

A New Intuitionistic Fuzzy ELECTRE II approach to study the Inequality of women in the society

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Abstract

In this paper a new model is proposed by combining intuitionistic with Fuzzy ELECTRE II approach to rank the inequalities faced by women in the society. First section deals with the introduction. In second section gives definitions. Third section focuses on Algorithm and description of the problem. In fourth section Adaptation of the model to the problem is analysed. Final section gives conclusion.

Keywords: Intuitionistic, ELECTRE II, , inequality of women, concordance, Discordance

1. INTRODUCTION

Decision makers finds hard to make decision when dealing with Multi criteria decision making problems with uncertain information. To deal with this situation, Zadeh [1] introduced Fuzzy sets which consists of membership functions lies between zero and one. In certain cases, Fuzzy set theory finds difficult to define membership function by using one specific value. To overcome this issue Atanassov [2] introduced the concept of intuitionistic fuzzy sets which is an extension of Fuzzy sets .IFS consists of membership degree, non-membership degree and hesitation degree to handle uncertainty and vagueness. Intuitionistic fuzzy sets has been applied to medical diagnosis [3], neural networks [3], stock market [4] and color region extraction [5]. The Electre method is one of the multi criteria decision making method which was pioneered by Benayoun et all [6]. Electre II method was designed to deal with ranking problems. This method use to analyses the outranking relation among the alternatives.

With the concept of Concordance and Discordance it has two embedded relations namely strong outranking relations and weak outranking relations. By using this relations a graph is pictured and ranking is allotted for the set of alternatives. Internal type 2 fuzzy sets [7], Hesitant ELECTRE I[8], Hesitant ELECTRE II [9], Intuitionistic Fuzzy ELECTRE I[10], Intuitionistic Fuzzy ELECTRE under group decision making[11] are some of the developed methods in ELECTRE. In this paper a new method is developed in which Intuitionistic fuzzy sets is combined with Electre II to give ranking for the sets of alternatives.

2) DEFINITIONS

Definition 2.1.1: An Intuitionistic Fuzzy Set (IFS) A in X defined as [2]

$A = \{ \langle x, \mu_A(x), \nu_A(x) \rangle \mid x \in X \}$ where $\mu_A(x)$, $\nu_A(x)$ represents membership and non-membership degree of x to A., $\mu_A : X \rightarrow [0,1], \nu_A : X \rightarrow [0,1]$ with the condition $0 \leq \mu_A(x) + \nu_A(x) \leq 1, \forall x \in X$

Where $\mu_A(x)$, $\nu_A(x)$ represents membership and non - membership degree of x to A. For each IFS A in X, hesitancy degree of x in A will be $\pi_A(x) = 1 - \mu_A(x) - \nu_A(x)$ with the condition $0 \leq \pi_A(x) \leq 1$.

Definitions 2.1.2: Intuitionistic Hamming distance is defined as [12]

$$d_{IFS}(A, B) = \frac{1}{2} \sum_{j=1}^n \left| \mu_A(x_j) - \mu_B(x_j) \right| + \left| \nu_A(x_j) - \nu_B(x_j) \right| + \left| \pi_A(x_j) - \pi_B(x_j) \right|$$

Definitions 2.1.3: Electre II method consists of two embedded outranking relations namely strong relationship S^F and weak relationship S^J . A strong relationship $A_m S^F A_n$ satisfies any one of the following conditions.[14]

$$\left. \begin{array}{l} 1) \left. \begin{array}{l} C(A_m, A_n) \geq c^* \\ D(A_m, A_n) \leq d^* \\ C(A_m, A_n) \geq C(A_n, A_m) \end{array} \right\} \\ 2) \left. \begin{array}{l} C(A_m, A_n) \geq c^0 \\ D(A_m, A_n) \leq d^0 \\ C(A_m, A_n) \geq C(A_n, A_m) \end{array} \right\} \end{array} \right\} \rightarrow (1)$$

Here c^* , c^0 and c^- consists of three decreasing levels of concordance which holds $0 < c^- < c^0 < c^* < 1$.

Definition 2.1.4 A weak Relationship $A_m S^f A_n$ is defined if and only if following conditions is satisfied [14]

$$\left. \begin{aligned} C(A_m, A_n) &\geq c^- \\ D(A_m, A_n) &\leq d^* \\ C(A_m, A_n) &\geq C(A_n, A_m) \end{aligned} \right\} \rightarrow (2)$$

Here d^0 and d^* be the two increasing levels of discordance sets which satisfies $0 < d^0 < d^* < 1$

Definition 2.1.5: ELECTRE II method uses two separate ranking namely forward ranking and reverse ranking.[13]

Forward ranking V' consist of following procedure

- 1) identify the nodes which having no precedent in the strong graph(the nodes which have no arcs directed towards them) and denote this as A.
- 2) The nodes in A should not have no precedent in the weak graph and name it as C. Assign them as rank one.
- 3) Eliminate the nodes in set C by reducing the graph in the strong and weak graphs.
- 4) The new graph will be obtained. Repeat the procedure until all the nodes are ranked by eliminating the nodes in strong and weak graphs.

Reversal ranking V''

- 1) Reverse the direction of the arcs in the strong and weak graphs to obtain a mirror image of the direct outranking relationships.
- 2) The remaining steps are same in forward ranking and rank is obtained name it as $\lambda(x)$
- 3) Re-establish the ranking order by

$$V''(x) = 1 + \max_{x \in X} \lambda(x) - \lambda(x)$$

Average ranking

In order to arrive at final ranking between the forward and reversal ranking the average ranking is used which was suggested by Roy & Bertier(1971)

$$V(x) = \frac{V' + V''}{2}(x)$$

Definition 2.1.6.

ELECTRE method satisfies two conditions [14]

Concordance: To validate the outranking aSb , the occurrence of the assertion should be above the minimum level of acceptability of an alternative.

Non Discordance: To validate the outranking aSb, the occurrence should be below the upper limit of non-acceptability of an alternative.

3) ALGORITHM

Let $\{A_1, A_2, \dots, A_m\}$ be a set of m alternatives and (C_1, C_2, \dots, C_n) consist of n criteria. The weights are given by decision makers on the subjective way for the criteria $W=(0.4, 0.3, 0.1, 0.2)$.

Step1: Construct the intuitionistic decision matrix M . Let $X_{mn} = \langle \mu_{mn}, \nu_{mn}, \pi_{mn} \rangle$ where μ_{mn} represents the degree of membership of the m th alternative with respect to n , ν_{mn} represents the degree of non membership m th alternative with respect to n and π_{mn} represents the hesitancy degree of m th alternative with respect to n .

Step 2: Determine fuzzy strong, medium and weak concordance sets. $(\omega_c, \omega'_c, \omega''_c, \omega_d, \omega'_d, \omega''_d)$ consists of the relative weight of the concordance and discordance sets given by decision makers.[10]

Strong Concordance set C_{mn}

$$C_{mn} = \{o | \mu_{mo} \geq \mu_{no}, \nu_{mo} < \nu_{no}, \pi_{mo} < \pi_{no}\}$$

Medium concordance set C'_{mn}

$$C'_{mn} = \{o | \mu_{mo} \geq \mu_{no}, \nu_{mo} < \nu_{no}, \pi_{mo} \geq \pi_{no}\}$$

Weak Concordance set C''_{mn}

$$C''_{mn} = \{o | \mu_{mo} \geq \mu_{no}, \nu_{mo} \geq \nu_{no}\}$$

Step 3: Determine Fuzzy Strong, Medium and Weak discordance sets

Strong Discordance set D_{mn}

$$D_{mn} = \{o | \mu_{mo} < \mu_{no}, \nu_{mo} \geq \nu_{no}, \pi_{mo} \geq \pi_{no}\}$$

Medium Discordance set D'_{mn}

$$D'_{mn} = \{o | \mu_{mo} < \mu_{no}, \nu_{mo} \geq \nu_{no}, \pi_{mo} < \pi_{no}\}$$

Weak Discordance set D''_{mn}

$$D''_{mn} = \{o | \mu_{mo} < \mu_{no}, \nu_{mo} < \nu_{no}\}$$

Step 3: Calculate fuzzy concordance index and concordance matrix

The fuzzy concordance index is the ratio of the sum of the weights related to the criteria in the fuzzy concordance sets. The concordance index of C_{mn} of A_m and A_n are defined as

$$C_{mn} = \omega_C \times \sum_{o \in C_{mn}} W_o + \omega_{C'} \times \sum_{o \in C'_{mn}} W_o + \omega_{C''} \times \sum_{o \in C''_{mn}} W_o$$

W_o represents the weight of the criteria X_o which satisfies $\sum_{o=1}^n W_o = 1$. $(\omega_C, \omega_{C'}, \omega_{C''})$ are the weights of fuzzy strong, medium and weak concordance sets. by using the values of index, the fuzzy concordance matrix C is formed .

Step 4: calculate the intuitionistic weighted distance between the two alternatives with respect to each criteria

Step 5: Calculate the discordance matrix ‘based on the weighted distance.

$$D_{mn} = \frac{\max_{o \in D_{mn} \cup D'_{mn} \cup D''_{mn}} \{\omega_D \times d(w_o h_{mo}, h_{no}), \omega_{D'} \times d(w_o h_{mo}, h_{no}), \omega_{D''} \times d(w_o h_{mo}, h_{no})\}}{\max_{o \in O} d(w_o h_{mo}, h_{no})}$$

$(\omega_D, \omega_{D'}, \omega_{D''})$ are the weights of the fuzzy discordance sets and $d(w_o h_{mo}, h_{no})$ is the distance measure.

Step 6: construct the outranking relations from the concordance and discordance levels by using equations 1 and 2.

Step 7: Draw the strong and weak graphs

Step 8: Rank the alternatives.

3.2 Description of the problem

Inequality of women is an inequality faced by women based on the gender. Gender inequalities creates difference between men and women where both sex do not have share equal in wealth and decision making power in the society (Ridgeway, 2004)[15]. According to kishor (2005) gender differences in power roles and right affect health, fertility control, survival and nutrition through women’s access to health care, lower control over their bodies , sexuality and restrictions in material and non-material resources. The Gender gap between men and women has negative impact on the development of the country, [16]

Jayachadran.s (2014) examined the gender inequalities in developing countries and says that the economic development could improve the relative outcome of women and gender gaps will be reduced as country grows.[17] Moreover the inequalities is determined by circumstances that lie beyond the control of individual and explore the different kinds of inequalities to women in their life's. Due to existence of inequality both the genders will face the consequences which directly affects the development of the country.

4) ADAPTATION OF THE PROBLEM

Let us consider C_1, C_2, \dots, C_n be the criteria related with lack of inequalities faced by women and A_1, A_2, \dots, A_t be the alternatives that are associated consequences of inequalities where n, t are finite. The following attributes are collected from 50 women in chennai by using an unsupervised method.

Attributes related to lack of inequalities faced by women are taken as criteria:

C_1 - Education

C_2 - Health and well being

C_3 - Economic participation

C_4 - Political participation

Attributes related to consequence of inequalities in the society are taken as Alternatives

A_1 - Poverty

A_2 -Fear of insecure

A_3 - lack of equal treatment

A_4 - denied from equal opportunities and outcome

A_5 - Violence against women

A_6 - lack of awareness on human rights

Step1: Intuitionistic Decision matrix is given below

$$M = \begin{bmatrix} \langle 0.63, 0.30, 0.07 \rangle & \langle 0.50, 0.30, 0.20 \rangle & \langle 0.70, 0.20, 0.10 \rangle & \langle 0.60, 0.24, 0.16 \rangle \\ \langle 0.66, 0.25, 0.09 \rangle & \langle 0.70, 0.25, 0.05 \rangle & \langle 0.60, 0.25, 0.15 \rangle & \langle 0.56, 0.28, 0.16 \rangle \\ \langle 0.70, 0.10, 0.20 \rangle & \langle 0.60, 0.30, 0.10 \rangle & \langle 0.75, 0.20, 0.05 \rangle & \langle 0.73, 0.15, 0.12 \rangle \\ \langle 0.50, 0.30, 0.20 \rangle & \langle 0.60, 0.10, 0.30 \rangle & \langle 0.55, 0.30, 0.15 \rangle & \langle 0.45, 0.30, 0.25 \rangle \\ \langle 0.45, 0.20, 0.35 \rangle & \langle 0.67, 0.25, 0.08 \rangle & \langle 0.65, 0.30, 0.05 \rangle & \langle 0.58, 0.15, 0.27 \rangle \\ \langle 0.65, 0.20, 0.15 \rangle & \langle 0.50, 0.20, 0.30 \rangle & \langle 0.60, 0.15, 0.25 \rangle & \langle 0.55, 0.20, 0.25 \rangle \end{bmatrix}$$

Step 2: Determine fuzzy strong, medium and weak concordance sets.

$$C = \begin{bmatrix} - & 3 & - & 1 & - & - \\ - & - & - & 1,4 & - & - \\ 2,4 & 3,4 & - & 3,4 & 1 & 4 \\ - & - & - & - & - & - \\ 2 & - & - & - & - & - \\ - & - & - & 1 & - & - \end{bmatrix}$$

For instance

$$\begin{aligned} C'_{12} &= \{\mu_{13} \geq \mu_{23}, \nu_{13} < \nu_{23}, \pi_{13} < \pi_{23}\} \\ &= 0.70 \geq 0.60, 0.20 < 0.25, 0.10 < 0.15 \\ &= \{3\} \end{aligned}$$

$$C' = \begin{bmatrix} - & 4 & - & - & 3 & - \\ 1 & - & - & - & - & - \\ - & - & - & 1 & 1,3 & 1 \\ 2 & - & 2 & - & - & 2 \\ 2 & 4 & - & 4 & - & 4 \\ 1,2 & 3 & - & 3,4 & - & - \end{bmatrix}$$

$$\begin{aligned} C'_{15} &= \{\mu_{13} \geq \mu_{53}, \nu_{13} < \nu_{53}, \pi_{13} \geq \pi_{53}\} \\ &= 0.70 \geq 0.65, 0.20 < 0.30, 0.10 \geq 0.05 \\ &= \{3\} \end{aligned}$$

$$C'' = \begin{bmatrix} - & - & - & 1 & 1,4 & 1,2,3,4 \\ - & - & 2 & 1,2 & 1,2,4 & 1,2,3,4 \\ 3 & - & - & 2 & 4 & 2,3 \\ - & - & - & - & 1 & - \\ - & 3 & 2 & 2,3 & - & 2,3 \\ - & - & - & - & 1 & - \end{bmatrix}$$

For instance

$$C_{24}'' = \{\mu_{21} \geq \mu_{41}, v_{21} \geq v_{41}\}$$

$$= 0.66 \geq 0.50, 0.25 \geq 0.20$$

$$C_{24}'' = \{\mu_{22} \geq \mu_{42}, v_{22} \geq v_{42}\}$$

$$= 0.70 \geq 0.60, 0.25 \geq 0.10$$

$$C_{24}'' = \{1, 2\}$$

Step 3:

Calculate fuzzy strong, medium and weak discordance sets

$$D = \begin{bmatrix} - & 2 & 2,3,4 & - & 2 & - \\ 3,4 & - & 3,4 & - & - & - \\ 3 & 2,3 & - & - & 2 & - \\ 1,3,4 & 1,3,4 & 1,3,4 & 3 & - & 1,4 \\ - & - & 1,3,4 & 2 & - & - \\ - & - & 4 & 2 & - & - \end{bmatrix}$$

For instance

$$D_{63} = \{\mu_{64} < \mu_{34}, v_{64} \geq v_{34}, \pi_{64} \geq \pi_{34}\}$$

$$= 0.55 < 0.73, 0.20 \geq 0.15, 0.25 \geq 0.12$$

$$= \{4\}$$

$$D = \begin{bmatrix} - & 1 & 1 & 2 & - & - \\ - & - & 1 & - & 4 & - \\ - & - & - & - & - & - \\ - & - & - & - & 1,4 & 3 \\ 3 & - & - & - & - & - \\ - & - & 1 & - & 4 & - \end{bmatrix}$$

$$D_{51}' = \{\mu_{53} < \mu_{13}, v_{53} \geq v_{13}, \pi_{53} < \pi_{13}\}$$

$$= 0.65 < 0.70, 0.30 \geq 0.20, 0.05 < 0.10$$

$$= \{3\}$$

$$D'' = \begin{bmatrix} - & - & 4 & - & - & - \\ - & - & - & - & - & - \\ - & - & - & - & - & - \\ - & - & - & - & 2 & - \\ 1,4 & 1 & - & 1 & - & - \\ 3,4 & 2,4 & 2,3 & - & 3 & - \end{bmatrix}$$

For instance

$$\begin{aligned} D''_{45} &= \{\mu_{42} < \mu_{52}, \nu_{42} < \nu_{52}\} \\ &= 0.60 < 0.67, 0.10 < 0.25 \\ &= \{2\} \end{aligned}$$

Step 4: Determine the concordance matrix through the fuzzy concordance index.

$$C_{mn} = \begin{bmatrix} - & 0.140 & 0 & 0.140 & 0.230 & 0.300 \\ 0.200 & - & 0.090 & 0.410 & 0.270 & 0.320 \\ 0.320 & 0.120 & - & 0.410 & 0.470 & 0.400 \\ 0.150 & 0 & 0.150 & - & 0.120 & 0.150 \\ 0.270 & 0.130 & 0.090 & 0.220 & - & 0.190 \\ 0.350 & 0.050 & 0 & 0.310 & 0.120 & - \end{bmatrix}$$

For instance

$$\begin{aligned} C_{12} &= \omega_C \times \sum_{o \in C_{12}} W_o + \omega_{C'} \times \sum_{o \in C'_{12}} W_o + \omega_{C''} \times \sum_{o \in C''_{12}} W_o \\ &= 0.5 \times 0.1 + 0.4 \times 0.2 \\ &= 0.13 \end{aligned}$$

Step 5 : calculate weighted intuitionistic distance between any two alternatives with respect to each criteria.

	h ₁₁	h ₂₁	h ₃₁	h ₄₁	h ₅₁	h ₆₁
h ₁₁		0.012	0.080	0.052	0.112	0.0400
h ₂₁	0.020	-	0.064	0.064	0.104	0.024
h ₃₁	0.080	0.060	-	0.080	0.100	0.040
h ₄₁	0.058	0.0640	0.080	-	0.060	0.060
h ₅₁	0.112	0.104	0.100	0.060	-	0.080
h ₆₁	0.046	0.020	0.040	0.060	0.0800	-

	h ₁₂	h ₂₂	h ₃₂	h ₄₂	h ₅₂	h ₆₂
h ₁₂		0.060	0.030	0.060	0.051	0.030
h ₂₂	0.060	-	0.030	0.075	0.009	0.075
h ₃₂	0.030	0.030	-	0.045	0.021	0.040
h ₄₂	0.060	0.075	0.045	-	0.060	0.060
h ₅₂	0.0510	0.009	0.021	0.057	-	0.080
h ₆₂	0.0300	0.075	0.045	0.060	0.066	-

	h ₁₃	h ₂₃	h ₃₃	h ₄₃	h ₅₃	h ₆₃
h ₁₃	-	0.010	0.005	0.015	0.0100	0.015
h ₂₃	0.010	-	0.015	0.005	0.0100	0.008
h ₃₃	0.005	0.015	-	0.020	0.0100	0.022
h ₄₃	0.015	0.005	0.0200	-	0.0100	0.0150
h ₅₃	0.0100	0.0100	0.0100	0.0100	-	0.0200
h ₆₃	0.015	0.010	0.0225	0.0150	0.0200	-

	h ₁₄	h ₂₄	h ₃₄	h ₄₄	h ₅₄	h ₆₄
h ₁₄	-	0.008	0.026	0.030	0.022	0.018
h ₂₄	0.008	-	0.034	0.022	0.026	0.018
h ₃₄	0.0260	0.0340	-	0.056	0.0300	0.0360
h ₄₄	0.030	0.0220	0.056	-	0.0300	0.0200
h ₅₄	0.0220	0.0260	0.0300	0.0133	-	0.0100
h ₆₄	0.0180	0.0180	0.0360	0.0200	0.0100	-

Step 6: calculate fuzzy discordance index and build fuzzy discordance matrix.

$$D_{mn} = \begin{vmatrix} - & 0.107 & 0.214 & 0.160 & 0.091 & 0.107 \\ 0.032 & - & 0.087 & 0 & 0.069 & 0 \\ 0.026 & 0.080 & - & 0 & 0.037 & 0 \\ 0.183 & 0.162 & 0.278 & - & 0.241 & 0.142 \\ 0.119 & 0.092 & 0.089 & 0.101 & - & 0.145 \\ 0.029 & 0.083 & 0.107 & 0.107 & 0.026 & - \end{vmatrix}$$

$$\begin{aligned} D_{12} &= \frac{\max\{0.2 \times d(w_2 h_{12}, w_2 h_{22}), 0.3 \times d(w_1 h_{11}, w_1 h_{21}), 0\}}{0.112} \\ &= \frac{\max\{0.2 \times 0.060, 0.3 \times 0.012, 0\}}{0.112} \\ &= \frac{\max\{0.0120, 0.0036, 0\}}{0.112} = 0.107 \end{aligned}$$

Step 7: construct the outranking relations from the concordance and discordance levels. The decision makers chose concordance and discordance levels for the strong and weak relations where as $(c^-, c^0, c^+) = (0.2, 0.3, 0.52)$ and $(d^0, d^+) = (0.5, 0.6)$

	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆
A ₁						
A ₂	S^f			S^F	S^f	S^F
A ₃	S^F			S^F	S^F	S^F
A ₄						
A ₅	S^f			S^f		
A ₆	S^F			S^F		

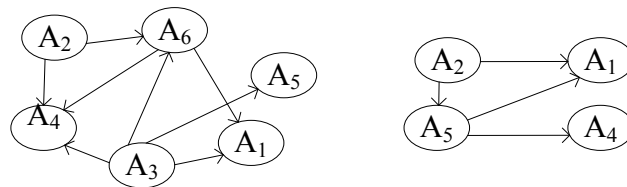


Figure 1a) strong outranking graph 1 b) weak outranking graph

Step 8 :

	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆
Forward ranking V^+	4	1	1	4	3	2
Reverse ranking V^-	3	1	1	3	2	2
Average ranking	3.5	1	1	3.5	2.5	2

The final ranking of the alternatives

$$A_2 \sim A_3 \sim A_6 \sim A_1 \sim A_4 \sim A_5$$

5) CONCLUSIONS

According to the Indian constitution law men and women are equal in the society but still some of the inequalities are practiced against women. In this paper, the criteria are taken as the inequalities faced by women in terms of Education, health and well being, economic participation and political. When it lacks the consequences which is chosen as alternatives are ranked by using new intuitionistic fuzzy ELECTRE II method. The ranking for the set of alternatives as follows are Fear of insecure , a lack of equal treatment are ranked as one , lack of awareness of human rights as 2, violence against women as 3 and poverty, denied from equal opportunities are ranked last.

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