An Interactive Approach for Solving Fuzzy Multi-objective Assignment Problems

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Authors’ contributions

This work was carried out in collaboration between both authors. Author HAK formulate the mathematical model, designed the steps of the interactive approach, wrote the first draft of the manuscript and did the analysis of the study. Author MAS wrote the literature review, provided the idea of the problem, checked the numerical results and the whole manuscript. Both authors read and approved the final manuscript.

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Abstract

This paper aims to study fuzzy multi-objective assignment (F-MOAS) problem. The problem is considered by incorporating trapezoidal fuzzy numbers. Through the $\alpha -$ level sets, the problem under consideration is converted into the corresponding ($\alpha -$ MOAS). An interactive approach to improve the weights in the Weighted Tchebysheff program is suggested. Then the stability set of the first kind without differentiability corresponding to the resulted solution is determined. A numerical example is given for illustration.

Keywords: Multi-objective assignment problem; fuzzy numbers; interactive decision making; $\alpha -$ efficient solution; parametric study.

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1 Introduction


The rest of the paper is as follows: In section 2, a fuzzy multi-objective assignment (F-MOAS) problem is investigated as specific definition. In section 3, an interactive approach is suggested for solving the $\alpha -$ MOAS problem. The stability set of the first kind corresponding to the obtained solution is determined in section 4. A numerical example is given for illustration in section 5. Finally, some concluding remarks are reported in section 6.

2 Problem Formulation and Solution Concepts

Consider the following fuzzy assignment problem:
(F-MOAS) \[ \min \tilde{Z}_r(x, \tilde{c}^r) = \sum_{i=1}^{n} \sum_{j=1}^{n} \tilde{c}_{ij}^r x_{ij}, \quad r = 1, 2, 3, \ldots, l \]

Subject to
\[ \sum_{j=1}^{n} x_{ij} = 1, \quad j = 1, 2, \ldots, n \] (Only one person should be assigned the \( j \)th job)
\[ \sum_{j=1}^{n} x_{ij} = 1, \quad i = 1, 2, \ldots, n \] (Only one job is done by the \( i \)th person)
\[ x_{ij} = 0 \text{ or } 1. \]

Where, \( x_{ij} (i = j = 1, 2, \ldots, n) \) denotes that \( j \)th job is to be assigned to the \( i \)th person, \( \tilde{c}_{ij}^r (i = j = 1, 2, \ldots, n; r = 1, 2, \ldots, l) \) represent fuzzy parameters coefficients. These fuzzy parameters are characterized by fuzzy numbers.

**Definition 1.** (Fuzzy efficient solution). A point \( x^* \in \mathcal{X} \) (\( \mathcal{X} \) is the feasible region) is said to be fuzzy efficient solution of the (F-MOAS) problem if \( \tilde{Z}_r(x^*, \tilde{c}^r) \leq \tilde{Z}_r(x, \tilde{c}^r) \) with \( \tilde{Z}_r(x^*, \tilde{c}^r) < \tilde{Z}_r(x, \tilde{c}^r) \) holds for at least one \( r = 1, 2, \ldots, l \).

**Definition 2.** The \( \alpha \) - level set of the fuzzy numbers \( \tilde{c}_{ij}^r \) is defined as the ordinary set \( L_\alpha(\tilde{c}_{ij}^r) \) for which the degree of their membership functions exceeds the level \( \alpha \):
\[ L_\alpha(\tilde{c}) = \left\{ c : \mu_{\tilde{c}_{ij}^r}(c_{ij}^r) \geq \alpha, \quad i = j = 1, 2, \ldots, n; \quad r = 1, 2, \ldots, l \right\} \]

For a certain degree of \( \alpha \), the (F-MOAS) problem can be written as in the following non fuzzy form (Rockefeller [26]):

(\( \alpha \) MOAS) \[ \min Z_r(x, c^r) = \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij}^r x_{ij}, \quad r = 1, 2, 3, \ldots, l \]

Subject to
\[ \sum_{j=1}^{n} x_{ij} = 1; \quad \forall j \]
\[ \sum_{j=1}^{n} x_{ij} = 1; \quad \forall i \]
\[ x_{ij} = 0 \text{ or } 1, \quad c_{ij}^r \in L_\alpha(\tilde{c}_{ij}^r), \quad i = j = 1, 2, \ldots, n; \quad r = 1, 2, \ldots, l. \]

**Definition 3.** A point \( x^*_{\alpha} \) is called \( \alpha \) - Pareto optimal solution to the (\( \alpha \) MOAS) problem, if and only if there does not exist another \( x, \ c_{ij}^r \in L_\alpha(\tilde{c}_{ij}^r) \) such that: \( Z_r(x, c_{ij}^r) \leq Z_r(x^*_{\alpha}, c_{ij}^{\alpha*}), i = j = 1, \ldots, n; \quad r = 1, \ldots, l, \) with strict inequality holding for at least one \( r \), where the corresponding values of parameters \( c_{ij}^{\alpha*} \) are called \( \alpha \) - level optimal parameters.
The (α MOAS) problem can be resolved by using Weighting Tchebyseff problem
\[
\min_i \max_{r \in I_i} \left\{ w_r \left( Z_r(x, c') - Z_r^* \right) : c \in L_\alpha (\bar{c}) \right\}
\] (1)

Or equivalently,
\[
\min \left\{ \lambda : w_r \left( Z_r(x, c') - Z_r^* \right) \leq \lambda, r = 1, 2, \ldots, l; \ x \in X, c \in L_\alpha (\bar{c}) \right\}
\] (2)

Where, \( w_r \geq 0, r = 1, \ldots, l, \ 0 \leq \lambda_r \in R, \) and \( Z_r^* \) are the reference point.

### 3 The Stability Set of the First Kind

In this section, the stability set of the first kind without differentiability is determined. By applying the following conditions:

\[
\xi_{ij}^r (c^r - d_{ij}^r) = 0,
\]

\[
\xi_{ij}^r (d_{ij}^r - c^r) = 0,
\]

\[
\xi_{ij}^r, \xi_{ij}^r \geq 0, i = j = 1, 2, \ldots, n; \ r = 1, 2, \ldots, l.
\]

Where, \( \left[ (d_{ij}^r), (d_{ij}^r) \right] = L_\alpha (\bar{c}^r), r = 1, 2, \ldots, l. \)

Consider the following three cases:

**Case 1:** \( \xi_{ij}^r > 0, \ r \in I_1 \subset \{1, 2, \ldots, l\}, \xi_{ij}^r = 0, r \notin I_1, i = j = 1, 2, \ldots, n. \)

\( \xi_{ij}^r > 0, \ r \in I_2 \subset \{1, 2, \ldots, l\}, \xi_{ij}^r = 0, r \notin I_2. \)

Let \( M \) be the set of all proper subsets of \( \{1, 2, \ldots, l\} \). Then \( S_{l_1, l_2}(x^*, c^*) \) is given by:

\[
S_{l_1, l_2}(x^*, c^*) = \left\{ \left[ (d_{ij}^r), (d_{ij}^r) \right] \in R^{2l} : (d_{ij}^r)^r = c^r, r \in I_1; (d_{ij}^r)^r \geq c^r, r \notin I_1; (d_{ij}^r)^r = c^r, r \in I_2 \right\}.
\] (3)

Hence,

\[
S_1(x^*, c^*) = \bigcup_{l_1, l_2 \in M} S_{l_1, l_2}(x^*, c^*). \] (4)

**Case 2:** \( \xi_{ij}^r, \xi_{ij}^r = 0, r = 1, 2, \ldots, l; i = j = 1, 2, \ldots, n. \)

Then \( S_2(x^*, c^*) \) is given by:

\[
S_2(x^*, c^*) = \left\{ \left[ (d_{ij}^r), (d_{ij}^r) \right] \in R^{2l} : (d_{ij}^r)^r \geq c^r, r = 1, 2, \ldots, l; (d_{ij}^r)^r \leq c^r, r = 1, 2, \ldots, l \right\}
\] (5)
Case 3: \( \zeta_{ij}^1, \xi_{ij}^r > 0, r = 1,2,...,l; i = j = 1,2,...,n. \)

Then \( S_j(x^*, c^*) \) is given by:

\[
S_j(x^*, c^*) = \left\{ \left( d_{ij}^r \right)^2, \left( d_{ij}^r \right)^2 \right\} \in \mathbb{R}^{2l} : \left( d_{ij}^r \right)^2 = c^r, r = 1,2,...,l; \left( d_{ij}^r \right)^2 = c^r, r = 1,2,...,l \}
\]

Thus \( S(x^*, c^*) = \bigcup_{q=1}^{3} S_q(x^*, c^*) \).

4 Interactive Approach

In this section an interactive approach to solve the (F-MOAS) problem is introduced as in the following steps:

**Step 1:** Ask the decision maker (DM) to specify the initial value of \( \alpha (0 < \alpha < 1) \) to formulate the problem (\( \alpha \) MOAS).

**Step 2:** Find \( Z_r^* \) by solving the following problem

\[(P_1) \quad \max_{r=1,2,...,l} \eta_r \]

Subject to

\[Z_r(x, c^r) \geq \eta_r, \]

\[x \in X, \ c \in L_\alpha (\bar{c}^r), r = 1, ..., l; \eta_r \in R. \]

**Step 3:** Given an initial reference point. DM provides an initial reference point \( \bar{Z}_r^0 \) such that

\[\bar{Z}_r > Z_r^* \text{ Let } J = \{1,2,...,l\}, J^0 = J, h = 0.\]

**Step 4:** Search for an \( \alpha \) - Pareto optimal solution. Let \( \bar{W}_r = (\bar{Z}_r - Z_r^*)^{-1}, r = 1,2,...,l, \) solve the Weighting Tchebysheff problem (2) at \( h \) - iteration .

\[(P_2) \quad \min \lambda \]

Subject to

\[w_r \left( Z_r(x, c^r) - Z_r^* \right) \leq \lambda, r \in J^h, \]

\[x \in X, \ \mu_{r^p} (c^r) \geq \alpha^h, p \in J^h. \]

Where \( J^h = J^0 \setminus \{p\} \) and solve to obtain \( \alpha \) - Pareto optimal \( \left(x^h, c^h\right) \).
Step 5: Find the set of parameters $S(x^h, c^h)$ corresponding to $\left( x^h, c^h \right)$ from the (3)-(7).

Step 6: Determine the termination. Ask the DM to compare

$$\left( Z_1(x^h, c^h), Z_2(x^h, c^h),..., Z_l(x^h, c^h) \right) \text{ with } \left( Z_1^*, Z_2^*,..., Z_l^* \right),$$

then there exists two cases:

(a) If the DM is satisfied with the current Pareto optimal solution, go to step 8 and stop - the best compromise solution is found.

(b) If there is no satisfactory objective and level of the Pareto optimal solution, go to step 8 and stop - no best compromise solution is found by this approach.

Step 7: Modify the reference point.

(i) The DM chooses $g_h$ in $J^h$ such that $Z_{g_h}$ is an unsatisfactory objective in $\{ Z_r : r \in J^h \}$ at $Z_r(x^h, c^h)$. Let $J^{h+1} = J^h \setminus \{ g_h \}$. Separate $J^{h+1}$ into the following two parts:

Part 1: $J^h = \{ r \in J^{h+1} : Z_r(x^h, c^h) < \bar{Z}_r^h, \text{ and DM wishes to release the value of } Z_r \}.$

Part 2: $J^h = J^{h+1} / J.$

(ii) For $r \in J_l^h$, the DM introduces $\Gamma_r^h$ the amount to be relaxed for $Z_r$ at $Z_r(x^h, c^h)$ such that $\Gamma_r^h \in \left[ 0, \left( \bar{Z}_r^h - Z_r(x^h, c^h) \right) \right]$. Let $Z_{r}^{h+1} = Z_r(x^h, c^h) + \Gamma_r^h$. For $r \in J_2^h$, let $i \in J_2^h$, and $Z_{r}^{h+1} = Z_r(x^h, c^h)$. For $r \in J^h \setminus J^{h+1}$, let $Z_{r}^{h+1} = \bar{Z}_r^h$.

(iii) In the case that $Z_{r}^{h+1} = Z_r(x^h, c^h)$ for all $r \in J^h \setminus \{ g_h \}$, return to (i) to separate $J^{h+1}$ again or to (ii) to increase the amount to be relaxed for some $Z_r(r \in J^h)$ at $Z_r(x^h, c^h)$, if the DM wishes to do so. Otherwise, stop and there is not satisfactory $\alpha$- Pareto optimal solution. In the case that $Z_{r}^{h+1} \neq Z_r(x^h, c^h)$ for some $r \in J^h \setminus \{ g_h \}$, go to (iv).

(iv) Let $g = g_h$, $Z_r = Z_{r}^{h+1}$, $r = 1, ..., l, r \neq g_h$, and solve the following auxiliary problem

\[(Ps) \quad \min Z_g(x, g_h) \]

Subject to

$$Z_r(x, c^r) \leq Z_r, \quad r \neq g,$$

$$x \in X, \quad c \in L_o(c^r), r = 1, 2, ..., l.$$ 

Let $(x^h, c^h)$ be an optimal solution. When $Z_{g_1}(x^h, c_{g_1}^h) = Z_{g_2}(x^h, c_{g_2}^h)$ or $Z_{g_3}(x^h, c_{g_3}^h)$, for objective $Z_{g_4}$ is not satisfactory to the DM, return to (ii) to increase the amount to be relaxed for some $Z_r(r \in J_1^h)$ at $Z_r(x^h, c^r)$ if the DM wishes to do so. Otherwise, go to step 8, there is no satisfactory
\( \alpha - \) Pareto optimal solution. When \( Z_{g_s}(x^a, c_{g_s}^a) \neq Z_{g_s}(x^b, c_{g_s}^b) \) and \( Z_{g_s}(x^a, c_{g_s}^a) \) for objective \( Z_{g_s} \) is satisfactory to the DM (he/ she) provides \( \Gamma_{g_s}^h \), the largest amount to be improved for \( Z_{g_s} \) at \( Z_{g_s}(x^c, c_{g_s}^c) \), such that \( \Gamma_{g_s}^h \in [0, \left( Z_{g_s}(x^b, c_{g_s}^b) - Z_{g_s}(x^a, c_{g_s}^a) \right)] \) Let \( \overline{Z}_{g_s}^{h+1} = Z_{g_s}(x^b, c_{g_s}^b) \backslash \Gamma_{g_s}^h \).

(v) If \( \overline{Z}_{g_s}^{h+1} < Z_{g_s}(x^a, c_{g_s}^a) \), let \( h = h + 1 \) and return to step (iii). Otherwise, let \( (x^{h+1}, c_{g_s}^{h+1}) = (x^a, c_{g_s}^a) \), let \( h = h + 1 \), and return to step (iv) when \( (x^a, c_{g_s}^a) \) is an unique optimal solution of the problem \( (P_i) \) or let \( (x^a, c_{g_s}^a) \) be an optimal solution of the problem \( (2) \). Let \( h = h + 1 \), and return to step (iii). If \( \overline{Z}_{g_s}^{h+1} \geq Z_{g_s}(x^a, c_{g_s}^a) \), let \( h = h + 1 \) and return to step 4.

Step 8: Stop.

5 Numerical Example

Consider the following problem

\[
\min_{x, c'} Z_c(x, c') = \sum_{r=1}^{3} \sum_{j=1}^{3} c_j' x_{ij}, \quad r = 1, 2
\]

Subject to

\[
\begin{align*}
\sum_{j=1}^{3} x_{ij} &= 1; \forall j \\
\sum_{i=1}^{3} x_{ij} &= 1; \forall i \\
x_{ij} &= 0 \text{ or } 1.
\end{align*}
\]

With membership functions

\[
\mu_{\alpha_{ij}}(c_{ij}') = \begin{cases} 
0, & \text{if } -\infty < c_{ij}' \leq (c_{ij}')^b, \\
1 - \left( \frac{c_{ij}' - (c_{ij}')^a}{(c_{ij}')^b - (c_{ij}')^a} \right)^3, & \text{if } (c_{ij}')^a \leq c_{ij}' \leq (c_{ij}')^b, \\
1, & \text{if } i = j, 1 \leq i, j \leq 3, \\
1 - \left( \frac{c_{ij}' - (c_{ij}')^a}{(c_{ij}')^b - (c_{ij}')^a} \right)^3, & \text{if } (c_{ij}')^a \leq c_{ij}' \leq (c_{ij}')^b, \\
0, & \text{if } (c_{ij}')^a \leq c_{ij}' < \infty
\end{cases}
\]

Where,

\[
\begin{align*}
c_{ij}^1 &= (7, 9, 10, 11), \quad c_{ij}^2 = (5, 7, 8, 10), \quad c_{ij}^3 = (12, 14, 15, 17), \quad c_{ij}^4 = (10, 12, 13, 15), \quad c_{ij}^5 = (9, 11, 12, 14), \\
c_{ij}^6 &= (10, 12, 13, 15), \quad c_{ij}^7 = (5, 7, 8, 10), \quad c_{ij}^8 = (7, 9, 10, 11), \quad c_{ij}^9 = (6, 8, 9, 11), \quad c_{ij}^{10} = (10, 12, 13, 15), \\
c_{ij}^{11} &= (12, 14, 15, 17), \quad c_{ij}^{12} = (5, 7, 8, 10), \quad c_{ij}^{13} = (7, 9, 10, 11), \quad c_{ij}^{14} = (16, 19, 20, 22), \quad c_{ij}^{15} = (9, 11, 12, 14), \\
c_{ij}^{16} &= (12, 14, 15, 17), \quad c_{ij}^{17} = (7, 9, 10, 11), \quad c_{ij}^{18} = (9, 11, 12, 14)
\end{align*}
\]
Step 1: Take $\alpha = 0.5$, then

\[
8 \leq c^1_{11} \leq 10.5, \ 6 \leq c^1_{12} \leq 9, \ 13 \leq c^1_{13} \leq 16, \ 11 \leq c^1_{21} \leq 14, \ 10 \leq c^1_{22} \leq 13, \ 11 \leq c^1_{23} \leq 14, \\
6 \leq c^2_{11} \leq 9, \ 8 \leq c^2_{12} \leq 10.5, \ 7 \leq c^2_{13} \leq 10, \ 11 \leq c^2_{21} \leq 14, \ 13 \leq c^2_{22} \leq 16, \ 6 \leq c^2_{23} \leq 9, \\
8 \leq c^2_{21} \leq 10.5, \ 17.5 \leq c^2_{22} \leq 21, \ 10 \leq c^2_{23} \leq 13, \ 13 \leq c^2_{31} \leq 16, \ 8 \leq c^2_{32} \leq 10.5, \ 10 \leq c^2_{33} \leq 13.
\]

Then the non-fuzzy ($\alpha$ MOAS) problem is

\[
\begin{align*}
\min Z_1(x, c^1) & = [8,10.5] x_{11} + [6,9] x_{12} + [13,16] x_{13} + [11,14] x_{21} + [10,13] x_{22} + [11,14] x_{23} \\
& \quad + [6,9] x_{31} + [8,10.5] x_{32} + [7,10] x_{33} \\
\min Z_2(x, c^2) & = [11,14] x_{11} + [13,16] x_{12} + [6,9] x_{13} + [8,10.5] x_{21} + [17,5,21] x_{22} + [10,13] x_{23} \\
& \quad + [13,16] x_{31} + [8,10.5] x_{32} + [10,13] x_{33} \\
\end{align*}
\]

Subject to

\[
\sum_{j=1}^{3} x_{ij} = 1, \\
\sum_{i=1}^{3} x_{ij} = 1, \\
x_{ij} = 0 \text{ or } 1 (i = j = 1,2,3).
\]

Step 2: Solve the problem (P$_1$) to get $Z^*_r$ as

\[
\max_{r=1,2} \eta_r
\]

Subject to

\[
\begin{align*}
10 x_{11} + 8 x_{12} + 15 x_{13} + 13 x_{21} + 12 x_{22} + 13 x_{23} + 8 x_{31} + 10 x_{32} + 9 x_{33} & \geq \eta_1, \\
13 x_{11} + 15 x_{12} + 8 x_{13} + 10 x_{21} + 20 x_{22} + 12 x_{23} + 15 x_{31} + 10 x_{32} + 12 x_{33} & \geq \eta_2, \\
\sum_{i=1}^{3} x_{ij} & = 1, \\
\sum_{j=1}^{3} x_{ij} & = 1, \\
x_{ij} & = 0 \text{ or } 1 (i = j = 1,2,3). \\
\eta_r & \in R, \ r = 1,2.
\end{align*}
\]

The solution is

\[
x^* = (0,1,1,1,0,1,1,0), c^r = (10,8,15,13,12,13,8,10,9), c^r' = (13,14,8,10,20,12,15,10,12), \\
Z^*_1 = Z_2(x^*, c^r) = 67, \quad Z^*_2 = Z_2(x^*, c^r') = 70.
\]
Step 3: Ask the DM to provide an initial reference point $Z^0_r$ such that $Z^0_r > Z^*_r$.

$$Z^0_1 = (55, 72.5)^T, \quad Z^0_2 = (58, 75)^T, \quad Z^0 (69, 72)^T.$$  

Step 4: Find $\overline{w}_1 = \frac{1}{2}$, $\overline{w}_2 = \frac{1}{2}$.

Solve the following problem

$$\min \lambda$$

Subject to

$$\begin{align*}
(23x_{11} + 23x_{12} + 23x_{13} + 23x_{22} + 25x_{23}) & \leq 137, \\
\sum_{j=1}^{3} x_{ij} & = 1, \quad j = 1, 2, 3, \\
\sum_{i=1}^{3} x_{ij} & = 1, \quad i = 1, 2, 3, \\
x_{ij} & = 0 \text{ or } 1 \quad (i = j = 1, 2, 3), \\
0 & \leq \lambda \in \mathbb{R},
\end{align*}$$

The solution is

$$x_{11}^0 = x_{12}^0 = x_{13}^0 = x_{23}^0 = x_{32}^0 = x_{33}^0 = 0, \quad x_{13}^0 = x_{22}^0 = x_{31}^0 = 1,$$

$$\lambda^* = 0.8, Z^*_1 \subset [29, 38], \quad Z^*_2 \subset [36.5, 46].$$

The corresponding fuzzy objectives value are: $Z_1 = (26, 32, 35, 41), Z_2 = (34, 40, 43, 49)$.

Is the solution satisfactory to the DM? Yes. The stability set of the first kind corresponding to $\left(x^0; c^0\right)$ is:

$$\zeta^0_{13} (c^1 - d^1_{13}) = 0,$$

$$\zeta^0_{22} (c^1 - d^1_{22}) = 0,$$

$$\zeta^0_{31} (c^1 - d^1_{31}) = 0,$$

$$\zeta^0_{21} (c^2 - d^2_{21}) = 0,$$

$$\zeta^0_{22} (c^2 - d^2_{22}) = 0,$$

$$\zeta^0_{31} (c^2 - d^2_{31}) = 0; \zeta^r, \xi^r \geq 0, r = 1, 2, i = j = 1, 2, 3.$$ 

We have $I_1 \subseteq \{1, 2\}$. For $I_1 = \phi$, $\zeta^0_{13} = \zeta^0_{22} = \zeta^0_{31} = 0, \zeta^2_{13} = \zeta^2_{22} = \zeta^2_{31} = 0$. Then

$$S_{I_1} (x^0; c^0) = \left\{d_2 \in \mathbb{R}^6 : 8 \leq d^1_{13} \leq 16, 10 \leq d^1_{22} \leq 13, 6 \leq d^1_{31} \leq 9, 6 \leq d^2_{13} \leq 9, \right.\
\left.17.5 \leq d^2_{22} \leq 21, 13 \leq d^2_{31} \leq 16\right\}.$$
For $I_2 = \{1\}$, $\xi' > 0$, $\xi'' = 0$. Then

$$S_{I_2} (x^0; c^0) = \{d_2 \in R^6: d_{13}^1 = 13, d_{21}^1 = 10, d_{31}^1 = 9.6 \leq d_{13}^2, 17.5 \leq d_{22}^2, 13 \leq d_{31}^2\}$$

For $I_3 = \{2\}$, $\xi_1 = 0$, $\xi_2 > 0$. Then

$$S_{I_3} (x^0; c^0) = \{d_2 \in R^6: 13 \leq d_{13}^1, 10 \leq d_{22}^1, 6 \leq d_{31}^1, d_{13}^2 = 6, d_{22}^2 = 17.5, d_{31}^2 = 13\}$$

For $I_4 = \{1, 2\}$, $\xi_1 > 0$, $\xi_2 > 0$. Then

$$S_{I_4} (x^0; c^0) = \{d_2 \in R^6: 13 = d_{13}^1, 10 = d_{22}^1, 6 = d_{31}^1, d_{13}^2 = 6, d_{22}^2 = 17.5, d_{31}^2 = 13\}$$

Thus, $S(x^0, c^0) = \bigcup_{q=1}^{4} S_{I_q} (x^0, c^0)$.

6 Conclusions

In this paper, a fuzzy multi-objective assignment (F-MOAS) problem has been investigated. The advantages of the fuzzy is that the problem with fuzzy allows the DM to deal with a situation realistically. An interactive approach to improve the weights in the Weighted Tchebysheff program has been suggested. The stability set of the first kind without differentiability corresponding to the obtained solution has been determined.

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Competing Interests

Authors have declared that no competing interests exist.

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