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Fuzzy Linear Programming Problem: - An Optimum Solution for Trapezoidal Number

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1. INTRODUCTION

Linear programming is an important tool in the arsenal of means at a decider's disposal. Indeed it is one of the most frequently applied operational research model in real world problems. Linear programming theoretical underpinning is now well established and as a result, a broader array of techniques including the simplex method [5] The concept of fuzzy mathematical programming on a general level was first proposed by Tanaka et al. [9]in the framework of the fuzzy decision of Bellman and Zadeh [16] The first formulation of fuzzy linear programming (FLP) is proposed by Zimmermann [7].* Afterwards, many authors have considered various kinds of FLP problems and have proposed several approaches for solving these problems [1,2,3,4,5]. Fuzzy set theory has been applied to many disciplines such as control theory and management science, mathematical modelling and industrial applications.

The concept of fuzzy linear programming (FLP) on general level was first proposed by Tanaka et al [9]. Afterwards, many authors considered various types of FLP problems and proposed several approaches for solving this problem. In particular, most convenient methods are based on the concept of comparison of fuzzy numbers by using linear ranking functions [8, 9, 11,15]. Of course, linear ranking functions have been proposed by researchers to suit their requirements of the problem under consideration and conceivably there are no generally accepted criteria for application of ranking functions. Nevertheless, usually in such situations authors define a crisp model which is equivalent to an FLP problem and then use optimal solution of the model as the optimal solution of the FLP problem. Mahdavi-Amiri and Nasseri [11] extended the concepts of duality in FNLP problems as a similar problem leading to the dual simplex algorithm [6] for solving such problems. Usually in such methods authors define a crisp model which is equivalent to the FLPP and then use optimal solution of the model as the optimal solution of the FLPP. In [9], by using a general linear ranking function we consider a fuzzy linear programming problem with trapezoidal

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numbers and solve by matrices, simplex with ranking and crisp method. Our main contribution here is the establishment of a new method for solving the FLPP with using ranking function. Moreover, we illustrate our method with an example.

1. PRELIMINARIES

Fuzzy Set : The Characteristic functions $\mu_{Æ}$ of crisp set $A \subseteq X$ assings a value either 0 or 1 to each member in

X. This function can be generalized to a function $\mu_{Æ}$ such that the value assigned to the all of the universal set X

fall with in a specified range i.e. $\mu_{Æ}: X \rightarrow [0,1]$ The assigned values $\mu_{\bar{Æ}}$ is called the membership function and the set $\tilde{A} = \{(x, \mu_{Æ}(x)): x \in X\}$ Defined by $\mu_{Æ}(x)$ for $x \in X$ is called fuzzy set.

Trapezoidal Numbers : A fuzzy number $\tilde{A} = (N_1, n_1, \alpha_1, \text{þ}_1)$ is said to be trapezoidal number if its membership function is given by function :

$$\mu_{Æ}(x) = \begin{cases} \dfrac{x - (N_1 - n_1)}{\alpha_1} & N_1 - \alpha_1 \leq x \leq N_1 \\ 1 & N_1 \leq x \leq n_1 \\ \dfrac{(n_1 + \text{þ}_1) - x}{\text{þ}_1} & n_1 \leq x \leq n_1 + \text{þ}_1 \\ 0 & \text{else} \end{cases}$$

Ranking Function : Function $R: F(R) \rightarrow R$ which maps each fuzzy number into the real line where a natural order exist. We define order on $F(R)$ by :

$$\tilde{A} \geq \tilde{B} \Leftrightarrow R(\tilde{A}) \geq R(\tilde{B})$$

$$\tilde{A} \geq \tilde{B} \Leftrightarrow R(\tilde{A}) > R(\tilde{B})$$

$$\tilde{A} \simeq \tilde{B} \Leftrightarrow R(\tilde{A}) = R(\tilde{B})$$

$$\tilde{A} \leq \tilde{B} \Leftrightarrow \tilde{B} \geq \tilde{A}$$

Where $\tilde{A}$ and $\tilde{B}$ are in $F(R)$.

We restrict our attention to linear ranking function i.e. a ranking function R such that

$$R(K\tilde{A} + \tilde{B}) = KR(\tilde{A}) + R(\tilde{B}) \; \forall \, \tilde{A}, \tilde{B} \in F(R)$$

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We consider the linear ranking function $F(R)$ as: $R(\tilde{A}) = C_1N_1 + C_2n_1 + C_3\alpha_1 + C_4\text{þ}_1$

Where C_1, C_2, C_3 and C_4 are constant at least one of which is non zero a special version of the above linear ranking function was first proposed by Yagar as follows:

$$R(\tilde{A}) = \frac{1}{2}\int_0^1 (\inf\tilde{A}_ß + \sup\tilde{A}_ß)dh$$

Which reduce to $R(\tilde{A}) = \frac{1}{2}(N_1 + n_1) + \frac{1}{4}(\text{þ}_1 - \alpha_1)$

Then for trapezoidal fuzzy number $\tilde{A} = (N_1, n_1, \alpha_1, \text{þ}_1)$ and $\tilde{B} = (N_2, n_2, \alpha_2, \text{þ}_2)$

We have $\tilde{A} \geq \tilde{B} \Leftrightarrow \frac{1}{2}(N_1 + n_1) + \frac{1}{4}(\text{þ}_1 - \alpha_1) \geq \frac{1}{2}(N_2 + n_2) + \frac{1}{4}(\text{þ}_2 - \alpha_2)$

Fuzzy Matrix : A matrix $\tilde{A} = (\widetilde{a_{ty}})$ is called the fuzzy matrix. If each element of $\tilde{A}$ is a fuzzy number. $\tilde{A}$ Will be positive (negative) and denoted by $\tilde{A} > 0$ $(\tilde{A} < 0)$ if each element of $\tilde{A}$ be positive (negative). $\tilde{A}$ a will be non negative (non-positive) and denoted by $\tilde{A} \leq 0$ $(\tilde{A} \geq 0)$ if each element of $\tilde{A}$ be non-positive (non-negative). We may represent $n \times N$ fuzzy metrics $\widetilde{A} = (\widetilde{a_{ty}})_{n\times N}$ where $\widetilde{a_{ty}} = (a_{ij}, b_{ij}, c_{ij}, d_{ij})$.

2. ARITHMETIC OPERATION ON TRAPEZOIDAL FUZZY NUMBER

In this sub-section addition and multiplication operation between two trapezoidal fuzzy number. Let $\tilde{A} = (N_1, n_1, \alpha_1, \text{þ}_1)$ and $\tilde{B} = (N_2, n_2, \alpha_2, \text{þ}_2)$ be two trapezoidal fuzzy number then :

$$\tilde{A}\oplus\tilde{B} = (N_1, n_1, \alpha_1, \text{þ}_1)\oplus(N_2, n_2, \alpha_2, \text{þ}_2) = (N_1 + N_2, n_1 + n_2, \alpha_1 + \alpha_2, \text{þ}_1 + \text{þ}_2)$$

$-\tilde{A} = -(N_1, n_1, \alpha_1, \text{þ}_1) = (-n_1, -N_1, \text{þ}_1, \alpha_1)$

If $\tilde{A} \geq 0$ and $\tilde{B} \geq 0$ then, $\tilde{A}\otimes\tilde{B} = (N_1, n_1, \alpha_1, \text{þ}_1)\otimes(N_2, n_2, \alpha_2, \text{þ}_2) = (N_1N_2, n_1n_2, \alpha_1\alpha_2, \text{þ}_1\text{þ}_2)$

3. PROPOSED METHOD

Method 1 : One of the method solving the crisp linear system of equation $Ax = b$ is row reduced echelon form. In this section the same method is extended to solve fully fuzzy linear system $\tilde{A}\otimes\tilde{x} = \tilde{b}$.

Assuming $\tilde{A} = (N_1, n_1, \alpha_1, \text{þ}_1) \geq 0$, $\tilde{x} = (x, y, z, w) \geq 0$ and $\tilde{B} = (N_2, n_2, \alpha_2, \text{þ}_2) \geq 0$

We can write as $(N_1, n_1, \alpha_1, \text{þ}_1)\otimes(x, y, z, w) = (N_2, n_2, \alpha_2, \text{þ}_2)$

$(N_1x, n_1y, N_1z + \alpha_1x, n_1w + \text{þ}_1y) = (N_2, n_2, \alpha_2, \text{þ}_2)$

$N_1x = N_2$, $n_1y = n_2$, $N_1z + \alpha_1x = \alpha_2$, $n_1w + \text{þ}_1y = \text{þ}_2$

Now we use the following steps to find the solution of FFLS :

Step 1 : Compute the row reduced echelon form of augmented metrics $(N_1, N_2)(n_1, n_2), (N_1, \alpha_2 -$

$\alpha_1 x$), (n_1, $\text{þ}_2 - \text{þ}_2 y$) by applying suitable row operation, they may be following three case:

Case1 : If rank (N_1) $\neq$ rank(N_1, N_2) or rank (n_1) $\neq$ rank(n_1, n_2) then FFLS is inconsistent and no. non- negative solution exists.

Case2 : If rank (N_1) = rank(N_1, N_2) and rank (n_1) = rank (n_1, n_2) but there exist at least one negative element in the (n+1)th column of the row reduced echelon form of augmented metrics (N_1, N_2) or (n_1, n_2) *or* (N_1, $\alpha_2 - \alpha_1 x$) or (n_1, $\text{þ}_2 - \text{þ}_2 y$) then the system of the equation are inconsistent and no. non-negative solution exists.

Case3 : If rank (N_1) = rank(N_1, N_2) and rank (n_1) = rank (n_1, n_2) all the element of the (n+1)th column of the row reduced echelon form of augmented metrics (N_1, N_2), (n_1, n_2), (N_1, $\alpha_2 - \alpha_1 x$), (n_1, $\text{þ}_2 - \text{þ}_2 y$) are non-negative then the system of equation are consistent i.e. non-negative solution exists.

Step 2 : Compute the value of x_i using the row reduced echelon form of augmented metrics (N_1, N_2), (n_1, n_2), (N_1, $\alpha_2 - \alpha_1 x$), (n_1, $\text{þ}_2 - \text{þ}_2 y$) respectively.

Method 2 : Kind of linear programming problem where all parameter are fuzzy number while the decision variables are crisp. They named this kind of number as fuzzy number linear programming problem [FNLP] and proved fuzzy analogues of some important theorems of linear programming. In this section, we first review these result and then give the simplex result of FNLP proposed Madhavi- Amiri and Nassari [11]

$$\text{Max } \tilde{Z} \simeq \tilde{C}x$$

Such that $$\tilde{A}x \leq \tilde{B}$$

$$x \geq 0$$

Where $\tilde{b} \in F(R)^N, x \in R^n, \tilde{A} = (\tilde{a}_{ij})_{N\times n} \in (F(R))^{N\times n}, \tilde{C}^T \in (F(R))^n$

Method 3 : A rank procedure by defining a distance between fuzzy numbers based on this ranking procedure, a ranking algorithm is developed for triangular and trapezoidal fuzzy numbers. Moreover, it is applied to FFLP under constraints with fuzzy co-efficient

4. ALGORITHM

Step 1: Consider the fuzzy number $\tilde{A}$ and $\tilde{B}$ which are either triangular or trapezoidal.

Step 2: Find supremum M = Sup{ S(A) ∪ S(B)} where S(A) = Support set on $\tilde{A}$ and S(B) = Support set of $\tilde{B}$.

Step 3: If $\tilde{A}$ and $\tilde{B}$ are triangular fuzzy numbers then go to step 6

Step 4: Otherwise, take $\tilde{A} = (N_1, n_1, \alpha_1, \text{þ}_1)$ and $\tilde{B} = (N_2, n_2, \alpha_2, \text{þ}_2)$ as trapezoidal fu,zzy numbers.

Step 5: Calculate D($\tilde{A}$,M) = M - $(N_1, n_1, \alpha_1, \text{þ}_1)/4$ and D($\tilde{B}$,M) = M- $(N_2, n_2, \alpha_2, \text{þ}_2)/4$ and go to step 8.

Step 6: Take $\tilde{A}$ = (a_1, a_2, a_3) and $\tilde{B}$ = (b_1, b_2, b_3)

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Step 7: Calculate $D(\tilde{A},M)= M - (a_1-2a_2+a_3)/4$ and $D(\tilde{B},M)= M - (b_1-2b_2+b_3)/4$

Step 8: If $D(\tilde{A},M) < D(\tilde{B},M)$ then $\tilde{A}$ is greater then $\tilde{B}$

If $D(\tilde{A},M) = D(\tilde{B},M)$ then $\tilde{A}$ is equal to $\tilde{B}$

If $D(\tilde{A},M) < D(\tilde{B},M)$ then $\tilde{A}$ is less then $\tilde{B}$

Step 9 : Process is stop.

We now consider a objective fuzzy linear programming problem with constraint having fuzzy coefficient having fuzzy coefficient is given by

Maximize $Z=c_1x_1+c_1x_{2+}$------------ $_+c_nx_n$

Subject to $\widetilde{a_{t1}}x_1+\widetilde{a_{t2}}x_2+$--------$+\widetilde{a_{tn}}x_n \le \widetilde{b_t}$ $x_1, x_2,$ --------------- $_n \ge 0$

Where fuzzy number are trapezoidal fuzzy ones that is $\widetilde{a_{t1}}= (\widetilde{a_{t11}},\widetilde{a_{t12}}\widetilde{a_{t13}},\widetilde{a_{t14}})$, $\widetilde{a_{t2}}=(\widetilde{a_{t21}},\widetilde{a_{t22}}\widetilde{a_{t23}},\widetilde{a_{t24}})$ …… $\widetilde{a_{tn}}=(\widetilde{a_{tn1}},\widetilde{a_{tn2}}\widetilde{a_{tn3}},\widetilde{a_{tn4}})$, $\widetilde{b_t}=(\widetilde{b_{t1}},\widetilde{b_{t2}}\widetilde{b_{t3}},\widetilde{b_{t4}})$, by Zadeh's extension principle, the sum of any trapezoidal fuzzy number is still a trapezoidal one. The above formulation can be written as :

$$\text{Max } Z = c_1x_1 \oplus c_2x_2 \ldots\ldots\ldots \oplus c_nx_n$$

Subject to $(\widetilde{a_{t11}}x_1 \oplus \widetilde{a_{t21}}x_2 \oplus \ldots . \oplus \widetilde{a_{tn1}}x_n$, $\widetilde{a_{t12}}x_1 \oplus \widetilde{a_{t22}}x_2 \oplus \ldots . \oplus \widetilde{a_{tn2}}x_n$, $\widetilde{a_{t13}}x_1 \oplus \widetilde{a_{t23}}x_2 \ldots . \oplus \widetilde{a_{tn3}}x_n, \widetilde{a_{t14}}x_1 \oplus \widetilde{a_{t24}}x_2 \oplus \ldots . \oplus \widetilde{a_{tn4}}x_n) \le (\widetilde{b_{t1}},\widetilde{b_{t2}}\widetilde{b_{t3}},\widetilde{b_{t4}})$

$x_1, x_2,$ ---------- $x_n \ge 0$ $i = 1, 2, 3 \ldots \ldots m$

By the ranking algorithm the above FFLP is transformed into LPP as follows :

$$\text{Max } Z = c_1x_1 \oplus c_2x_2 \ldots\ldots\ldots \oplus c_nx_n$$

Subject to $(\widetilde{a_{t11}}x_1 \oplus \widetilde{a_{t21}}x_2 \oplus \ldots . \oplus \widetilde{a_{tn1}}x_n$, $\widetilde{a_{t12}}x_1 \oplus \widetilde{a_{t22}}x_2 \oplus \ldots . \oplus \widetilde{a_{tn2}}x_n$, $\widetilde{a_{t13}}x_1 \oplus \widetilde{a_{t23}}x_2 \ldots . \oplus \widetilde{a_{tn3}}x_n, \widetilde{a_{t14}}x_1 \oplus \widetilde{a_{t24}}x_2 \oplus \ldots . \oplus \widetilde{a_{tn4}}x_n) \le (\widetilde{b_{t1}},\widetilde{b_{t2}}\widetilde{b_{t3}},\widetilde{b_{t4}})$

$x_1, x_2,$ ---------- $x_n \ge 0$ $i = 1, 2, 3 \ldots \ldots m$

In this method the most important objective subject to the fuzzy constraint is considered first. Using I and II this can be converted into a single objective problem. Subject constraint with transform crisp number coefficient and hence solved accordingly. Then the next objective is optimized subject to a requirement that the first achieve its optimum value which is nothing but the primitive optimization.

Numerical Example : Consider the following FFLP and solve it by method I

$(3, 6, 2, 2) \otimes x_1 \oplus (4, 6, 1, 2) \otimes x_2 = (27, 66, 26, 58)$

$(4, 5, 1, 1) \otimes x_1 \oplus (5, 8, 1, 2) \otimes x_2 = (35, 70, 25, 55)$

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Solution : The given LPP may be written as

$$\begin{bmatrix} (3,6,2,2) & (4,6,1,2) \\ (4,5,1,1) & (5,8,1,2) \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} (27,66,26,58) \\ (35,70,25,55) \end{bmatrix}$$

$$N_1 = \begin{bmatrix} 3 & 4 \\ 4 & 5 \end{bmatrix} n_1 = \begin{bmatrix} 6 & 6 \\ 5 & 8 \end{bmatrix} \alpha_1 = \begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix} þ_1 = \begin{bmatrix} 2 & 2 \\ 2 & 1 \end{bmatrix} N_2 = \begin{bmatrix} 2 & 7 \\ 3 & 5 \end{bmatrix} n_2 = \begin{bmatrix} 6 & 6 \\ 7 & 0 \end{bmatrix} \alpha_2 = \begin{bmatrix} 2 & 6 \\ 2 & 5 \end{bmatrix} þ_2 = \begin{bmatrix} 5 & 0 \\ 5 & 5 \end{bmatrix}$$

The augmented metrics :

$$(N_1, N_2) = \begin{bmatrix} 3 & 4 & 27 \\ 4 & 5 & 35 \end{bmatrix}$$

The reduced echelon form of this metrics is obtained as follows :

Apply the row operation $R_1 \rightarrow R_1/3$ to get $\begin{bmatrix} 1 & 4/3 & 9 \\ 4 & 5 & 35 \end{bmatrix}$ again we apply row operation in sequence $R_2 \rightarrow R_2\text{-}R_4$; $R_2 \rightarrow -3R_2$; $R_1 \rightarrow R_1 - 4R_2/3$ and, we get $\begin{bmatrix} 1 & 0 & 5 \\ 0 & 1 & 3 \end{bmatrix}$

Using the row reduce echelon form of the augmented matrix(N_1, N_2), $x_1 = 5, x_2 = 3$ Similarly the row reduced echelon form of the augmented matrix $(n_1, n_2) = \begin{bmatrix} 6 & 6 & 66 \\ 5 & 8 & 70 \end{bmatrix}$ is $\begin{bmatrix} 1 & 0 & 6 \\ 0 & 1 & 5 \end{bmatrix}$ which gives $y_1 = 6, y_2 = 5$.

Similarly the row reduced echelon form of the augmented matrix $(N_1, \alpha_2 - \alpha_1 x) = \begin{bmatrix} 3 & 4 & 13 \\ 4 & 5 & 17 \end{bmatrix}$ is $\begin{bmatrix} 1 & 0 & 3 \\ 0 & 1 & 1 \end{bmatrix}$ which gives$z_1 = 3, z_2 = 1$.

Finally, the row reduced echelon form of the augmented matrix $(n_1, þ_2 - þ_2 y) = \begin{bmatrix} 6 & 6 & 36 \\ 5 & 8 & 39 \end{bmatrix}$ is $\begin{bmatrix} 1 & 0 & 3 \\ 0 & 1 & 3 \end{bmatrix}$ which gives$w_1 = 3, w_2 = 3$.

Since rank (N_1) = rank(N_1, N_2)= 2 and rank (n_1) = rank (n_1, n_2) = 2 all the element of the $(n+1)^{th}$ column of the row reduced echelon form of augmented metrics (N_1, N_2), (n_1, n_2), $(N_1, \alpha_2 - \alpha_1 x)$, $(n_1, þ_2 - þ_2 y)$ are non-negative. Hence the systems of equation are consistent and unique. Non-negative solution exists. Substituting appropriate value in $\tilde{x}_i = (x_i, y_i, z_i, w_i)$ for all *i*= 1 and 2 $\widetilde{x_1}$= (5, 6, 3, 3) and $\widetilde{x_2}$ = (3, 5, 1, 3)

Example : Consider the following FNLP problem Max $\tilde{Z} = (5,6,3,3) \otimes \tilde{x}_1 \oplus (3,5,1,3) \otimes \tilde{x}_2$

Such that $(3,6,2,2) \otimes \tilde{x}_1 \oplus (4,6,1,2) \otimes \tilde{x}_2 \leq (27,66,26,58)$

$$(4,5,1,1) \oplus \tilde{x}_1 \otimes (5,8,1,2) \oplus \tilde{x}_2 \leq (35,70,25,55)$$

$$x_1, x_2 \geq 0$$

We apply the yougers ranking function as a sample of the linear ranking function to the fuzzy co-efficient matrix $\tilde{A}$ and the fuzzy R.H.S. vector $\tilde{b}$. Thus with the introduction of the slack variable S_1 and S_2 the problem

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reduces to

$\text{Max } \tilde{Z} = (5, 6, 3, 3)\otimes\tilde{x}_1\oplus (3, 5, 1, 3)\otimes\tilde{x}_2$

Subject to $(4.5)\oplus\tilde{x}_1\otimes(4.2)\oplus\tilde{x}_2 \leq (54.5)$

$(4.5)\oplus\tilde{x}_1\otimes(6.7)\oplus\tilde{x}_2 \leq (22)$

$\tilde{x}_1, \tilde{x}_2 \geq 0$

Table 1

B.V.	C.B	$\widetilde{x_1}$	$\widetilde{x_2}$	S_1	S_2	$\widetilde{x_B}$	Min Ratio
S_1	0	4.5	4.2	1	0	54.5	12.11
S_2	0	4.5	6.7	0	1	22	4.8
	C_j	0	0	0	0		
	Z_j	5.5	4.5	0	0		
	Z_j-C_j	5.5	4.5	0	0		

Table 2

B.V.	C.B	$\widetilde{x_1}$	$\widetilde{x_2}$	S_1	S_2	$\widetilde{x_B}$
S_1	0	0	-2.50	1	-1	32.50
X_1	5.5	1	1.49	0	0.22	4.879
	C_j	5.5	8.95	0	1.21	
	Z_j	5.5	4.5	0	0	
	Z_j-C_j	0	-3.695	0	-1.21	

Hence the solution is optimum. X1 = 4.89 x2 = 0 z= 26.894

Example : $\text{Max } \tilde{Z} = (5, 6, 3, 3)\otimes\tilde{x}_1\oplus (3, 5, 1, 3)\otimes\tilde{x}_2$

Subject to $(3, 6, 2, 2)\otimes\tilde{x}_1 \oplus(4, 6, 1, 2)\otimes\tilde{x}_2 \leq (27, 66, 26, 58)$

$(4, 5, 1, 1)\oplus\tilde{x}_1\otimes(5, 8, 1,2)\oplus\tilde{x}_2 \leq (35,70, 25, 55)$

$\tilde{x}_1, \tilde{x}_2 \geq 0$

Where $\tilde{a}_{11}$ = (3,6,2,2) , $\widetilde{a_{12}}$ = (1,5,2,3) , $\widetilde{b_1}$ = (27,66,26,58)

$\widetilde{a_{21}}$ =(4,5,1,1) , $\widetilde{a_{22}}$ = (5,8,1,2) , $\widetilde{b_2}$ = (35,70,25,55)

by the Method-3 this can be transformed into a Crisp L.P.P as :

Max Z = (5,6,3,3)$\otimes\widetilde{x_1}\oplus$(3,5,1,3)$\otimes\widetilde{x_2}$

Subject to $(3\otimes \widetilde{x_1}\oplus4\otimes \widetilde{x_2}) \oplus (6\otimes \widetilde{x_1}\oplus6\otimes \widetilde{x_2}) \oplus (2\otimes \widetilde{x_1}\oplus1\otimes \widetilde{x_2}) \oplus (2\otimes \widetilde{x_1}\oplus1\otimes \widetilde{x_2}) \leq (27+66+26+58)$

$(4\otimes \widetilde{x_1}\oplus5\otimes \widetilde{x_2})\oplus(5\otimes \widetilde{x_1}\oplus8\otimes \widetilde{x_2})\oplus(1\otimes \widetilde{x_1}\oplus1\otimes \widetilde{x_2})\oplus(1\otimes \widetilde{x_1}\oplus2\otimes\widetilde{x_2}) \leq (35+70+25+58)$

$\tilde{x}_1, \tilde{x}_2 \geq 0$

Finally the L.P.P as $\text{Max } \tilde{Z} = 17\otimes \widetilde{x_1}\oplus12\otimes \widetilde{x_2}$

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$10 \otimes \widetilde{x_1} \oplus 13 \otimes \widetilde{x_2} \leq 177$

$11 \otimes \widetilde{x_1} \oplus 16 \otimes \widetilde{x_2} \leq 185$

$$\tilde{x}_1, \tilde{x}_2 \geq 0$$

Simplex method

Table 3

B.V.	C.B	$\widetilde{x_1}$	$\widetilde{x_2}$	S_1	S_2	$\widetilde{x_b}$	Min Ratio
S_1	0	10	13	1	0	177	17.7
S_2	0	11	16	0	1	185	16.81
	C_j	0	0	0	0		
	Z_j	17	12	0	0		
	Z_j-C_j	17	12	0	0		

Table 4

B.V.	C.B	$\widetilde{x_1}$	$\widetilde{x_2}$	S_1	S_2	$\widetilde{x_b}$
S_1	0	0	-1.55	1	-0.91	8.82
X_1	12	1	1.45	0	0.09	16.82
	C_j	12	17.4	0	1.08	
	Z_j					
	Z_j-C_j	0	-12.73	0	-1.55	

5. CONCLUSION

In this paper we are proposed few methods to find the fuzzy optimal solution of FLPP with inequality constraints by representing all the parameters as trapezoidal fuzzy numbers. Here row reduced echelon form of matrices is used to construct a new method for solving FLPP and Fuzzy simplex algorithms for solving fuzzy number linear programming and using the general linear ranking functions on fuzzy numbers. The proposed method is easy to understand and apply in real situations. The method is illustrated with the help of numerical example.

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