Optimal Solution of Neutrosophic Linear Fractional Programming Problems With Mixed Constraints

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Optimal solution of Neutrosophic Linear Fractional Programming Problems with mixed constraints

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Abstract:

In this paper, Linear Fractional Programming (LFP) problems have been extended to neutrosophic sets (NSs) and the operations and functionality of these laws are studied. Moreover, the new algorithm is based on aggregation ranking function and arithmetic operations of triangular neutrosophic sets (TNSs). Furthermore, for the first time, in this paper, we take up a problem where the constraints are both equality and inequality neutrosophic triangular fuzzy number. Lead from genuine issue, a few numerical models are considered to survey the legitimacy, profitability and materialness of our technique. At last, some numerical trials alongside one contextual analysis are given to show the novel techniques are better than the current strategies.

Keywords: Neutrosophic linear fractional programming, Crisp linear fractional programming, Triangular neutrosophic numbers, Ranking function.

1. Introduction

These days, the issue of LFP is one of the most key tool feasible analyses. Various physical issues can be converted into a LFP model; see [10, 22]. As a result the present template is the crucial for the present applications in various genuine zones, for example, creation arranging, money related area, medicinal services and all designing fields [10]. Be that as it may, in certifiable applications, conviction, unwavering quality and accuracy of information is regularly deceptive. In general the ultimate goal of LFP just relies upon a set number of imperatives; consequently a significant part of the gathered data has little effect on the arrangement. It is helpful to think about the information on specialists regarding the parameters as invisible information. Zadeh proposed fuzzy theory [5], researchers used it when the data are imprecise. Numerous specialists have deciphered numerous models of fuzzy linear programming and fuzzy linear fractional programming problem. They have taken different approaches to take care of the

fuzzy issue like (i) where coefficients are fuzzy, (ii) variables are fuzzy, (iii) both are fuzzy. In the event that the issue consider both fuzzy, at that point it is called completely fuzzy programming issue. That kind of issue was planned by Zimmerman. After that Edalatpanah [24], Das [20], Das et al. [11] has defined to tackle FFLP issue with the assistance of ranking function and lexicographic technique. Nayak & Ojha [39-40] have proposed a technique to take care of multi-objective LFP issue with interval parameters. Some of analysts [12-15, 23, 35-38, 41] have proposed various strategies for tackling multi-objective FLFP issue. Veeramani and Sumathi [4] proposed a technique for tackling FFLFP issue by utilizing the ideas of α, r - acceptable optimal value of a LFP problem with fuzzy coefficients and fuzzy decision variables and build up a strategy to register them. As of late, Das et al. [10] have proposed a strategy for tackling fuzzy LFP issue by utilizing multi-target LP issue. These creators utilized the strategy for lexicographic procedure and the FFLFP issue convert into multi-target LP issue; see additionally [10, 11-19, 25].

Afterward, intuitionistic fuzzy hypothesis was presented by Atanassov [3], some mathematician likewise utilized it to display vulnerability in streamlining issues. In any case, these two ideas can just explore inadequate data, not wide data. Be that as it may, Smarandache [27] tackled this issue by adding an autonomous indeterminacy enrollment to intuitionistic fuzzy sets and this strategy is called neutrosophic set. Due to their greatness attribution the neutrosophic issue is becoming exceptionally quick. As a matter of first importance, Ye [54-55] proposed a capacity including neutrosophic numbers and utilized it for taking care of neutrosophic linear programming problem. Presently numerous specialists consider the neutrosophic capacities to take care of different issues like goal programming [43-47, 50-52], non-linear programming [13, 48], geometric programming [52], integer programming [47] and data envelopment analysis [32]. Abdel Basset and Mohamed [28] proposed a neutrosophic triangular numbers to take care of LFP issues. They consider neutrosophic LFP (NLFP) issue into multi-objective LFP issue and afterward convert to single target LFP issue. By utilizing existing technique [28] to acquire arrangements are not accurate and the requirements are taken disparity. It is hard to utilize the current technique [28] for taking care of FFLFP issue with both equity and imbalance limitations. Recently, Das and Dash [53] consider a neutrosophic linear fractional

programming problem with mixed constraints with using score function. To overcome this existing method [53], the aim of this paper is introduced aggregation ranking function.

To conquer these weaknesses, another technique is proposed for discovering NLFP issue with both uniformity and imbalance limitations. This examination, at the first occasion when we use total positioning capacity to tackle neutrosophic LFP issue and it will change over to fresh LFP issue. This fresh LFP issue is explained by any standard techniques.

The remainder of the paper is composed by in this way: some essential ideas and documentations are available in clause 2. In clause 3, the general type of direct partial programming (LFP) issue is introduced. The general type of neutrosophic LFP issue is displayed in clause 4. In clause 5, another methodology is introduced for taking care of NLFP issues with imbalance requirements and fairness imperatives having unhindered neutrosophic triangular numbers are introduced. To outline the utilization of the proposed technique for a mechanical application is understood in clause 6. At long last, end has been attracted the last segment.

2. Preliminaries

An audit of significant ideas and meanings of neutrosophic set is introduced right now.

Definition 1. [27]

Assume X stick a universal neutrosophic set in addition to $s \in X$. A neutrosophic set X may be defined via three membership functions for truth, indeterminacy along with falsity and denoted by $\tau_M(s)$, $\rho_M(s)$ and $\nu_M(s)$. These are realistic abnormal subgroups containing $]0^-, 1^+[$. There may be no limitation on the whole of $\tau_M(s)$, $\rho_M(s)$ and $\nu_M(s)$, so $0^- \leq \sup \tau_M(s) + \sup \rho_M(s) + \sup \nu_M(s) \leq 3^+$.

Definition 2. [29]

A single-valued neutrosophic set (SVNS) M excess of X may be an article giving powerful structure $M = \{s, \tau_M(s), \rho_M(s), \nu_M(s)\}$, where X be a space of discourse, $\tau_M(s): X \rightarrow [0, 1]$, $\rho_M(s): X \rightarrow [0, 1]$ and $\nu_M(s): X \rightarrow [0, 1]$ with $0 < \tau_M(s) + \rho_M(s) + \nu_M(s) < 3$ $0 \leq TA(x) + IA(x) + FA(x) \leq 3$ for all $s \in X$.

Definition 3 [28]. A triangular neutrosophic number (TNNs) is signified via

$M = \langle (a^q, a^r, a^s), (\mu, i, \omega) \rangle$ is an extended version of the three membership functions for the truth, indeterminacy, and falsity of s can be defined as follows:

$$\tau_M(s) = \begin{cases} \frac{(s - a^q)}{(a^r - a^q)} \mu & a^q \leq s < a^r, \\ \mu & s = a^q, \\ \frac{(a^s - s)}{(a^s - a^r)} \mu & a^r \leq s < a^s, \\ 0 & \text{something else.} \end{cases}$$

$$\rho_M(s) = \begin{cases} \frac{(a^r - s)}{(a^r - a^s)} i, & a^q \leq s < a^r, \\ i, & s = a^r, \\ \frac{(s - a^s)}{(a^s - a^u)} i, & a^r \leq s < a^s, \\ 1, & \text{something else.} \end{cases}$$

$$\nu_M(s) = \begin{cases} \frac{(a^m - s)}{(a^m - a^l)} \omega, & a^q \leq s < a^r, \\ \omega, & s = a^r, \\ \frac{(s - a^s)}{(a^s - a^r)} \omega, & a^r \leq s < a^s, \\ 1, & \text{something else.} \end{cases}$$

Where, $0 \leq \tau_M(s) + \rho_M(s) + \nu_M(s) \leq 3, s \in M$. Additionally, when $a^q \geq 0$, M is called anonnegative TNN.

Similarly, when $a^q < 0$, M becomes a negative TNN.

Definition 4 [28]. Arithmetic Operation

Suppose $A_1^M = \langle (a_1^q, b_1^r, c_1^s), (\mu_1, \nu_1, \omega_1) \rangle$ and $A_2^M = \langle (a_2^q, b_2^r, c_2^s), (\mu_2, \nu_2, \omega_2) \rangle$ be two TNNs. Then the arithmetic relations are defined as:

$$(i) A_1^M \oplus A_2^M = \langle (a_1^q + a_2^q, b_1^r + b_2^r, c_1^s + c_2^s), (\mu_1 \wedge \mu_2, \nu_1 \vee \nu_2, \omega_1 \vee \omega_2) \rangle$$

$$(ii) A_1^M - A_2^M = \langle (a_1^q - c_2^s, b_1^r - b_2^r, c_1^s - a_2^q), (\mu_1 \wedge \mu_2, \nu_1 \vee \nu_2, \omega_1 \vee \omega_2) \rangle$$

$$(iii) A_1^M \otimes A_2^M = \langle (a_1^q a_2^q, b_1^r b_2^r, c_1^s c_2^s), (\mu_1 \wedge \mu_2, \nu_1 \vee \nu_2, \omega_1 \vee \omega_2) \rangle, \text{ if } a_1^q > 0, b_1^r > 0,$$

$$(iv) \lambda A_1^M = \begin{cases} \langle (\lambda a_1^q, \lambda b_1^r, \lambda c_1^s), (\mu_1, \nu_1, \omega_1) \rangle, & \text{if } \lambda > 0 \\ \langle (\lambda c_1^s, \lambda b_1^r, \lambda a_1^q), (\mu_1, \nu_1, \omega_1) \rangle, & \text{if } \lambda < 0 \end{cases}$$

$$(v) \frac{A_1^M}{A_2^M} = \begin{cases} \left\langle \left(\frac{a_1^q}{c_2^s}, \frac{b_1^r}{b_2^r}, \frac{c_1^s}{a_2^q} \right); \mu_1 \wedge \mu_2, v_1 \wedge v_2, w_1 \wedge w_2 \right\rangle (c_1^s > 0, c_2^s > 0) \\ \left\langle \left(\frac{c_1^s}{c_2^s}, \frac{b_1^r}{b_2^r}, \frac{a_1^q}{a_2^q} \right); \mu_1 \wedge \mu_2, v_1 \wedge v_2, w_1 \wedge w_2 \right\rangle (c_1^s < 0, c_2^s > 0) \\ \left\langle \left(\frac{c_1^s}{a_2^q}, \frac{b_1^r}{b_2^r}, \frac{a_1^q}{c_2^s} \right); \mu_1 \wedge \mu_2, v_1 \wedge v_2, w_1 \wedge w_2 \right\rangle (c_1^s < 0, c_2^s < 0) \end{cases}$$

Definition 5 [10]. Arithmetic Operation

Assume A^M and B^M be two TNNs. Then the ranking function is:

- (i) $A^M \leq B^M$ if and only if $\Re(A^M) \leq \Re(B^M)$.
- (ii) $A^M < B^M$ if and only if $\Re(A^M) < \Re(B^M)$.

Where $\Re(.)$ is a ranking function.

Here, we present a new type of ranking function:

Definition 6. One can compare any two TNNs based on the ranking functions. Let $A^N = \langle (a, b, c); (\mu, v, w) \rangle$ be a TNN: then $\Re(A^N) = \frac{a+b+c}{9}(\mu + (1-v) + (1-w))$.

Example-1. Let $A^N = ((4, 8, 10); 0.5, 0.3, 0.6)$ then $\Re(A^N) = 3.91$

Since $\Re(\tilde{a} + \tilde{b}) \neq \Re(\tilde{a}) + \Re(\tilde{b})$, therefore, we define an aggregation ranking function as follows:

Definition 7. Let $A_i^N = \langle (a_i, b_i, c_i); (\mu_i, v_i, w_i) \rangle$ be some TNNs: then the aggregation ranking function is as follows:

$$\Re\left(\sum_{i=1}^n A_i^N\right) = \frac{(2 + \min \mu_i - \max v_i - \max w_i)}{9} \sum_{i=1}^n (a_i + b_i + c_i)$$

Example-2. Let $A^N = ((4, 8, 10); 0.5, 0.3, 0.6)$ and $B^N = ((3, 7, 11); 0.4, 0.5, 0.6)$ then based on Definition 6 we get:

$$\Re(A^N) = 3.91,$$

$$\Re(B^N) = 3.03.$$

But, by Definition 4:

$$A^N + B^N = ((7, 15, 21); 0.4, 0.5, 0.6)$$

$$\Re(A^N + B^N) = 6.21 \neq \Re(A^N) + \Re(B^N) = 6.94.$$

However, based on Definition 7. We get,

$$\Re(A^N + B^N) = \frac{(2 + 0.4 - 0.5 - 0.6)}{9} \times (22 + 21) = 6.94 = \Re(A^N) + \Re(B^N).$$

3. Linear fractional programming model

Right now, general model of LFP issue is examined. Besides, Charnes plus Cooper's [1] linear transformation is outlined.

$$\text{Max } Z(s) = \frac{\sum c'_j s_j + p}{\sum d'_j s_j + q} = \frac{F(s)}{G(s)} \quad (1)$$

Subject to

$$s \in S = \{s \in R^n . As \leq b, s \geq 0\}$$

where $j=1,2,\dots,n$, $A \in R^{m \times n}$, $b \in R^m$, $c, d \in R^n$, $p, q \in R$. Just for values of s , $G(s)$ might be equal to zero. In order to keep away from given situations, one requires which either $\{s \geq 0, As \leq b, \Rightarrow G(s) > 0\}$ or $\{s \geq 0, As \leq b, \Rightarrow G(s) < 0\}$. Since appliance, put on a well-known LFP problem provides the status that

$$\{s \geq 0, As \leq b, \Rightarrow G(s) > 0\} \quad (2)$$

Theorem 3.1[3]: Accept that no point $(s, 0)$ as well as $s \geq 0$ is feasible in the accompanying linear programming issue.

$$\begin{aligned} & \text{Max } c^t s + pt \\ & \text{Subject to} \\ & \quad d^t s + qt = 1, \\ & \quad As - bt = 0, \\ & \quad t > 0, s \geq 0, s \in R^n, t \in R. \end{aligned} \quad (3)$$

At that point, with the state of connection (2), the LFP issue (1) is equal in order to generallinear programming issue model (3).

Presently, think about the two associated issues

$$\begin{aligned} & \text{Max } tF(s/t) \\ & \text{Subject to} \end{aligned} \quad (4)$$

$$\begin{aligned} A(s/t) - b &\leq 0, \\ tG(s/t) &= 1, \\ t > 0, s &\geq 0. \end{aligned}$$

and,

$$\begin{aligned} &\text{Max } tF(s/t) \\ \text{Subject to } &A(s/t) - b \leq 0, \\ &tG(s/t) \leq 1, \\ &t > 0, s \geq 0. \end{aligned} \tag{5}$$

where, model (4) is acquired from model (1) through the change $t = 1/G(s)$, $z = ts$ and model (5) contrasts from the model (4) by supplanting the equity constraints $tG(s/t) = 1$ by inequality requirements $tG(s/t) \leq 1$.

Theorem 3.2[3]: On the off chance that the model (1) may be well-knownconcave-convex programming issue that arrives at a most extreme at a point S^* , then the comparing changed issue model (5) rises up sensational same limit at a point (t^*, s^*) wherever $\frac{s^*}{t^*} = x^*$. Additionally model (5) seems to have concave objective function along with a feasible convex set.

Suppose that:

$$\text{Max } Z(s) = \frac{F(s)}{G(s)} \tag{6}$$

$$\text{Subject to } s \in S = \{s \in R^n. As \leq b, s \geq 0\},$$

Where $F(s)$ may be concave as well as negative for every $s \in S$ and $G(s)$ may be concave as well as positive as to S , then

$$\text{Max}_{s \in S} \frac{F(s)}{G(s)} \Leftrightarrow \text{Min}_{s \in S} \frac{-F(s)}{G(s)} \Leftrightarrow \text{Max}_{s \in S} \frac{G(s)}{-F(s)},$$

where $-F(s)$ are often convex plus positive. In this manner, the issue (6) may be changed over into a well-knownconcave-convex programming issue changed into the accompanying linear programming issue:

$$\text{Max } tF(s/t)$$

$$\begin{aligned} \text{Subject to } & A(s/t) - b \leq 0, \\ & tG(s/t) \leq 1, \\ & t > 0, s \geq 0. \end{aligned} \quad (7)$$

4. Neutrosophic LFP model dependent on triangular numbers

At the present time, we proposed a general model for NLFP issue is examined.

$$\text{Max (or Min) } Z(s^M) = \frac{\sum c_j^M s_j + p^M}{\sum d_j^M s_j + q^M}$$

$$\text{Subject to} \quad (8)$$

$$\begin{aligned} \sum a_{ij}^M s_j &\leq b_i^M, i = 1, 2, \dots, m, \\ \sum a_{ij}^M s_j &= 1^M, i = 1, 2, \dots, m, \\ s_j &\geq 0, j = 1, 2, \dots, n. \end{aligned}$$

The first run through, Abdel-Basset [28] proposed another strategy for taking care of NLFP issue by utilizing a multi-target LP issue with just inequality constraints and gets an ideal arrangement. They utilize a technique to change over to its multi-objective, which is increment the quantity of factors and imperatives, while in our strategy, the quantity of requirements and factors stays unaltered. The proposed model contrasted with other technique is very tedious and expensive.

5. Proposed strategy

Right now, here we solve the model (8), we propose the following algorithm:

Step 1. Construct the problem as the model (8).

Step 2. By Definition 5, We assume that $c_j^N, p^N, d_j^N, q^N, a_{ij}^N$ and b_i^N are triangular neutrosophic for each $i = 1, 2, \dots, m$ & $i = 1, 2, \dots, n$ therefore, the model (8) can be composed as :

$$\text{Max (or Min) } Z(s^M) = \frac{\sum (c_{j1}, c_{j2}, c_{j3}; \mu_c, \nu_c, w_c) s_j + (p_1, p_2, p_3; \mu_p, \nu_p, w_p)}{\sum (d_{j1}, d_{j2}, d_{j3}; \mu_d, \nu_d, w_d) s_j + (q_1, q_2, q_3; \mu_q, \nu_q, w_q)}$$

subject to

$$\begin{aligned} \sum (a_{ij1}, a_{ij2}, a_{ij3}; \mu_a, \nu_a, w_a) s_j &\leq (b_{i1}, b_{i2}, b_{i3}; \mu_b, \nu_b, w_b), i = 1, 2, \dots, m. \\ \sum (a_{ij1}, a_{ij2}, a_{ij3}; \mu_a, \nu_a, w_a) s_j &= 1^M, i = 1, 2, \dots, m. \end{aligned} \quad (9)$$

$$s_j \geq 0, j = 1, 2, \dots, n.$$

Step 3. Utilizing aggregation ranking function, the model (9) convert into model (10) as :

$$\begin{aligned} \text{Max (or Min)} Z(s^M) &= \frac{\Re \sum (c_{j1}, c_{j2}, c_{j3}; \mu_c, v_c, w_c) s_j + (p_1, p_2, p_3; \mu_p, v_p, w_p)}{\Re \sum (d_{j1}, d_{j2}, d_{j3}; \mu_d, v_d, w_d) s_j + (q_1, q_2, q_3; \mu_q, v_q, w_q)} \\ \text{subject to} \end{aligned} \quad (10)$$

$$\Re \sum (a_{ij1}, a_{ij2}, a_{ij3}; \mu_a, v_a, w_a) s_j \leq \Re(b_{i1}, b_{i2}, b_{i3}; \mu_b, v_b, w_b), i = 1, 2, \dots, m.$$

$$\Re \sum (a_{ij1}, a_{ij2}, a_{ij3}; \mu_a, v_a, w_a) s_j = \Re(1^M), i = 1, 2, \dots, m.$$

$$s_j \geq 0, j = 1, 2, \dots, n.$$

Step 4. Utilizing Definition 7, the model (10) is changed over into next crisp model:

$$\begin{aligned} \text{Max (or Min)} Z(s^M) &= \frac{\left[\frac{(2 + \min \mu_c - \max v_c - \max w_c)}{9} \sum_{j=1}^n (c_{j1} + c_{j2} + c_{j3}) \right] s_j + \left[\frac{(2 + \min \mu_p - \max v_p - \max w_p)}{9} \sum_{j=1}^n (p_1 + p_2 + p_3) \right]}{\left[\frac{(2 + \min \mu_d - \max v_d - \max w_d)}{9} \sum_{j=1}^n (d_{j1} + d_{j2} + d_{j3}) \right] s_j + \left[\frac{(2 + \min \mu_q - \max v_q - \max w_q)}{9} \sum_{j=1}^n (q_1 + q_2 + q_3) \right]} \\ \text{subject to} \end{aligned} \quad (11)$$

$$\left[\frac{(2 + \min \mu_a - \max v_a - \max w_a)}{9} \sum_{j=1}^n (a_{ij1} + a_{ij2} + a_{ij3}) \right] s_j \leq \left[\frac{(2 + \min \mu_b - \max v_b - \max w_b)}{9} \sum_{j=1}^n (b_{i1} + b_{i2} + b_{i3}) \right]$$

$$\left[\frac{(2 + \min \mu_a - \max v_a - \max w_a)}{9} \sum_{j=1}^n (a_{ij1} + a_{ij2} + a_{ij3}) \right] s_j = 1,$$

$$s_j \geq 0, j = 1, 2, \dots, n.$$

Step 5. The model (11) is presently a crisp LFP issue. Presently the Model (11) is transformed into LP issue by utilizing the Charnes-Cooper strategy (or any well known technique).

Step 6. From Step 5, we use LINGO to take care of the fresh LP issue and get the ideal arrangement.

The flow chart describes the procedure of the proposed method as shown in Fig. 1.

6. Numerical Example

Here, we select a case of [28] to represent the model alongside correlation of existing technique.

Example-1 (Industrial Application)

Organization fabricates three sorts of items A, B and C with benefit round 8, 7 and 9 dollars for every component, separately. Be that as it may, the expense for every one component of the items is round 8, 9 and 6 dollars, individually. Additionally, it is accepted that a fixed expense of round 1.5 dollars is added to the cost work because of anticipated term through the procedure of production. Assume the materials required for assembling the items A, B and C are about 4, 3 and 5 component for each pound, separately. The stockpile given crude material is confined to round 28 pounds. Worker hour's accessibility for item A is around five hours, for item B is around three hours, and that for C is around three hours in manufacturing per component. Absolute worker hour's accessibility is round 20 hours day by day. Decide how many products of A, B and C ought to be made so as to maximize the complete benefit. Also during the entire procedure, the administrator wavers in expectation of parametric qualities due to some wild factors.

Let x_1, x_2 and x_3 component be the measure of A, B and C, individually to be created. After prediction of evaluated parameters, the above issue can be defined as the following NLFPP:

Step-1

$$\text{Max } Z = \frac{8^N x_1 + 7^N x_2 + 9^N x_3}{8^N x_1 + 9^N x_2 + 6^N x_3 + 1.5^N}$$

Subject to

$$4^N x_1 + 3^N x_2 + 5^N x_3 \leq 28^N$$

$$5^N x_1 + 3^N x_2 + 3^N x_3 \leq 20^N$$

$$x_1, x_2, x_3 \geq 0.$$

Here we consider,

$$8^N = (7, 8, 9; 0.5, 0.8, 0.3), 7^N = (6, 7, 8; 0.2, 0.6, 0.5), 9^N = (8, 9, 10.8, 0.1, 0.4), 6^N = (4, 6, 8; 0.75, 0.25, 0.1), \\ 1.5^N = (1, 1.5, 2; 0.75, 0.5, 0.25), 4^N = (3, 4, 5; 0.4, 0.6, 0.5), 3^N = (2, 3, 4; 1, 0.25, 0.3), 5^N = (4, 5, 6; 0.3, 0.4, 0.8) \\ 28^N = (25, 28, 30; 0.4, 0.25, 0.6), 20^N = (18, 20, 22; 0.9, 0.2, 0.6)$$

Step-2

Presently the issue is modified as follows:

$$Max Z = \frac{(7, 8, 9; 0.5, 0.8, 0.3)x_1 + (6, 7, 8; 0.2, 0.6, 0.5)x_2 + (8, 9, 10; 0.8, 0.1, 0.4)x_3}{(7, 8, 9; 0.5, 0.8, 0.3)x_1 + (8, 9, 10.8, 0.1, 0.4)x_2 + (4, 6, 8; 0.75, 0.25, 0.1)x_3 + (1, 1.5, 2; 0.75, 0.5, 0.25)}$$

Subject to

$$(3, 4, 5; 0.4, 0.6, 0.5)x_1 + (2, 3, 4; 1, 0.25, 0.3)x_2 + (4, 5, 6; 0.3, 0.4, 0.8)x_3 \leq (25, 28, 30; 0.4, 0.25, 0.6) \\ (4, 5, 6; 0.3, 0.4, 0.8)x_1 + (2, 3, 4; 1, 0.25, 0.3)x_2 + (2, 3, 4; 1, 0.25, 0.3)x_3 \leq (18, 20, 22; 0.9, 0.2, 0.6)$$

$$x_1, x_2, x_3 \geq 0.$$

Step-3

Utilizing Step 3 the aggregation function the issue might be composed as follows:

$$Max Z = \frac{\Re[(7, 8, 9; 0.5, 0.8, 0.3)x_1 + (6, 7, 8; 0.2, 0.6, 0.5)x_2 + (8, 9, 10; 0.8, 0.1, 0.4)x_3]}{\Re[(7, 8, 9; 0.5, 0.8, 0.3)x_1 + (8, 9, 10.8, 0.1, 0.4)x_2 + (4, 6, 8; 0.75, 0.25, 0.1)x_3 + (1, 1.5, 2; 0.75, 0.5, 0.25)]}$$

Subject to

$$\Re[(3, 4, 5; 0.4, 0.6, 0.5)x_1 + (2, 3, 4; 1, 0.25, 0.3)x_2 + (4, 5, 6; 0.3, 0.4, 0.8)x_3] \leq (25, 28, 30; 0.4, 0.25, 0.6) \\ \Re[(4, 5, 6; 0.3, 0.4, 0.8)x_1 + (2, 3, 4; 1, 0.25, 0.3)x_2 + (2, 3, 4; 1, 0.25, 0.3)x_3] \leq (18, 20, 22; 0.9, 0.2, 0.6)$$

$$x_1, x_2, x_3 \geq 0.$$

Step-4

By applying Step 4. And the problem converted into the crisp model.

$$Max Z = \frac{3.73x_1 + 2.1x_2 + 6.9x_3}{3.73x_1 + 6.9x_2 + 4.8x_3 + 1}$$

Subject to

$$1.73x_1 + 2.45x_2 + 1.83x_3 \leq 14.29$$

$$1.83x_1 + 2.45x_2 + 2.45x_3 \leq 14$$

$$x_1, x_2, x_3 \geq 0.$$

Step-5

As per the Step-5, we transform the crisp LFP problem into the crisp LP problem and solved by any popular method.

$$Max Z(y, t) = 3.73y_1 + 2.1y_2 + 6.9y_3$$

Subject to

$$3.73y_1 + 6.9y_2 + 4.8y_3 + t \leq 1,$$

$$1.73y_1 + 2.45y_2 + 1.8y_3 - 14.29t \leq 0,$$

$$1.83y_1 + 2.45y_2 + 2.45y_3 - 14t \leq 0,$$

$$y_1, y_2, y_3, t \geq 0.$$

Step-6

The ideal arrangement of the above CLP issue is explained by LINGO 18.0 and gets the ideal arrangement is:

$$y_1 = 0 = y_2, y_3 = 0.2, t = 0.25$$

Finally, the objective solution is 1.4.

Table-1. Comparison of the objective function

Objective value	Proposed Method	Existing Method[28]
y_1	0	0
y_2	0	0
y_3	0.2	0.0893
T	0.25	0.1429
Z	1.4	1

In Abdel Basset et al.'s method [28] the optimal solution of the objective functions are:

$$\tilde{y}_1 = (y_1, y_2, y_3) = (0, 0, 0.0893), T = 0.1429$$

The objective value is:

$$Z=1$$

In our proposed the optimal solution of the objective functions is:

$$\tilde{y}_1 = (y_1, y_2, y_3) = (0, 0, 0.2), T = 0.25$$

The objective value is:

$$Z=1.4$$

By comparing the results of proposed method with Abdel-Basset et al.'s method, based on Definition 2.7, we can conclude that our result is better than the existing result, because:

$$(\tilde{c}\tilde{x}^*)_{\text{proposed method}} = 1.4 > (c^t x)_{\text{Abdel-Basset et al.'s method}} = 1$$

From the above table, unmistakably the proposed target work is expanding contrast with existing strategy [28]. Therefore, our method is superior and the elapsed time is very less than the existing method. Subsequently we may reason that the proposed arrangement is increasingly exact.

It is pointed out that the proposed method is no restriction of all variables and parameters and the obtained results are satisfied all the constraints. We used in neutrosophic sets of the objective function is neglected by linear ranking function in decision makers.

Our model represents reality efficiently than existing model, because we consider all aspects of decision-making process in our calculations (i.e. the truthiness, indeterminacy, and falsity degree). Our model reduces complexity of problem, by reducing the number of constraints and variables. Their model is a time-consuming and complex, but our model is not.

In our proposed model, we solved both inequality and equality constraints (mixed constraints), but in existing model they have concentrated only inequality constraints. Hence, it is very easy and comfortable for applied in real life application as compared as to existing methods.

7. Conclusions

Right now, present the neutrosophic LFP and propose a novel model to illuminate it. Another ranking function is acquainted with defeat the current strategy. The new ranking function gives the augmenting the target work an incentive in neutrosophic LFP issue. Additionally, we utilize a

mechanical application issue to represent the common sense and legitimacy of the proposed technique. At long last, from the acquired outcomes, it very well may be inferred that the model is proficient and helpful.

8. Compliance with Ethical Standards

8.1 Conflict of Interest

All the authors declare that they have no conflict of interest.

8.2 Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

References

- [1] A. Charnes and W. W. Cooper, Programming with linear fractional functions, *Nav. Res. Log. Quar.* 9 (1962) 181-186.
- [2] B. Pop and I. M. Stancu-Minasian, A method of solving fully fuzzified linear fractional programming problems, *J. of Appl. Math. Comp.* 27 (2008) 227-242.
- [3] Krassimir T. Atanassov, Intuitionistic fuzzy sets, *Fuzzy sets*, 20 (1986) 87-96.
- [4] C. Veeramani and M. Sumathi, Fuzzy mathematical programming approach for solving fuzzy linear fractional programming problem, *RAIRO Oper. Res.* 48 (2014) 109-122.
- [5] L. A. Zadeh, Fuzzy Sets, *Inf. and Cont.* 8 (1965) 338-353.
- [6] N. Mahdavi-Amiri, S. H. Nasser, Duality in fuzzy number linear programming by use of a certain linear ranking function, *Appl. Math. Comp.* 180 (2006) 206-216.
- [7] N. Safaei, A new method for solving fully fuzzy linear fractional programming with triangular fuzzy numbers, *3* (2014) 273-281
- [8] S. Das and T. Mandal, A single stage single constraints linear fractional programming problem: An approach, *Oper. Res. and Appl. : An Inter. J.* 2 (2015) 1-5.
- [9] S. M. Hashemi, M. Modarres, E. Nasrabadi, M. M. Nasrabadi, Fully fuzzified linear programming, solution and duality, *J. Intell. Fuzzy Syst.* 17 (2006) 253-261.
- [10] S. Das, T. Mandal, S. A. Edalatpanah, A new approach for solving fully fuzzy linear fractional programming problems using multi objective linear programming problem, *RAIRO- Operations Research*, 51 (2017) 285-297.

- [11] S.Das, T.Mandal, S.A.Edalatpanah, A mathematical model for solving fully fuzzy linear programming problem with trapezoidal fuzzy numbers, *Applied Intelligence*, 46(2016)509-519.
- [12] S.Das, T.Mandal, S.A.Edalatpanah, A New Procedure for Solving Fuzzy Linear Fractional Programming Problem: Numerical Point of View, *Journal of Computational Science*, (2018) (In press).
- [13] S.Das, T.Mandal, S.A.Edalatpanah, “A new method for solving fuzzy linear fractional programs with Triangular Fuzzy numbers, *International Journal of Mathematical Engineering and Science (IJMES)*, 4(2015)22-29.
- [14] S.Das, T.Mandal, S.A.Edalatpanah, A note on “A new method for solving fully fuzzy linear fractional programming with a triangular fuzzy numbers”, *App.Math.and Comp.Intel.*, 4 (2015) 361–367.
- [15] S.Das, T.Mandal, S.A.Edalatpanah, A new method for solving linear fractional programming problem with absolute value functions, *International Journal of Operation Research*, (2016) (In Press).
- [16] S.Das, T.Mandal, A general form of fuzzy linear fractional programs with trapezoidal fuzzy numbers, *International Journal of Data Envelopment Analysis and Operations Research*, 1 (2016), 16-19.
- [17] S.Das, T.Mandal, S.A.Edalatpanah, Erratum to: A mathematical model for solving fully fuzzy linear programming problem with trapezoidal fuzzy numbers, *Applied Intelligence*, 46(2017) 520-520.
- [18] S.Das, T.Mandal, A new model for solving fuzzy fuzzy linear fractional programming problem with ranking function. *Journal of Applied Research on Industrial Engineering*. 4(2017), 189-96.
- [19] S.Das, T.Mandal, A MOLFP method for solving linear fractional programming under fuzzy environment, *International Journal of Research in Industrial Engineering*, 6(2017), 202-213.
- [20] S.Das, Modified Method for Solving Fully Fuzzy Linear Programming Problem with Triangular Fuzzy Numbers, *International Journal of Research in Industrial Engineering*, 6(2017), 293-311.
- [21] S.Schaible, Fractional programming II: duality, *Manage.Sci.*, 22 (1976) 658-667.

- [22] Veeramani, C. and M. Sumathi, Solving the linear fractional programming problem in a fuzzy environment: Numerical approach. *Applied Mathematical Modelling*, 2016. 40(11–12): pp. 6148-6164.
- [23] Stanojević, B. and Stanojevic, M. i, Solving method for linear fractional optimization problem with fuzzy coefficients in the objective function, *International Journal of Computers Communication & Control*, 2013, 8:p.136-145.
- [24] Saberi Najafi, H. and S. Edalatpanah, A Note on “A new method for solving fully fuzzy linear programming problems”. *Applied Mathematical Modelling*, 2013. 37(14): pp. 7865-7867.
- [25] Saberi Najafi, H., S.A. Edalatpanah, and H. Dutta, A nonlinear model for fully fuzzy linear programming with fully unrestricted variables and parameters. *Alexandria Engineering Journal*, 2016.
- [26] A. Mehra, S. Chandra and C. R. Bector, Acceptable optimality in linear fractional programming with fuzzy coefficients, *Fuzzy Optimization Decision Making*, 6,5-16 (2007).
- [27] Smarandache, F. *A Unifying Field in Logics: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability: Neutrosophic Logic. Neutrosophy, Neutrosophic Set, Neutrosophic Probability*, Infinite Study.
- [28] M. Abdel-basset, M. Mohamed and F. Smarandache, Linear fractional programming based on triangular neutrosophic numbers, *International Journal of Applied Management Sciences*, 11, 11-20, (2019).
- [29] P. Biswas, S. Pramanik & B. C. Giri, TOPSIS method for multi-attribute group decision making under single-valued neutrosophic environment, *Neural Computing and Applications*, 27(3), 727-737.
- [30] M. Darehmira, A solution for the neutrosophic linear programming problem with a new ranking function, *Optimization theory based on Neutrosophic and Plithogenic Sets*, (2020).
- [31] A. Nafei et al., A new method for solving interval neutrosophic linear programming problems, *Acta Polytechnica Hungarica*, (2020), 11-17

- [32]Edalatpanah, S. A., & Smarandache, F.(2019).Data Envelopment Analysis for Simplified Neutrosophic Sets.Neutrosophic Sets and Systems, 29, 215-226.
- [33]Edalatpanah, S.A.(2019).A Nonlinear Approach for Neutrosophic Linear Programming.Journal of Applied Research on Industrial Engineering, 6(4), 358-366.
- [34]Edalatpanah, S.A.(2020).A Direct Model for Triangular Neutrosophic Linear Programming.International Journal of Neutrosophic Science i, 11(1), 15-24.
- [35]Ammar, E. S., & Eljerbi, T.(2019).On solving fuzzy rough multiobjective integer linear fractional programming problem.Journal of Intelligent & Fuzzy Systems, (Preprint), 11-13.
- [36]Stanojevic, B., Dzitic, S., & Dzitic, I.(2020).Crisp-linear-and Models in Fuzzy Multiple Objective Linear Fractional Programming. International Journal of Computers, Communications & Control,15(1).
- [37]Arya, R., & Singh, P.(2019).Fuzzy efficient iterative method for multi-objective linear fractional programming problems.Mathematics and Computers in Simulation, 160, 39-54.
- [38]Arya, R., Singh, P., Kumari, S., & Obaidat, M.S.(2019).An approach for solving fully fuzzy multi-objective linear fractional optimization problems.Soft Computing, 11-15.
- [39]Nayak, S., & Ojha, A.K.(2019).Multi-objective Linear Fractional Programming Problem with Fuzzy Parameters.In Soft Computing for Problem Solving (pp. 79-90).Springer, Singapore.
- [40]Nayak, S., & Ojha, A.(2019).On multi-level multi-objective linear fractional programming problem with interval parameters. RAIRO-Operations Research,53(5), 1601-1616.
- [41]Perić, T., Babić, Z., & Rešić, S.(2020).A Fuzzy Linear Programming Approach to Solve Bi-level Multi-objective Linear Programming Problems.In Advances in Operational Research in the Balkans (pp. 125-135).

- [42]Mohamed,iM., iAbdel-Basset, iM., iZaied, iA.iN.iH., i& iSmarandache, iF. (2017). iNeutrosophic iinteger iprogramming iproblem.iInfinite iStudy.
- [43]Abdel-Baset,iM., iHezam, iI.iM., i& iSmarandache, iF.i(2016). Neutrosophic igoal iprogramming.iNeutrosophic iSets i& iSystems, i11, i25-34.
- [44]Mohamed,iM., iAbdel-Baset, iM., iHussein, iN., i& iSmarandache, iF. Neutrosophic ilinear ifractional iprogramming iproblem.iOctogon Mathematical iMagazine, ivol,25, ino i1, ipp i202-220.i(2017)
- [45]Pramanik, iS., i& iDey, iP.iP.i(2018).iBi-level ilinear iprogramming problem iwith ineutrosophic inumbers.iNeutrosophic iSets iand iSystems, 21(1), i12.
- [46]Pramanik, iS., i& iBanerjee, iD.i(2018).iNeutrosophic inumber igoal programming ifor imulti-objective ilinear iprogramming iproblem iin neutrosophic inumber ienvironment.iInfinite iStudy.
- [47]Hezam, iI.iM., iAbdel-Baset, iM., i& iSmarandache, iF.i(2017). Neutrosophic igoal iprogramming.iInfinite iStudy.
- [48]Ahmad,iF., iAdhami, iA.iY., i& iSmarandache, iF.i(2018).iSingle ivalued neutrosophic ihesitant ifuzzy icomputational ialgorithm ifor imultiobjective nonlinear ioptimization iproblem.iInfinite iStudy.
- [49]Smarandache,iF., iAbdel-Basset, iM., i& iZhou, iY.i(Eds.).i(2017). Neutrosophic iOperational iResearch, iVol. iI.iInfinite iStudy.
- [50]Maiti,iL., iMandal, iT., i& iPramanik, iS.i(2019).iNeutrosophic igoal programming istrategy ifor imulti-level imulti-objective ilinear programming iproblem.iJournal iof iAmbient iIntelligence iand iHumanized Computing, i1-12.
- [51]Pramanik, iS., i& iDey, iP.iP.i(2019).iMulti-level ilinear iprogramming problem iwith ineutrosophic inumbers: iA igoal iprogramming istrategy. Neutrosophic iSets i& iSystems, i29.
- [52]Pramanik, iS., iMallick,iR., i& iDasgupta, iA.i(2018).iNeutrosophic iGoal Geometric iProgramming iProblem ibased ion iGeometric iMean iMethod iand iits Application.iNeutrosophic iSets iand iSystems, i20(1), i11.

- [53] S.Das, J.K. Dash, (2020). Modified solution for neutrosophic linear fractional programming problems with mixed constraints. International Journal of Research in Industrial Engineering 9(1), 13-24.
- [54] S.Das, S.A. Edalatpanah, J.K. Dash (2021). A novel lexicographical based method for trapezoidal neutrosophic linear programming problem, Neutrosophic Sets and Systems, 46(1), 12-26.
- [55] J.iYe, iNeutrosophic inumber ilinear iprogramming imethod iand iits iapplication iunder ineutrosophic inumber ienvironments, iSoft iComputing, i22(14)(2018) i4639-4646.
- [55]iJ.Ye, iPriortized iaggregation ioperators iof itrapezoidal iintuitionistic ifuzzy isets iand itheir iapplication ito imulticriteria idecision imaking, iNeural iComputation iApplication, i25 i(6) i(2014) i1447-1454.