . The developed new method is extended to fully fuzzy transportation problem and Vogel's Approximation method , MODI method . Section 5 finally the conclusion is given in Section 6.

2. Basic Definitions:

In this section , we recall some definitions and results that we need in the sequel.

2.1 Definition :-

Let x = [x, y] be in z . Then x is said to be integer if x and y are integers.
Now, the mid – value of an interval
Let x = [x, y] be in z . Then x is said to be integer if x and y are integers.
Now, the mid – value of an interval

x = [x, y] , m (x) is defined as m (x) = $\frac{x+y}{2}$ and

the half width – value of an interval x = [x, y] , w(x) is defined as w(x) = $\frac{y-x}{2}$

2.2 Result:-

If m (x) = m_1 & w (x) = w_1 , then
x = [$m_1 - w_1$, $m_1 + w_1$]

2.3 Definition :-

Let x be a classical set and λx (a) be a membership function from x to [0,1] .
A fuzzy set x^* with the membership

$$x^* = \{(a , \lambda x(a)) : a \in x \ \& \ \lambda x (a) \in [0, 1]\}$$

2.4 Definition :-

A fuzzy number $\tilde{x}$ is a triangular fuzzy number denoted by (x_1, x_2, x_3) where x_1, x_2 and x_3 are real numbers and its membership function $\lambda_{\tilde{x}}(a)$ is given below

$\lambda_{\tilde{x}}(a) = 0$ if $a \le x$, $\lambda_{\tilde{x}}(a) = \frac{(a-x_1)}{(x_2-x_1)}$ if $x_1 \le a \le x_2$

$\lambda_{\tilde{x}}(a) = \frac{(x_3-a)}{(x_3-x_2)}$ if $x_2 \le a \le x_3$ and $\lambda_{\tilde{x}}(a) = 0$ if $a \ge x_3$

Let E (R) be a set of all triangular fuzzy numbers over R, a set real numbers.

2.5 definition :-

Let $\tilde{x}$ = (x_1, x_2, x_3) and $\tilde{y}$ = (y_1, y_2, y_3) be in E (R) then

(i) $\tilde{x} \oplus \tilde{y} = (x_1 + y_1 , x_2 + y_2 , x_3 + y_3)$

(ii) $\tilde{x} \otimes \tilde{y} = (s_1, s_2, s_3)$

where s_1 = minimum { $x_1 y_1$, $x_1 y_3$, $y_3 x_1$, $x_3 y_3$ }
$s_2 = x_2 y_2$ and
s_3 = { $x_1 y_1$, $x_1 y_3$, $x_3 y_1$, $x_3 y_3$ }

3. Mathematical formulation :-

3.1 Mid – width method

We, now introduce a new algorithm namely, mid – width method for finding an optional solution to a fully interval integer transportation problem (p) .

Step 1. Construct two independent transportation problems called, mid – value transportation problem (M) and half – width transportation problem (W) from the given problem (p).

Step 2. Solve the problem (M) using a transportation algorithm. Let { m_g^* , for all i and j} be an optional solution of the problem (M) .

Step 3. Solve the problem (W) using any transportation algorithm. Let { m_g^* , for all i and j} be an optional solution of the problem (W).

Step 4. The optional solution of the given problem (p) is {[$m_g^* - w_g^*$, $m_g^* + w_g^*$] , for all i and j} if [$m_g^* - w_g^*$, $m_g^* + w_g^*$] , for all i and j are integers (By the theorem 3.1)

3.2 Fully interval integer transportation problem:-

Consider the following fully interval integer transportation problem (p) :-

(p) Minimize A = [a_1 , a_2]

$$= \sum_{i21}^{m} , \sum_{j21}^{n} \quad [E_{ij} , F_{ij}] \otimes [U_{ij} , V_{ij}]$$

Subject to

$$\sum_{j21}^{n} \; [U_{ij} , V_{ij}] = [b_i , q_i] \qquad i = 1, 2, ... m$$

$$\sum_{i21}^{n} \; [U_{ij} , V_{ij}] = [c_i , s_i] \qquad j = 1, 2, ... n$$

$U_{ij} \geq 0$, $V_{ij} \geq 0$, i = 1, 2, ... m and j = 1, 2, ... n and are integers.

Where E_{ij} , and d_{ij} are positive real numbers for all i and j , b_i and q_i are positive real numbers for all i and c_i and are positive real numbers for all j. A triangular fuzzy number (a , b, c) can be represented as an interval number as follows.

$$[x, y, z] = [x + (y - x) \lambda , z - (z- y) \lambda] , 0 \leq \lambda \leq 1.$$

3.3 Vogel's Approximation Method (VAM)

The Vogel's approximation method is preferred for obtaining the initial basic feasible solution because the obtained solution is either optional or very close to optimal solution. Hence , it takes less time to reach the final solution.

Various **steps** involved in Vogel's approximation method are as follows :-

Step 1: Identify the smallest and next – to – smallest cost in each row of the transportation table. For each row calculate the differences between them which are known as **'Penalties'.** Write the penalties of each row and column alongside the transportation table against the respective rows and columns.

Step 2: Among all the rows and columns identify that row and column which has the largest penalty. Select the cell with least cost in this identified row or column and allocate the feasible number of units to this cell. That row or column is eliminated whose demand and supply requirements are satisfied. If there is any tie in the largest penalties for two or more rows then one selects either of them.

Step 3: For the reduce transportation table repeat the step 1 to calculate the column and row penalties and then go to step 2. Repeat the process until all the requirements are satisfied.

3.4 MODI Method

Step 1 : Add a column on the right hand side and a row in the bottom of the transportation table titled u_i and v_i respectively.

Step 2: In this step following sub steps are performed:

i) For the rows / columns which have maximum number of allocations, select the value of u_i and v_i equal to zero. Normally, the first row has allocated the value 0 (zero) i.e $u_i = 0$

ii) In the first row, consider every occupied cell individually and allocate the column value v_j . When the occupied cell is in the j^{th} column of the row, which is such that the sum of the row and the column values is equal to the unit cost value in the occupied cell, consider these values and pick other occupied cells one by one and find the appropriate values of u_i's , taking in each case $u_i + v_j = c_{ij}$. Thus, if u_i is the row value of the i^{th} row , v_j is the column value of the j^{th} column and c_{ij} is the unit cost of the cell in the i^{th} row and j^{th} column , then the following equation gives the row and column values: $u_i + v_j = c_{ij}$.

Step 3: After finding all values of u_i and v_j , calculate for each unoccupied cell $\Delta_{ij} = c_{ij} - (u_i + v_j)$, where Δ_{ij}'s represent the opportunity costs of various cells. After calculating the opportunity costs follow the same process which is performed in the stepping stone method. The solution is called an optimal solution if all the empty cells have positive opportunity. If values of Δ_{ij}'s are negative then the given solution is not an optimal solution and if one or more Δ_{ij}'s values are negative i. e , $\Delta_{ij} < 0$, then choose the cell which has the largest opportunity cost value and form a closed loop. According to the procedure of this method transfer the units along the route. Test the result solution for optimality condition and improve if required . The process is repeated until an optimal solution is obtained.

Hence the condition for the solution of being optimal solution is : $c_{ij} - (u_i + v_j) \geq 0$.

4. Numerical Examples:-

4.1 A pharmaceutical company produces a product in its three factories F_1, F_2 and F_3 three factories. Determine a shipping plan for the company , from three factories to four destination such that the total shipping cost should be minimum using the following numerical data obtained from the company.

The minimum supply F_1, F_2, F_3 are 3, 6 , 5 respectively the maximum supply F_1, F_2, F_3 11, 12, 11 respectively. The minimum demand D_1, D_2, D_3, D_4 are (4, 2, 6, 2). The maximum demand D_1, D_2, D_3, D_4 are (8, 6, 12, 8) respectively.

	D_1	D_2	D_3	D_4
F_1	[3, 6]	[4, 6]	[6, 8]	[1, 3]
F_2	[1, 2]	[1, 5]	[5, 11]	[3, 8]
F_3	[7, 11]	[3, 5]	[7, 9]	[5, 9]

Solution ; -

Step : - 1

	D_1	D_2	D_3	D_4	Supply
F_1	[3, 6]	[4, 6]	[6, 8]	[1, 3]	[3, 11]
F_2	[1, 2]	[1, 5]	[5, 11]	[3, 8]	[6, 12]
F_3	[7, 11]	[3, 5]	[7, 9]	[5, 9]	[5, 11]
demand	[4, 8]	[2, 6]	[6, 12]	[2, 8]	[14, 34]

Step :- 2

The mid – value of an interval X = [x , y] , M (X) defined as

$$M(X) = \frac{x+y}{2}$$

$$[3, 6] = \frac{3+6}{2} = \frac{9}{2} = 4.5$$

	D_1	D_2	D_3	D_4	Supply
F_1	4.5	5	7	2	7
F_2	1.5	3	8	5.5	9
F_3	9	4	8	7	8
demand	6	4	9	5	24

Apply Vogel's Approximation Method (VAM)

4.5	5	7	2 5	7	2.5
1.5	3	8	5.5	9	1.5
9	4	8	7	8	3
6	4	9	5		
3	1	1	3.5		

$x_{14} = 5$

4.5	5	7	2	0.5
1.5	3	8	9	1.5
9	4 4	8	4	4
6	4	9		
3	1	1		

$x_{32} = 4$

4.5	7	2	2.5
1.5 6	8	3	6.5
9	8	4	1
6	9		
3	1		

$x_{21} = 6$

7	2	7
8	3	8
8 4	4	8
5		
1		

$x_{33} = 4$

7	2	7
8 3	3	8
2		
1		

$x_{28} = 3$

7 2	2
2	

$x_{13} = 2$

4.5	5	7 2	2 5
1.5 6	3	8 3	5.5
9	4	8 4	7

Transportation cost is

$$z = (7 \times 2) + (2 \times 5) + (1.5 \times 6) + (8 \times 3) + (4 \times 4) + (8 \times 4)$$
$$= 14 + 10 + 9 + 24 + 16 + 32$$
$$z = 105$$

The initial transportation cost is z = 105

MODI Method:-

4.5	5	7 2	2 5
1.5 6 $-\theta$	3	8 3 θ	5.5
9 θ	4 4	8 $-\theta$ 4	7

$\theta = \min\{-\theta\}$

$= \min\{6, 4\}$

$\boxed{\theta = 4}$

Step 3:-

4.5	5	7 2	2 5
1.5 2	3	8 5	5.5
9 4	4 4	8	7

Total transportation cost

z = 7 (2) + 2 (5) + 1.5 (2) + 8 (5) + 9 (4) + 4 (4)

. = 14 + 10 + 3 + 40 + 36 + 16

∴ Total transportation cost z = 119

Step 4 :-

The half width - value of an interval X = [x , y] , w(X) is defined as

$$w(X) = \frac{y-x}{2} \Rightarrow \frac{\max - \min}{2}$$

1.5	1	1	1	4
0.5	2	3	2.5	3
2	1	1	2	3
2	2	3	3	

Vogel's method:-

1.5	1	1 3	1	1	0.5
0.5	2	8	2.5	3	1.5
2	1	1	2	3	1
2	2	5	3		
1	1	2	1		

$\boxed{x_{13} = 3}$

1.5	1	1	1	0.5
0.5 2	2	2.5	1	1.5
2	1	2	3	1
2	2	3		
1	1	1		

$\boxed{x_{21} = 2}$

1 1	1	1	1
2	2.5	1	0.5
1	2	3	1
1	3		
1	1		

$\boxed{x_{12} = 1}$

2	2.5	1	0.5
1 1	2	3	1
1	3		
1	0.5		

$\boxed{x_{32} = 1}$

2.5	1
2 2	2
3	

$\boxed{x_{34} = 2}$

2.5 1	1
1	

$\boxed{x_{24} = 1}$

15	1 1	1 3	1
0.5 2	2	3	2.5 1
2	1 1	1 2	2

Transportation cost is

$z = (1\times 1) + (1\times 3) + (0.5\times 2) + (2.5\times 1) + (1\times 1) + (1\times 2)$

$= 1 + 3 + 1 + 2.5 + 1 + 2$

$z = 10.5$.

MODI Method

1.5	1 1 -θ	1 θ 3	1
0.5 2	2	3	2.5 1
2	1 1 θ	1 -θ 2	2

$\theta = \min\{1, 2\}$

$\theta = 1$

1.5	1	1 4	1
0.5 2	2	3	2.5 1
2	1 2	1 1	2

Transportation is

$= 1\times 4 + 0.5\times 2 + 2.5\times 1 + 1\times 2 + 1\times 1$

$= 4 + 2 + 1 + 1 + 2 + 2.5$

$= 10.5$

∴ The total transportation cost $z = 10.5$

4.2 Example :-

A pharmaceutical company has three plants at three locations v_1 , v_2 , v_3 which supply to three warehouse u_1 , u_2 , u_3 monthly plant capacities (3, 6, 9) , (4, 8, 12) and (2, 4, 6) triangular fuzzy units respectively, monthly warehouse requirements are (6, 8, 10) , (0, 4, 8) and (3, 6, 9) triangular fuzzy units respectively. Determine an optimal distribution for the company in order to minimize the total shipping cost given that the unit transportation costs in triangular fuzzy parameters are

	u_1	u_2	u_3
v_1	(1, 6, 11)	(2, 3, 4)	(4, 5, 6)
v_2	(0, 1, 2)	(5, 6, 7)	(1, 5, 9)
v_3	(1, 2, 3)	(4, 7, 10)	(0, 1, 2)

Solution :-

	u_1	u_2	u_3	supply
v_1	(1, 6, 11)	(2, 3, 4)	(4, 5, 6)	(3, 6, 9)
v_2	(0, 1, 2)	(5, 6, 7)	(1, 5, 9)	(4, 8, 12)
v_3	(1, 2, 3)	(4, 7, 10)	(0, 1, 2)	(2, 4, 6)
Demand	(6, 8, 10)	(0, 4, 8)	(3, 6, 9)	(9, 18, 27)

Interval from of the given fully fuzzy transportation problem :-

$[x, y, z] = [x + (y - x)\lambda, z - (z - y)\lambda] ; 0 \le \lambda \le 1$

Applying the table values:-

$(1, 6, 11) = (1 + (6 - 1)\lambda, 11 - (11 - 6)\lambda)$

$(1, 6, 11) = (1 + 5\lambda, 11 - 5\lambda)$

	u_1	u_2	u_3	supply
v_1	$(1 + 5\lambda, 11 - 5\lambda)$	$(2 + \lambda, 4 - \lambda)$	$(4 + \lambda, 6 - \lambda)$	$(3 + 3\lambda, 9 - 3\lambda)$
v_2	$(\lambda, 2 - \lambda)$	$(5 + \lambda, 7 - \lambda)$	$(1 + 4\lambda, 9 - 4\lambda)$	$(4 + 4\lambda, 12 - 4\lambda)$
v_3	$(1 + \lambda, 3 - \lambda)$	$(4 + 3\lambda, 10 - 3\lambda)$	$(\lambda, 2 - \lambda)$	$(2 + 2\lambda, 6 - 2\lambda)$
Demand	$(6 + 2\lambda, 0 - 2\lambda)$	$(0 + 4\lambda, 8 - 4\lambda)$	$(3 + 3\lambda, 9 - 3\lambda)$	$(9 + 9\lambda, 27 - 9\lambda)$

Mid value transportation (M) of the problem

$$M(X) = \frac{x+y}{2} \Rightarrow \frac{1+5\lambda+11-5\lambda}{2} = \frac{12}{2} = 6$$

	u_1	u_2	u_3	supply
v_1	6	3	5	6
v_2	2	6	5	8
v_3	2	7	2	4
Demand	8	4	6	18

Applying Vogel's Approximation method :-

6	3 4	5	6	2
2	6	5	8	3
2	7	2	4	0
8	6	4		
0	3	3		

$x_{12} = 4$

6	5	2	1
2	5	8	3
2	2 4	4	0
8	6		
0	3		

$x_{33} = 4$

6	5	2	0.5
2 8	5	8	1
8	2		
4	0		

$x_{21} = 8$

5 2	1
2	

$x_{13} = 2$

6	3 4	4 2
2 8	6	5
2	7 1	2 4

The initial transportation cost is

$$z = 3 \times 4 + 4 \times 2 + 2 \times 8 + 2 \times 4$$

$= 12 + 8 + 16 + + 8$

$\boxed{z = 44}$

Applying MODI method

6	3 4 - θ	5 θ 2
2 8	6	5
2	7 θ	2 -θ 4

θ = min {2, 4}
= min {2}
θ = {2}

6	3 2	5 4
2 8	6	5
2	7 2	2 2

The total transportation cost is

$$z^* = 3 \times 2 + 5 \times 4 + 2 \times 8 + 7 \times 2 + 2 \times 2$$
$$= 6 + 20 + 16 + 14 + 4$$
$$z^* = 60$$

Step :-

Applying Half – width transportation problem

$$W(x) = \frac{y-x}{2}$$

$5-5\lambda$	$1-\lambda$ $3-3\lambda$	$1-\lambda$	$3-3\lambda$	0
$1-\lambda$	$4-4\lambda$	$1-\lambda$	$4-4\lambda$	0
$1-\lambda$	$3-3\lambda$	$1-\lambda$	$2-2\lambda$	0
$2-2\lambda$	$4-4\lambda$	$3-3\lambda$		
0	$2-2\lambda$	0		

$\boxed{x_{12} = 3-3\lambda}$

$1-\lambda$	$4-4\lambda$	$1-\lambda$	$4-4\lambda$	0
$1-\lambda$	$3-3\lambda$ $1-\lambda$	$1-\lambda$	$2-2\lambda$	0
$2-2\lambda$	$1-\lambda$	$3-3\lambda$		
0	$1-\lambda$	0		

$\boxed{x_{32} = 1-\lambda}$

$1-\lambda$ $2-2\lambda$	$1-\lambda$	$4-4\lambda$	0
$1-\lambda$	$1-\lambda$	$1-\lambda$	0
$2-2\lambda$	$3-3\lambda$		

0 0 $\boxed{x_{21} = 2-2\lambda}$

$1-\lambda$	$2-2\lambda$
$1-\lambda$ $1-\lambda$	$1-\lambda$
$3-3\lambda$	

$\boxed{x_{33} = 1-\lambda}$

$1-\lambda$ $2-2\lambda$	$2-2\lambda$
$2-2\lambda$	

$\boxed{x_{23} = 2-2\lambda}$

$5-5\lambda$	$1-\lambda$ $3-3\lambda$	$1-\lambda$
$1-\lambda$ $2-2\lambda$	$4-4\lambda$	$1-\lambda$ $2-2\lambda$
$1-\lambda$	$3-3\lambda$ $1-\lambda$	$1-\lambda$ $1-\lambda$

The initial transportation cost is

$$z = (1-\lambda)(3-3\lambda) + (1-\lambda)(2-2\lambda) + (1-\lambda)(2-2\lambda) + (3-3\lambda)(1-\lambda) + (1-\lambda)(1-\lambda)$$
$$= 3-3\lambda-3\lambda+3\lambda^2+2-2\lambda-2\lambda+2\lambda^2+2-2\lambda-2\lambda+2\lambda^2+3-3\lambda-3\lambda+3\lambda^2+1-\lambda-\lambda+\lambda^2$$
$$z = 11\lambda^2+22\lambda+11$$
$$z = \lambda^2-2\lambda+1$$
$$\therefore (\lambda-1)(\lambda-1)$$
$$\Rightarrow \boxed{\lambda = 1}$$

Applying MODI method

$5-5\lambda$	$1-\lambda$ $3-3\lambda$ $-\theta$	$1-\lambda$ θ
$1-\lambda$ $2-2\lambda$	$4-4\lambda$	$1-\lambda$ $2-2\lambda$
$1-\lambda$	$3-3\lambda$ θ $1-\lambda$	$1-\lambda$ $-\theta$ $1-\lambda$

$$\theta = \min\{3-3\lambda, 1-\lambda\}$$
$$= \min\{1-\lambda\}$$
$$\theta = 1-\lambda$$

$5-5\lambda$	$1-\lambda$ $2-2\lambda$	$1-\lambda$ $1-\lambda$
$1-\lambda$ $2-2\lambda$	$4-4\lambda$	$1-\lambda$ $2-2\lambda$
$1-\lambda$	$3-3\lambda$ $2-2\lambda$	$1-\lambda$

$z = (1-\lambda)(2-2\lambda) + (1-\lambda)(1-\lambda) + (1-\lambda)(2-2\lambda) + (1-\lambda)(2-2\lambda) + (3-3\lambda)(2-2\lambda)$
$= 2 - 2\lambda + 2 + 2\lambda^2 + 1 - \lambda - \lambda + \lambda^2 + 2 - 2\lambda - 2\lambda + 2\lambda^2 + 2 - 2\lambda - 2\lambda + 2\lambda^2 + 6 - 6\lambda - 6\lambda + 6\lambda^2$
$z = 11\lambda^2 - 22\lambda + 11$
$z = \lambda^2 - 2\lambda + 1$
$= (1-\lambda)(1-\lambda)$
$\boxed{\lambda = 1}$

5. Conclusion :-

The proposed mid width method the optimal value for fuzzy transportation problem, that gives the better results than Vogel's Approximation method and MODI method.

Reference :-

(1) . L.A . Zadeh , Fuzzy sets, information & control, 8, 338 – 353.
(2) . Althada Ramesh Babu, B. Rama Bhupal reddy, Feasibility of fuzzy New method in finding initial Basic feasible solution for a fuzzy transportation problem Vol. 10 (1) , 43 – 54 . 2019.
(3) . S. Solaiappan , Dr. K . Jeyaraman , A new optimal solution method for trapezoid fuzzy transportation problem.
(4). Surjeet Singh Chauhan & Nidhi Joshi , Solution of fuzzy transportation problem using improved VAM with Roubast Ranking technique Volu 82 - No 15 – Nov 13.
(5) Dr. K . Kalaiarasi , Dr . M . Arunadevi , S . Sindhu 2014. Optimization of trapezoidal balanced transportation problem using zero – suffix and robust ranking methodology with fuzzy demand and fuzzy supply method. 2 (2) , 15 – 19
(6) . Dr . K . Kalaiarasi , Dr. M . Arunadevi , S. Sindhu , 2014. Optimization of fuzzy assignment model with triangular fuzzy number using robust ranking techniques . 3, 2848 – 7968.
(7) . Dr. K. Kalaiarasi , Dr . M . Sumathi, S . Daisy 2018. Optimization of fuzzy EOQ model with unit time depended constrant demand and shortages 9 (11) , 1520 – 1527.
(8) . oheigeartaigh , M , 1982. A fuzzy transportation algorithum. Fuzzy sets sys. 8 (3) , 235 – 243.
(9) . Mathur , N. Srivastara, P . K . Paul . A – 2018. Algorithum for solving fuzzy transportation Int , J. Math Oper Res , 12 (2) , 190 – 219.
(10) .Bellman , R. E, Zadeh , L . A , 1970. Decision making in a fuzzy environment ,Manage Sci. 17 (4) , p., b 141.
(11) . Pandian , P. Nadarajan, G. 2010 . A new algorithum for finding a fuzzy optimal solution for fuzzy transportation problem . Appl . math Sci 4 (2) , 79 – 90.

(12) . Liu, S.T , Kao, C, 2004 , solving fuzzy transportation problem based on extension principle. Eur. J. Oper res 153 (3) , 661 – 674.
(13). Chans. S , Kuchta , D . 1998. Fuzzy integer problem fuzzy sets sys 98 (3), 291 – 298.
(14). Cuena mira . Ja. Miguel Garcia . F, On the parametric decomposition theorem in multi objective optimization . J optim theor Appl 2017 , 174: 945 – 953.
(15). Chans. S , Kuchta , D . A concept of solution of the transportation problem with fuzzy cost coefficient , Fuzzy sets sys 1996: 82 ; 299 – 305.
(16). Klir. GJ. Yuan B. Fuzzy sets and fuzzy logic theory and applications New Jersey prentice – Hall ; 2008.
(17) Palmer AZ, Vladimirsky A . Optimal stopping with probabilistic constraint . J optim theor. Appl 2017; 175 : 795 – 817.
(18). Moore R E . method and applications of interval analysis , Philadelphia, PA ; SLAM ; 1979.
(19) . Tong S. interval number and fuzzy number linear programming . Fuzzy set system 1994 ; 66 ; 301 – 6.
(20) . Zadeh , I.A . Fuzzy sets. Inf . contr 1995 ; 8 ; 338 – 53.

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