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A New Method for Solving Fuzzy Transportation Problem using Dodecagonal Fuzzy Numbers

M.Thamaraiselvi[1] | B.Srividhya[2]

[1]PG Scholar, Department of Mathematics, Dr.SNS Rajalakshmi College of Arts and Science, Coimbatore, Tamilnadu, India.
[2]Professor, Department of Mathematics, Dr.SNS Rajalakshmi College of Arts and Science, Coimbatore, Tamilnadu, India.

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ABSTRACT

In this paper, proposed to solve the Fuzzy Transportation Problem using Dodecagonal Fuzzy number. The transportation problem is solved using proposed Ranking Method of Dodecagonal Fuzzy Number. The Proposed transportation is formulated to a crisp Transportation Problem and Solved by using Vogel's approximation method and using Ranking of Dodecagonal Fuzzy number. Numerical examples Show that the fuzzy proposed ranking method offers an effective tool for handling the balanced transportation problem.

Keywords: *Dodecagonal Fuzzy number, Fuzzy number, Fuzzy transportation problem, Proposed ranking method and Ranking method.*

I. INTRODUCTION

The transportation problem is one of the earliest applications of linear programming problems. Transportation models have wide applications in logistics and supply chain for reducing the cost efficient algorithms have been developed for solving the transportation problem when the cost coefficients and the supply and demand quantities are known exactly. A fuzzy transportation problem is a transportation problem in which the transportation cost, supply and demand quantities are fuzzy quantities. The method is to rank the fuzzy objective values of the objective function by some ranking method for numbers to find the best alternative. On the basis of this idea the proposed Ranking method with the help of α solution has been adopted a transform the fuzzy transportation problem. The idea is to transform a problem with fuzzy parameters in the form of Linear programming problem and solve it by the Vogel Approximation Method.

II. PRELIMINARIES

2.1 Fuzzy set:

A fuzzy set is characterized by a membership function mapping element of a domain space or the universe of discourse X to the unit interval [0, 1].

(i.e.) A={x,$\mu_A(x)$; x∈ X}.Here $\mu_A(x) = 1$

2.2 Normal fuzzy set:

A fuzzy set A of the universe of discourse X is called a normal fuzzy set implying that there exist at least one x ∈ X such that$\mu_A(x) = 1$.

2.3 Support of a fuzzy set:

The support of a fuzzy set in the universal set X is the set that contains all the elements of X that have a non- zero membership grade in A.
i.e., Supp (A) = {x ϵ X / $\mu_A(x) > 0$.

2.4α − cut:
Given a fuzzy set A defined on X and any number the $\alpha \epsilon [0,1]$ the α - Cut, $\alpha_A$is the crisp Set α_A = {x ϵ X / $A(x) \geq \alpha$, $\alpha \in [0,1]$.

2.5 Fuzzy Number:
A fuzzy set $\tilde{A}$defined on the set of real numbers R is said to be a fuzzy number if its membership function $\mu_{\tilde{A}}(x): R \rightarrow [0,1]$has the following properties

i. A must be normal & convex fuzzy set.
ii. α_A must be a closed interval for every$\alpha \in (0,1]$.
iii. The support of$\tilde{A}$, must be bounded.

III. DODECAGONAL FUZZY NUMBER (DoFN)

A fuzzy number $\tilde{A}$ is a DoFN denoted by $\tilde{A} = (a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12})$where $a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12}$are real numbers and its membership function is given by

$$\begin{cases} 0 & x \leq a_1 \\ k_1\left(\frac{x-a_1}{a_2-a_1}\right) & a_1 \leq x \leq a_2 \\ k_2 & a_2 \leq x \leq a_3 \\ k_1 + (k_2 - k_1)\left(\frac{x-a_3}{a_4-a_3}\right) & a_3 \leq x \leq a_4 \\ k_2 & a_4 \leq x \leq a_5 \\ k_2 + (1-k_2)\left(\frac{x-a_5}{a_6-a_5}\right) & a_5 \leq x \leq a_6 \\ 1 & a_6 \leq x \leq a_7 \\ k_2 + (1-k_2)\left(\frac{a_8-x}{a_8-a_7}\right) & a_7 \leq x \leq a_8 \\ k_2 & a_8 \leq x \leq a_9 \\ k_1 + (k_2 - k_1)\left(\frac{a_{10}-x}{a_{10}-a_9}\right) & a_9 \leq x \leq a_{10} \\ k_1 & a_{10} \leq x \leq a_{11} \\ k_1\left(\frac{a_{12}-x}{a_{12}-a_{11}}\right) & a_{11} \leq x \leq a_{12} \\ 0 & a_{12} \leq x \end{cases}$$

Where $0 < k_1 < k_2 < 1$.

3.1 Arithmetic Operations on Dodecagonal Fuzzy Number

Let$\tilde{A}_{DOD}$ = $(a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12})$and $\tilde{B}_{DOD} = (b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8, b_9, b_{10}, b_{11}, b_{12})$ be two Dodecagonal Fuzzy Numbers then addition and subtraction can be performed as

$\tilde{A}_{Dode} + \tilde{B}_{Dode} = [a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4, a_5 + b_5, a_6 + b_6, a_7 + b_7, a_8 + b_8, a_9 - b_9, a_{10} + b_{10}, a_{11} + b_{11}, a_{12} + b_{12}]$.

$\tilde{A}_{Dode} - \tilde{B}_{Dode} = [a_1 - b_1, a_2 - b_2, a_3 - b_3, a_4 - b_4, a_5 - b_5, a_6 - b_6, a_7 - b_7, a_8 - b_8, a_9 - b_9 a_{10} - b_{10}, a_{11} - b_{11}, a_{12} - b_{12}]$.

IV. PROPOSED RANKING METHOD

Let$\tilde{A}$ be a normal dodecagonal fuzzy number. The value M_0^{Dode} $(\tilde{A})$ called the measure of$\tilde{A}$ is calculated as follows:

M_0^{Dode} $(\tilde{A})$= $\frac{1}{2}\int_0^{k_1}(f_1(r) + f_2(r))dr + \frac{1}{2}\int_{k_1}^{k_2}(g_1(s) +$ *g2(s)ds+12k21h1t+h2(t)dt*

$\mathbf{M_0^{Dode}}$ $(\tilde{A})$= $\frac{1}{6}\{(\boldsymbol{a_1 + a_2 + a_3 + a_{10} + a_{11} + a_{12}})(\boldsymbol{k_1}) + (\boldsymbol{a_4 + a_5 + a_6 + a_7 + a_8 + a_9})(\boldsymbol{1 - k_2})\}$

Where $0 < k_1 < k_2 < 1$.

4.1RANKING METHOD:

Let $\tilde{A}$ be a normal dodecagonal fuzzy number. The value M_0^{Dode} $(\tilde{A})$ called the measure of $\tilde{A}$ is calculated as follows:

$\mathbf{M_0^{Dode}}$ $(\tilde{A})$= $\frac{1}{4}[(\boldsymbol{a_1 + a_2 + a_{11} + a_{12}})(\boldsymbol{k_1}) + (\boldsymbol{a_3 + a_4 + a_9 + a_{10}})(\boldsymbol{k_2 - k_1}) + (\boldsymbol{a_5 + a_6 + a_7 +}$ ***a81−k2]***

Where $0 < k_1 < k_2 < 1$.

V. NUMERICAL EXAMPLE

5.1 Example:

Consider the following fuzzy transportation problem

Table-1Dodecagonal fuzzy transportation problem

	D_1	D_2	D_3	D_4	Supply
S_1	(−3,−2,−1 0,1,2 3,4,5 ,6,7,8)	(−2,−1,0, 1,2,3 4,5,6, 7,8,9)	(6,7,8, 9,10,11 12,13,14, 15,16,17)	(2,3,4, 5,6,7 8,9,10 11,12,13)	(2,3,5, 6,8,9,10, 11,12, 15,16,17)
S_2	(−4,−3,−2 −1,0,1 ,2,3,4, 5,6,7)	(−5,−4,− −2,−1,0 1,2,3, 4,5,6)	(0,1,2, 4,5,6 7,8,9, 11,12,13)	(−5,−4,−3, −1,0,1, 2,4,5, 6,7,9)	(−3,−2,−1 ,0,1,2 3,4,5, 6,7,8)
S_3	(0,1,2 ,3,4,5, 6,7,8, 9,10,11)	(1,2,3 ,6,7,8, 9,10,12, 13,15,16)	(8,9,11, 12,14,15, 16,17,18 ,21,22,23)	(2,3,5 6,8,9, 10,11,12, 15,16,17)	(1,2,3, 6,7,8, 9,10,12, 13,15,16)
Demand	(2,3,4, 5,6,7, 8,9,10, 11,12,13)	(−2,0,1 ,2,3,5, 6.7,8, 10,11,12)	(−2,−1,0 ,1,2,3, 4,5,6 ,7,8,9)	(−3,−2,−1 ,0,1,2 3,4,5, 6,7,8)	

Source: Dodecagonal fuzzy numbers

Solution:

Now, the measure $\tilde{A}$of is calculated as discussed in section 4.This problem is done by taking the values ofk_1= 0.2 and k_1 = 0.6.Therefore, we obtain the values are

$$R(-3,-2,-1,0,1,2,3,4,5,6,7,8) = \frac{1}{6}\{(-3-2-1+6+7+8)(0.2) + (0+1+2+3+4+5)(1-0.6)\}$$

$=\frac{1}{6}\{15(0.2)+15(1-0.6)\}$

$= \frac{1}{6}\{15(0.2) + 15(0.4)\}$ $= \frac{1}{6}(9) = 3$;

Similarly,

$R(-2,-1,0,1,2,3,4,5,6,7,8,9)$= 2.1;

$R(6,7,8,9,10,12,13,14,15,16,17)$= 10.35

$R(2,3,4,5,6,7,8,9,10,11,12,13)$=4.5;

$R(-4,-3,-2,-1,0,1,2,3,4,5,6,7)$= 0.9

$R(-5,-4,-3,-2,-1,0,1,2,3,4,5,6)$=0.3;

$R(0,1,2,4,5,6,7,8,9,10,11,12,13)$= 3.9

$R(-5,-4,-3,-1,0,1,2,4,5,6,7,9)$=1;

$R(0,1,2,3,4,5,6,7,8,9,10,11)$=3.3

$R(1,2,3,6,7,8,9,10,12,13,15,16)$=5.17;

$R(8,9,11,12,14,15,16,17,18,21,22,23)$= 9.4

$R(2,3,5,6,8,9,10,11,12,15,16,17)$= 5.67

Rank of all supply:

$R(-1,0,1,3,5,6,7,8,10,12,13,14)$= 3.9;

$R(-4,-3,-2,-1,0,1,2,3,4,5,6,7)$= 0.9

R(2,4,5,6,8,10,12,13,15,17,18,19) = 6.43

Rank of all demand:

$R(2,3,4,5,6,7,8,9,10,11,12,13)$= 4.5;

$R(-2,0,1,2,3,5,6,7,8,10,11,12)$= 3.13

$R(-2,-1,0,1,2,3,4,5,6,7,8,9)$= 2.1;

$R(-3,-2,-1,0,1,2,3,4,5,6,7,8)$= 1.5

Table-2 using VAM Method

	D_1	D_2	D_3	D_4	Supply
S_1	3	2.1 **3.13**	10.35	4.5 **0.77**	3.9
S_2	0.9	0.3	3.9 **0.9**	1	0.9
S_3	3.3 **4.5**	5.17	9.4 **1.2**	5.67 **0.73**	6.43
Demand	4.5	3.13	2.1	1.5	

The total transportation cost is,

= (3.13) (2.1) + (0.77)(4.5) + (0.9)(3.9) + (4.5)(3.3) + (9.4)(1.2) + (5.67)(0.73)= 6.573 + 3.465 + 3.51 + 14.85 + 11.28 + 4.1391

= 43.8171

5.2 Example:

Consider the following fuzzy transportation problem

	D_1	D_2	D_3	D_4	Supply
S_1	$\begin{pmatrix}-3,-2,-1\\0,1,2\\3,4,5\\,6,7,8\end{pmatrix}$	$\begin{pmatrix}-2,-1,0,\\1,2,3\\4,5,6,\\7,8,9\end{pmatrix}$	$\begin{pmatrix}6,7,8,\\9,10,11\\12,13,14,\\15,16,17\end{pmatrix}$	$\begin{pmatrix}2,3,4,\\5,6,7\\8,9,10\\11,12,13\end{pmatrix}$	$\begin{pmatrix}2,3,5,\\6,8,9,10,\\11,12,\\15,16,17\end{pmatrix}$
S_2	$\begin{pmatrix}-4,-3,-2\\-1,0,1\\,2,3,4,\\5,6,7\end{pmatrix}$	$\begin{pmatrix}-5,-4,-3\\-2,-1,0,\\1,2,3,\\4,5,6\end{pmatrix}$	$\begin{pmatrix}0,1,2,\\4,5,6\\7,8,9,\\11,12,13\end{pmatrix}$	$\begin{pmatrix}-5,-4,-3,\\-1,0,1,\\2,4,5,\\6,7,9\end{pmatrix}$	$\begin{pmatrix}-3,-2,-1\\,0,1,2\\3,4,5,\\6,7,8\end{pmatrix}$
S_3	$\begin{pmatrix}0,1,2\\,3,4,5,\\6,7,8,\\9,10,11\end{pmatrix}$	$\begin{pmatrix}1,2,3\\,6,7,8,\\9,10,12,\\13,15,16\end{pmatrix}$	$\begin{pmatrix}8,9,11,\\12,14,15,\\16,17,18\\,21,22,23\end{pmatrix}$	$\begin{pmatrix}2,3,5\\6,8,9,\\10,11,12,\\15,16,17\end{pmatrix}$	$\begin{pmatrix}1,2,3,\\6,7,8,\\9,10,12,\\13,15,16\end{pmatrix}$
Demand	$\begin{pmatrix}2,3,4,\\5,6,7,\\8,9,10,\\11,12,13\end{pmatrix}$	$\begin{pmatrix}-2,0,1\\,2,3,5,\\6.7,8,\\10,11,12\end{pmatrix}$	$\begin{pmatrix}-2,-1,0\\,1,2,3,\\4,5,6\\,7,8,9\end{pmatrix}$	$\begin{pmatrix}-3,-2,-1\\,0,1,2\\3,4,5,\\6,7,8\end{pmatrix}$	

Solution:

Mo[Dode] $(\tilde{A})$= $\frac{1}{4}\{(a_1+a_2+a_{11}+a_{12})(k_1) + (a_3+a_4+a_9+a_{10})(k_2-k_1) + (a_5+a_6+a_7+a_8)(1-k_2)\}$

Where $k_1 = 0.4$ and $k_2 = 0.8$

$$R(-3,-2,-1,0,1,2,3,4,5,6,7,8) = \frac{1}{4}\{(-3-2+7+8)(0.4) + (-1+0+6+7)(0.8-0.4) + (1+2+3+4)(1-0.8)\}$$

$=\frac{1}{4}\{10(0.4)+10(0.4)+10(0.2)\}$

$=\frac{1}{4}(4+4+2)=\frac{10}{4}= 2.5$

$R(-3,-2,-1,0,1,2,3,4,5,6,7,8)$= 2.5

Similarly,

$R(-2,-1,0,1,2,3,4,5,6,7,8,9)$ = 3.5$R(6,7,8,9,10,12,13,14,15,16,17)$= 11.5

$R(2,3,4,5,6,7,8,9,10,11,12,13)$=7.5

$R(-4,-3,-2,-1,0,1,2,3,4,5,6,7)$ = 1.5

$R(-5,-4,-3,-2,-1,0,1,2,3,4,5,6)$= 0.5$R(0,1,2,4,5,6,7,8,9,10,11,12,13)$= 6.5

$R(-5,-4,-3,-1,0,1,2,4,5,6,7,9)$=1.75

$R(0,1,2,3,4,5,6,7,8,9,10,11)$ = 6.5

$R(1,2,3,6,7,8,9,10,12,13,15,16)$=8.5

$R(8,9,11,12,14,15,16,17,18,21,22,23)$= 15.5

$R(2,3,5,6,8,9,10,11,12,15,16,17)$ = 9.5

Rank of all supply

$R(-1,0,1,3,5,6,7,8,10,12,13,14)$ =6.5R$(-4,-3,-2,-1,0,1,2,3,4,5,6,7)$ = 1.5

R(2,4,5,6,8,10,12,13,15,17,18,19) =10.75

Rank of all demand

$R(2,3,4,5,6,7,8,9,10,11,12,13)$=7.5

$R(-2,0,1,2,3,5,6,7,8,10,11,12)$= 5.25

$R(-2,-1,0,1,2,3,4,5,6,7,8,9)$=3.5

$R(-3,-2,-1,0,1,2,3,4,5,6,7,8)$= 2.5

Table-3 using VAM Method

	D_1	D_2	D_3	D_4	Supply
S_1	2.5 **1.25**	3.5 **5.25**	11.5	7.5	6.5
S_2	1.5	0.5	6.5	1.75 **1.5**	1.5
S_3	6.5 **6.25**	8.5	15.5 **3.5**	9.5 **1**	10.75
Demand	7.5	5.25	3.5	2.5	

The total transportation cost is,

= (2.5) (1.25) + (3.5) (5.25) + (1.75) (1.5) + (6.5) (6.25) + (15.5) (3.5) + (9.5) (1)

= 3.125 + 18.375 + 2.625 + 34.375 + 54.25 + 9.5

= 122.25

VI. CONCLUSION

In this paper, a new form of a fuzzy Transportation problem as Dodecagonalfuzzy numbers using proposed ranking method. The numerical examples are solved using proposed ranking method is more optimal than other ranking method. Moreover, one can conclude that the solution of fuzzy problems can be obtained by proposed ranking methods effectively, this technique can also be used in solving other types of problems like, project schedules,game approximately, game problems and network flow problems.

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