Comparative Study of ELECTRE Methods with Intuitionistic Fuzzy Sets Applied on Consumer Decision Making Case

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Abstract—**This article proposes an intuitionistic fuzzy (IF) Elimination and Choice Translating Reality (ELECTRE) method to rank consumers' alternatives ranking order with subjects' questionnaires by using IF data and the ranking order applied the proposed method are closer to consumers their own ranking order. Moreover, the mean value of Spearman correlation coefficients are higher than 80% in each product category, and also higher than 90% at bank service product category especially. This study uses IF sets characteristics to handle uncertain decision environment and to classify the concordance and discordance sets according to their score function for measuring the degree of suitability of each alternative and also using the concept of the positive and negative ideal solutions to rank all candidate alternatives in the proposed method. Furthermore, analyzer can use this method to gain valuable information from questionnaires, and consumers rarely provide preference data directly. Additionally, an empirical study is given to illustrate the proposed method and also compared with Wu and Chen 2011's paper which considered not only score function but also accuracy function. The results show that using the proposed method, decision makers can easily predict candidate alternatives ranking order and make decisions accurately.**

Index Terms—**Decision Making, Intuitionistic Fuzzy Set, Intuitionistic Fuzzy ELECTRE Method, Score Function.**

I. Introduction

Customers' preference and intention are important market survey subjects which will influence some marketing strategies for better outcome and finding the potential market and customers for companies in a rapidly changing business environment. These commerce data can be collected from official data [1], questionnaire [2], [3], social media [4], e-commerce websites [5], [6], transactional data [7], or existing studies [8] etc. The collected data can be receipted before purchase or after purchase period [2]. These are many useful methods to handle and analysis those collected commerce data, such as RFM methods (Recency, Frequency, and Monetary methods) for retail customers categorization [7], an e-service quality evaluation model for utilitarian quality evaluation in B2C websites [3], a fuzzy set qualitative comparative analysis approach for restaurants online reviews case [6], meta-analysis for electronic word of mouth communications in a single model [8], the partial least squares based structural equation modeling for the proposed model analysis [4].

An empirical study including four kinds of utilitarian and hedonic product categories are provided to predict consumers' alternatives ranked order by using the proposed method in current study. Moreover, an intuitionistic fuzzy (IF) Elimination and Choice Translating Reality (ELECTRE) method is proposed for ranking consumers' alternatives and subjects' questionnaires are filled out by using IF data. The main reason of applied the proposed method is its logic simple and direct; furthermore, the ranking order applied the proposed method are closer to consumers' their own ranking order, and the mean value of Spearman rank order correlation coefficients (S.C.C. for short) are higher than 80% for each product category individually, and also higher than 90% at bank service product category especially. The remainder of this paper is organized as follows: Section II literature review. Section III introduces the decision environment with intuitionistic fuzzy set (IFS) data and the construction of the IF decision matrix. Section IV identifies concordance and discordance sets using the score function of the IF value, in addition to developing the proposed method and its procedures. Section V illustrates the proposed method with a numerical example. Section VI illustrates an empirical study of consumer ranked prediction case with the proposed and Wu and Chen 2011's methods. Section VII presents the discussion and conclusions.

II. Literature Review

ELECTRE method is one of multiple attribute decision making methods which was first introduced by Benayoun, Roy, and Sussman [9]. ELECTRE method family has ELECTRE I, ELECTRE II, ELECTRE III, ELECTRE IV, ELECTRE IS, ELECTRE TRI, and ELECTRE^{GKMS} methods, and each of them has different versions, ELECTRE TRI-C and ELECTRE TRI-NC methods [10], for instance.

As mentioned, ELECTRE I method is proposed because of the simplicity of its logic but after applied with IF data, the proposed method can predict alternatives ranking order easily. Moreover, the threshold values in the classical ELECTRE I method are playing an importance role to filtering alternatives, and different threshold values produce different filtering results. This study applies IFS for evaluated different candidate alternatives to fit the real and uncertain decision making environment as well.

Furthermore, IFS was first introduced by Atanassov [11], and the IFS generalize the fuzzy set, which was introduced by Zadeh [12]. In recent decade, ELECTRE methods with

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type-2 fuzzy sets have been proposed by many outstanding scholars for decision analysis [10], [13]–[19]. Galo, Calache, and Carpinetti [13] proposed an approach to supplier categorization based on ELECTRE TRI combined with hesitant fuzzy. Ghoseiri and Lessan [14] proposed a fuzzy pair-wise comparison and ELECTRE method for the waste disposal sites selection problem in Iran. Kumar, Singh, and Kharab [15] used an ELECTRE approach with triangular fuzzy data to compare the performance of cellular mobile telephone service providers in India. Liao, Wu, Mi, and Herrera [16] proposed ELECTRE III method under hesitant fuzzy linguistic environment for the hospital ranking in China. Zhong and Yao [17] proposed an ELECTRE method with interval type-2 fuzzy information for supplier selection. Wu and Chen [18] proposed an IF ELECTRE method, which use IFS character to distinguish different kinds of sets and then use the result and the proposed method to rank all alternatives, for solving multi-criteria decision making (MCDM) problems. The major difference between Wu and Chen 2011's study and current study are that current study is only use the factor of score function to distinguish different kinds of sets (Wu and Chen 2011's paper used score and accuracy functions in their study). This study also applies a real life consumer ranked prediction case without consumer's candidate alternatives ranking order.

As the literature review shows that some studies applied ELECTRE method with type-2 fuzzy sets meticulously for solving real life cases. The main purpose of this paper is to further extend ELECTRE method to solve MCDM problems in IF environments according to score function for measure the degree of suitability of evaluations. The proposed method also compare with Wu and Chen 2011's study to identify the proposed method more effectively.

III. Decision Environment with IFS Data

In this section, IFS and the construction of the IF decision matrix are introduced as follows.

A. Intuitionistic fuzzy sets

The definition of IFS [11] is given as follows. Let $X=\{x_1,x_2,...,x_n\}$ be a finite universal set. An IFS A in X is defined as $A=\left\{\langle x_j,\mu_A(x_j),\nu_A(x_j)\rangle \mid x_j\in X\right\}$, where $\mu_A(x_j)$ and $\nu_A(x_j)$ are the degrees of membership and non-membership, respectively, and $0\le \mu_A(x_j)+\nu_A(x_j)\le 1$.We refer to $\pi_A(x_j)=1-\mu_A(x_j)-\nu_A(x_j)$ as the intuitionistic index of the element x_j in the set. The operations of IFS [11], [20]–[22] are defined as follows: for two of $A,B\in \mathrm{IFS}(X)$,

(a) $A\subset B$ iff $\forall x\in X,(\mu_A(x)\le\mu_B(x)$ and $\nu_A(x)\ge\nu_B(x))$;

(b) $A=B$ iff $A\subset B$ and $B\subset A$;

(c) $\overline{A}=\{(x,\nu_A(x),\mu_A(x))\}$;

(d)

$$d(A,B)=(\frac{1}{2n}\times(\sum_{j=1}^{n}(\mu_A(x_j)-\mu_B(x_j))^2+(\nu_A(x_j)-\nu_B(x_j))^2+(\pi_A(x_j)-\pi_B(x_j))^2))^{\frac{1}{2}}. \tag{1}$$

$d(A,B)$ is the normalized Euclidean distance between A and B.

B. Construction of the IF decision matrix

An MCDM problem can be expressed in a canonical format of decision matrix M with IF data and the decision matrix M can be expressed as follows:

$$M=\begin{matrix} A_1 \\ \vdots \\ A_m \end{matrix}\begin{bmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{m1} & \cdots & X_{mn} \end{bmatrix} =\begin{bmatrix} (\mu_{11},\nu_{11}) & . & . & . & (\mu_{1n},\nu_{1n}) \\ . & . & & & . \\ . & & . & & . \\ . & & & . & . \\ (\mu_{m1},\nu_{m1}) & . & . & . & (\mu_{mn},\nu_{mn}) \end{bmatrix}. \tag{2}$$

Moreover, a set of criteria weights W are given and defined as follows:

$$W=\left\{\langle x_j,w_j\rangle \mid x_j\in X\right\}. \tag{3}$$

where $0\le w_j\le 1$, and the sum of w_j are equal to 1. Meanwhile, the IFS theory is mathematically equivalent to the interval valued fuzzy sets (IVFS) theory [23]–[25]. The decision maker's evaluation with IVFS data is easier than that with IF data.

IV. ELECTRE Method Based on IFS

The IF ELECTRE method and its algorithm are introduced in this section.

A. Concordance and discordance sets with IF data

Chen and Tan [26] proposed a score function to measure a vague value for decision making problems. The different sets of concordance and discordance sets are defined as follows. The concordance set C_{kl} is defined as follows:

$$C_{kl}=\{j \mid \mu_{kj}\ge\mu_{lj} \text{ and } \nu_{kj}<\nu_{lj}\}. \tag{4}$$

where $J=\{j\mid j=1,2,...,n\}$; a larger value of score stands for the alternative on the criterion is more suitable for the decision markers' requirement. k and l stand for different alternatives and j is for each criterion. The weak concordance set C'_{kl} is defined as follows:

$$C'_{kl}=\{j \mid \mu_{kj}\ge\mu_{lj} \text{ and } \nu_{kj}\ge\nu_{lj}\}. \tag{5}$$

The discordance set D_{kl} is defined as follows:

$$D_{kl}=\{j \mid \mu_{kj}<\mu_{lj} \text{ and } \nu_{kj}\ge\nu_{lj}\}. \tag{6}$$

The weak discordance set D'_{kl} is defined as follows:

$$D'_{kl} = \{j \mid \mu_{kj} < \mu_{lj} \text{ and } \nu_{kj} < \nu_{lj}\}. \quad (7)$$

B. IF ELECTRE method

The concordance index g_{kl} of the proposed method is defined as follows:

$$g_{kl} = w_C \times \sum_{j \in C_{kl}} w_j + w_{C'} \times \sum_{j \in C'_{kl}} w_j. \quad (8)$$

where w_C and $w_{C'}$ are weights of the concordance and weak concordance sets, respectively, and w_j, defined in (3), is weight of each criterion. The concordance matrix G is defined as follows:

$$G = \begin{bmatrix} - & g_{12} & \cdots & \cdots & g_{1m} \\ g_{21} & - & g_{23} & \cdots & g_{2m} \\ \cdots & \cdots & - & \cdots & \cdots \\ g_{(m-1)1} & \cdots & \cdots & - & g_{(m-1)m} \\ g_{m1} & g_{m2} & \cdots & g_{m(m-1)} & - \end{bmatrix}. \quad (9)$$

where the maximum value of g_{kl} is denoted by g^*. The discordance index h_{kl} is defined as follows:

$$h_{kl} = \frac{\max_{j \in D_{kl}} w_D^* \times d(X_{kj}, X_{lj})}{\max_{j \in J} d(X_{kj}, X_{lj})}. \quad (10)$$

where $d(X_{kj}, X_{lj})$ is defined in (1), and w_D^* is equal to w_D or $w_{D'}$ depending on the different types of discordance set. The discordance matrix H is defined as follows:

$$H = \begin{bmatrix} - & h_{12} & \cdots & \cdots & h_{1m} \\ h_{21} & - & h_{23} & \cdots & h_{2m} \\ \cdots & \cdots & - & \cdots & \cdots \\ h_{(m-1)1} & \cdots & \cdots & - & h_{(m-1)m} \\ h_{m1} & h_{m2} & \cdots & h_{m(m-1)} & - \end{bmatrix}. \quad (11)$$

where the maximum value of h_{kl} is denoted by h^*. The concordance dominance matrix K is defined as follows:

$$K = \begin{bmatrix} - & k_{12} & \cdots & \cdots & k_{1m} \\ k_{21} & - & k_{23} & \cdots & k_{2m} \\ \cdots & \cdots & - & \cdots & \cdots \\ k_{(m-1)1} & \cdots & \cdots & - & k_{(m-1)m} \\ k_{m1} & k_{m2} & \cdots & k_{m(m-1)} & - \end{bmatrix}. \quad (12)$$

where

$$k_{kl} = g^* - g_{kl}. \quad (13)$$

The discordance dominance matrix L is defined as follows:

$$L = \begin{bmatrix} - & l_{12} & \cdots & \cdots & l_{1m} \\ l_{21} & - & l_{23} & \cdots & l_{2m} \\ \cdots & \cdots & - & \cdots & \cdots \\ l_{(m-1)1} & \cdots & \cdots & - & l_{(m-1)m} \\ l_{m1} & l_{m2} & \cdots & l_{m(m-1)} & - \end{bmatrix}. \quad (14)$$

where

$$l_{kl} = h^* - h_{kl}. \quad (15)$$

The aggregate dominance matrix R is defined as follows:

$$R = \begin{bmatrix} - & r_{12} & \cdots & \cdots & r_{1m} \\ r_{21} & - & r_{23} & \cdots & r_{2m} \\ \cdots & \cdots & - & \cdots & \cdots \\ r_{(m-1)1} & \cdots & \cdots & - & r_{(m-1)m} \\ r_{m1} & r_{m2} & \cdots & r_{m(m-1)} & - \end{bmatrix}. \quad (16)$$

where

$$r_{kl} = \frac{l_{kl}}{k_{kl} + l_{kl}}. \quad (17)$$

k_{kl} and l_{kl} are defined in (13) and (15). In the selection process,

$$\bar{T}_k = \frac{1}{m-1} \sum_{l=1, l \neq k}^{m} r_{kl}, k = 1, 2, \ldots, m, \quad (18)$$

that $\bar{T}_k$ is the final score of the proposed method. All alternatives can be ranked according to $\bar{T}_k$. The best alternative A^*, which is simultaneously the shortest distance to the positive ideal point and the farthest distance from the negative ideal point, can be generated and defined as follows:

$$\bar{T}_k^*(A^*) = \max\{\bar{T}_k\}, \quad (19)$$

where $\bar{T}_k^*$ is the final score of the best alternative and A^* is the best alternative. The proposed IF ELECTRE method algorithm is defined as follows.

C. Algorithm for the proposed method

The algorithm and decision process can be presented in the following eight steps.

Step 1. Construct the decision matrix with evaluative information: Either IF values or comparison information between different alternatives is given. This step is summed up as the following three steps.

Step 1-1. Select the relevant criteria and non-inferior alternatives: these criteria can be selected based on the problem, i.e., different MCDM problems should have certain focused criteria.

Step 1-2. Obtain a set of grades of importance for the decision criteria, the weights of the criteria are defined in (3), and the sum of criteria weights are equal to 1.

Step 1-3. Construct the decision matrix: the IF decision matrix is constructed using (2).

Step 2. Classify the concordance and discordance sets: apply the score function to distinguish the different kinds of concordance and discordance sets using (4)–(7).

Step 3. Calculate the concordance matrix G: the concordance matrix index is the calculated result of the different kinds of concordance sets and their weights, defined in (8) and (9).

Step 4. Calculate the discordance matrix *H*: this matrix index is the calculated result of discordance sets and their weights, defined in (10) and (11).

Step 5. Construct the concordance dominance matrix *K*: they are defined in (12) and (13).

Step 6. Construct the discordance dominance matrix *L*: they are defined in (14) and (15).

Step 7. Determine the aggregate dominance matrix *R*: they are defined in (16) and (17).

Step 8. Choose the best alternative: calculate the scores of evaluation using (18) and (19) to select the best alternative.

V. Numerical Example

We illustrate an example of a decision making problem with house selection by using the proposed method. A buyer intends to choose a house from a group of candidates (houses). Suppose that four criteria, x_1 (environmental characteristics), x_2 (distance to work), x_3 (size), and x_4 (price), are taken into consideration in the selection problem and also have six candidates, named A_1, A_2, A_3, A_4, A_5, and A_6 (Step 1-1). The subjective importance levels of the different criteria W are defined as follows: $W=[w_1,w_2,w_3,w_4]=[0.1,0.2,0.3,0.4]$ (Step 1-2). The relative weights are defined as follows. $W^{'}=[w_C,w_{C^{'}},w_D,w_{D^{'}}]=[1,0.5,1,0.5]$.

The IVFS decision matrix M is given and transformed into the IF matrix decision with cardinal information (Step 1-3, as Fig. 1-Decision matrix M shown.).

$$M=\begin{array}{c} \\ A_1\\A_2\\A_3\\A_4\\A_5\\A_6\end{array}\begin{array}{c} \begin{array}{cccc} x_1 & x_2 & x_3 & x_4\end{array}\\ \begin{bmatrix} [0.35,0.67] & [0.22,0.56] & [0.23,0.41] & [0.10,0.13]\\ [0.24,0.66] & [0.26,0.58] & [0.31,0.72] & [0.44,0.61]\\ [0.11,0.84] & [0.19,0.53] & [0.11,0.66] & [0.19,0.34]\\ [0.09,0.62] & [0.43,0.71] & [0.44,0.76] & [0.41,0.74]\\ [0.37,0.44] & [0.34,0.61] & [0.37,0.65] & [0.34,0.75]\\ [0.25,0.66] & [0.29,0.65] & [0.30,0.72] & [0.45,0.52] \end{bmatrix}\end{array}$$

$$=\begin{array}{c} \\ A_1\\A_2\\A_3\\A_4\\A_5\\A_6\end{array}\begin{array}{c} \begin{array}{cccc} x_1 & x_2 & x_3 & x_4\end{array}\\ \begin{bmatrix} (0.35,0.33,0.32) & (0.22,0.44,0.34) & (0.23,0.59,0.18) & (0.10,0.87,0.03)\\ (0.24,0.34,0.42) & (0.26,0.42,0.32) & (0.31,0.28,0.41) & (0.44,0.39,0.17)\\ (0.11,0.16,0.73) & (0.19,0.47,0.34) & (0.11,0.34,0.55) & (0.19,0.66,0.15)\\ (0.09,0.38,0.53) & (0.43,0.29,0.28) & (0.44,0.24,0.32) & (0.41,0.26,0.33)\\ (0.37,0.56,0.07) & (0.34,0.39,0.27) & (0.37,0.35,0.28) & (0.34,0.25,0.41)\\ (0.25,0.34,0.41) & (0.29,0.35,0.36) & (0.30,0.28,0.42) & (0.45,0.48,0.07) \end{bmatrix}\end{array}$$

Fig. 1. Decision matrix *M*

Applying Step 2, the concordance and discordance sets are classified by using the result of Step 1-3.

The concordance set, applying (4), is:

$$C_{kl}=\begin{bmatrix} - & 1 & 2 & 1 & - & 1\\ 2,3,4 & - & 2,3,4 & 1 & - & -\\ 4 & - & - & 1 & - & -\\ 2,3,4 & 2,3 & 2,3,4 & - & 2,3 & 2,3\\ 2,3,4 & 2 & 2,4 & - & - & -\\ 2,3,4 & 2 & 2,3,4 & 1 & - & - \end{bmatrix}.$$

For example, $C_{24}=\{1\}$, which is in the 2nd (horizontal) row and the 4th (vertical) column of the concordance set, is "1." $C_{15}=\{-\}$ stands for the concordance set is "empty" .

The weak concordance, discordance, and weak discordance sets, are obtained applying (5)–(7), respectively, and they are as follows.

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

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

$$D_{kl}^{'}=\begin{bmatrix} - & - & - & - & 1 & -\\ - & - & - & - & 1,3 & 4\\ 1,3 & 1 & - & - & 1,3 & 1\\ - & 4 & - & - & 1 & 4\\ - & 4 & - & 4 & - & 4\\ - & - & - & - & 1,2,3 & - \end{bmatrix}.$$

Applying Step 3, the concordance matrix is calculated as follows:

$$G=\begin{bmatrix} - & 0.100 & 0.400 & 0.100 & 0 & 0.100\\ 0.900 & - & 0.950 & 0.300 & 0.200 & 0.150\\ 0.400 & 0 & - & 0.100 & 0 & 0\\ 0.900 & 0.500 & 0.900 & - & 0.700 & 0.500\\ 0.950 & 0.400 & 0.800 & 0.050 & - & 0.300\\ 0.900 & 0.450 & 0.950 & 0.300 & 0.200 & - \end{bmatrix},$$

$$\text{For example}: g_{13}=w_C\times w_2+w_{C^{'}}\times w_1+w_{C^{'}}\times w_3$$
$$=1\times 0.2+0.5\times 0.1+0.5\times 0.3=0.400$$

Applying Step 4, the discordance matrix is calculated as follows.

$$H=\begin{bmatrix} - & 1 & 0.512 & 1 & 1 & 1\\ 0.246 & - & 0 & 1 & 0.500 & 0.638\\ 0.500 & 0.966 & - & 1 & 0.624 & 0.830\\ 0.452 & 0.874 & 0.607 & - & 0.500 & 0.593\\ 0 & 0.341 & 0 & 0.240 & - & 0.500\\ 0.257 & 0.105 & 0 & 0.515 & 0.497 & - \end{bmatrix},$$

For example : $h_{46} = \dfrac{\max_{j \in D_{12}} w_D^* \times d(X_{4j}, X_{6j})}{\max_{j \in J} d(X_{4j}, X_{6j})} = \dfrac{0.144}{0.243} = 0.593$

where

$$d(X_{44}, X_{64}) = (0.5((0.41-0.45)^2 + (0.26-0.48)^2 + (0.33-0.07)^2))^{0.5} = 0.243,$$

$$w_D \times d(X_{41}, X_{61}) = 1 \times (0.5((0.09-0.25)^2 + (0.38-0.34)^2 + (0.53-0.41)^2))^{0.5} = 0.144.$$

Applying Step 5, the concordance dominance matrix is constructed as follows:

$$K = \begin{bmatrix} - & 0.850 & 0.550 & 0.850 & 0.950 & 0.850 \\ 0.050 & - & 0 & 0.650 & 0.750 & 0.800 \\ 0.550 & 0.950 & - & 0.850 & 0.950 & 0.950 \\ 0.050 & 0.450 & 0.050 & - & 0.250 & 0.450 \\ 0 & 0.550 & 0.150 & 0.900 & - & 0.650 \\ 0.050 & 0.500 & 0 & 0.650 & 0.750 & - \end{bmatrix}.$$

Applying Step 6, the discordance dominance matrix is constructed as follows:

$$L = \begin{bmatrix} - & 0 & 0.489 & 0 & 0 & 0 \\ 0.754 & - & 1 & 0 & 0.500 & 0.362 \\ 0.500 & 0.034 & - & 0 & 0.376 & 0.170 \\ 0.548 & 0.126 & 0.393 & - & 0.500 & 0.405 \\ 1 & 0.659 & 1 & 0.760 & - & 0.500 \\ 0.743 & 0.895 & 1 & 0.485 & 0.503 & - \end{bmatrix}.$$

Applying Step 7, the aggregate dominance matrix is determined as follows:

$$R = \begin{bmatrix} - & 0 & 0.470 & 0 & 0 & 0 \\ 0.938 & - & 1 & 0 & 0.400 & 0.312 \\ 0.476 & 0.034 & - & 0 & 0.284 & 0.152 \\ 0.916 & 0.219 & 0.887 & - & 0.667 & 0.474 \\ 1 & 0.545 & 0.870 & 0.458 & - & 0.435 \\ 0.937 & 0.642 & 1 & 0.427 & 0.402 & - \end{bmatrix}.$$

Applying Step 8, the best alternative is chosen:
$\overline{T}_1 = 0.094$, $\overline{T}_2 = 0.530$, $\overline{T}_3 = 0.189$, $\overline{T}_4 = 0.633$, $\overline{T}_5 = 0.662$, $\overline{T}_6 = 0.682$.

The optimal ranking order of alternatives is given by $A_6 \succ A_5 \succ A_4 \succ A_2 \succ A_3 \succ A_1$, and A_6 is the best alternative.

VI. An Empirical Study of Consumer Ranked Prediction Case for Decision Making

This study provides an empirical study on customer ranked prediction case for decision making. This method estimates the ranking order of customer personal preference using the proposed method and the method's data from individual questionnaire which filled out by customers themselves.

Moreover, the study verified the proposed method and Wu and Chen 2011's method for consumers' decision making in different product categories, i.e. utilitarian and hedonic product categories. The utilitarian product is valued as a useful function; the hedonic product is valued for its intrinsically pleasing properties [27]. According to the experimental results, scholars have suggested that vehicles, cameras, air conditioners, batteries, and investment services, for example, have been regarded as utilitarian products. The opera, perfume, coffee, chocolate, and greeting cards, for example, have been viewed as hedonic products [28], [29].

Forty-nine graduate students, in north Taiwan, participated on the pretest to confirm the selected four product categories represented utilitarian or hedonic product categories by the questionnaires. One hundred twenty-four college students in north Taiwan participated in the experiment. The pretest of the questionnaire, questionnaire design, and the results of both of IF ELECTRE methods presented are as follows.

A. *Pretest for the questionnaire*

As mentioned, forty-nine graduate students participated in the pretest in north Taiwan. The pretest is to identify the selected four products categories, i.e. digital camera, bank service, chocolate and amusement park, represented utilitarian or hedonic product categories. Additionally, the subjects are asked to write down the evaluative criteria which subjects considered when purchasing the four product categories in the pretest.

The respondents are given a four-item questionnaire derived from that provided by [29], and measured on 5-point scales anchored by extreme disagreement and extreme agreement. The items included "The decision to buy a brand in this product category is not/is mainly logical or objective," "The decision to buy a brand in this product category is/is not based a lot on feeling," "The decision to buy a brand in this product category is/is not based on mainly functional facts," and "The decision to buy a brand in this product category is/is not based mainly on emotions."

The results of the Mean Test showed that the digital camera (t=12.02, p<0.001) and bank service (t=8.94, p<0.001) undoubtedly belonged in the utilitarian product categories; chocolate (t=-9.37, p<0.001) and amusement parks (t= -4.47, p<0.001) were hedonic product categories. Positive and higher t values indicate that the product is utilitarian, while products with negative t values are hedonic.

In this study, the bank service and digital camera are selected as utilitarian product categories, and the amusement park and chocolate are established as hedonic product categories. Furthermore, the top three evaluative criteria of each product category are voted by the subjects for the following questionnaire including function (0.653), price (0.531), and figure (0.449) for the digital camera, brand awareness (0.571), service attitude (0.571), and deposit interest rate (0.571) for the bank service, flavor (0.633), price (0.224), and packaging (0.163) for the chocolate, and amusement facility (0.469), ticket price (0.306), and transportation (0.286) for the amusement park during pretest. These top three evaluative criteria of each product categories are applied in the following questionnaire.

B. *Questionnaire design*

We use a questionnaire, which is designed for this study, to gather consumer evaluated information in different product categories. To generate a decision matrix, five alternatives are determined by their brand images in Taiwan.

The five alternatives of the four product categories are as follows: (1) Digital camera: Canon, Sony, Olympus, Nikon, and Pentax; (2) Bank service: Bank of Taiwan, Chinatrust Commercial Bank, Cathay United Bank, First Bank, and HSBC; (3) Chocolate: Ferrero Rocher, Dove, M&M's, Tappl, and Godiva; (4) Amusement park: Leofoo Village Theme Park, Janfusun Fancyworld, Formosan Aboriginal Culture Village, Hualien Farglory Ocean Park, and Yamay Recreation World.

The whole questionnaire can be divided into three parts. The first part collects basic information and criteria weights that filled out by the subjects. The subjects compare different evaluation criteria with pair-wise comparisons, and then the weights of the criteria are captured. In the second part, the criteria are evaluated with interval scores to complete a decision matrix. The final part of the questionnaire is to determine the preference order of the alternatives. The subjects rank the alternatives (product categories) by their own experience or the product's image, and the ranked order can be either a sequential or duplicate order.

C. Questionnaire results applied with both the proposed and Wu and Chen 2011's method

The questionnaire final results of 124 samples after deleted unqualified 26 samples and the basic data of subjects are as the following table.

TABLE I: THE BASIC DATA ON GENDER, AGE, AND INCOME

Variable	Count	Percentage
Total	124	100%
Gender		
Male	45	36.3%
Female	79	63.7%
Age		
Under 20 years old	18	14.5%
21-30 years old	97	78.2%
Exceed 31 years old	9	7.3%
Income		
Under $5,000(NT$)	30	24.2%
$5,001-10,000	51	41.1%
$10,001-15,000	15	12.1%
$15,001-20,000	7	5.7%
$20,001-25,000	8	6.5%
$25,001-30,000	5	4.0%
$30,001-35,000	3	2.4%
Exceed $35,001	5	4.0%

There are 124 subjects participate in this questionnaire, including 79 females (63.7%), and most of them whose age between 20 and 30 (97 adults, 78.2%), and the income between NT$5,001 and 10,000 is majority population (51 adults, 41.1%), and the detail information as Table I shown.

Table II shows that the subjects familiarity with four kinds of product categories, i.e. digital cameras, amusement parks, chocolate, and bank service.

TABLE II: SUBJECTS FAMILIARITY WITH DIGITAL CAMERAS, AMUSEMENT PARKS, CHOCOLATE, AND BANK SERVICE

	*DC	**P	***C	****B
strongly unfamiliar	1	4	0	2
unfamiliar	6	18	9	26
neutral	49	63	44	59
familiar	49	34	59	30
strongly familiar	19	5	12	7

All 124 subjects are filled out all 4 product categories measurement individually.
*"DC" stands for digital cameras
**"P" stands for amusement parks
***"C" stands for chocolate
****"B" stands for bank service

For example, there are 49 adults (39.5%) familiar with digital cameras, and also have 49 adults (39.5%) who are neutral on digital cameras, and only one adult (0.8%) strongly unfamiliar with this product. On the amusement parks, there are 63 adults (50.8%) who are neutral on this product, and also have 34 adults (27.4%) familiar with it, and only 4 adults (3.2%) strongly unfamiliar with this product. On the chocolate, there are 59 adults (47.5%) familiar with chocolate, and nobody unfamiliar with this product. On the bank service, there are 59 adults (47.5%) who are neutral on this product, and also have 30 adults (24.1%) familiar with this product, only 2 adults (1.6%) strongly unfamiliar with this product. The detail information is shown in Table II.

The S.C.C. of four products categories are compared each subject their own individual alternative ranking order data with the ranking order by using the proposed method. Moreover, the proposed method data source from products evaluation information by subjects themselves and the results as Table III shown. Additionally, the higher S.C.C. stands for subjects individual alternative ranking order closer to the ranking order by using the proposed method and S.C.C. value is between -1 to 1.

TABLE III: THE SPEARMAN RANK ORDER CORRELATION COEFFICIENTS OF THE PROPOSED METHOD

	<0.5	0.6-0.7	0.8-0.9	1	***MEAN***
*DC	6	28	46	44	0.82
**P	3	18	58	45	0.87
***C	11	39	47	27	0.81
****B	3	4	48	69	0.92

There are124 subjects measure each kind of product.
*"DC" stands for digital cameras
**"P" stands for amusement parks
***"C" stands for chocolate
****"B" stands for bank service

For example, for the bank service, the mean value of S.C.C. is 0.92, and it is also the highest value of mean among four product categories. The rest of the mean values of S.C.C. are 0.87 for amusement parks, 0.82 for digital cameras and 0.81 for chocolate. Furthermore, for the bank service, there are 69 adults (55.6%) who are one hundred percent match subjects ranking order compared with the ranking order by using the proposed method and 48 adults (38.8%) whose S.C.C. are between 0.8 and 0.9 and rest of 7 adults (5.6%) whose S.C.C. are less than or equal to 0.7. The details of S.C.C. of 4 kinds of products are shown in Table III.

As mentioned, this study also compares the proposed method with Wu Chen 2011's study. The S.C.C. of four product categories applied Wu and Chen 2011's method are shown as Table IV.

TABLE IV: THE SPEARMAN RANK ORDER CORRELATION COEFFICIENTS OF WU AND CHEN 2011'S METHOD

	<0.5	0.6-0.7	0.8-0.9	1	***MEAN***
*DC	8	27	51	38	0.80
**P	4	17	55	48	0.87
***C	14	38	48	24	0.80
****B	2	12	49	61	0.91

There are124 subjects measure each kind of product.
*"DC" stands for digital cameras
**"P" stands for amusement parks
***"C" stands for chocolate
****"B" stands for bank service

For example, for the bank service, the mean value of S.C.C. is 0.91 which applied Wu and Chen 2011's method, and it also the highest value of mean among four product categories ranked by using Wu and Chen 2011's method. The rest of the mean values of S.C.C. by using Wu and Chen 2011's method is 0.87 for amusement parks, 0.80 for both digital cameras and chocolate. Moreover, for the bank service, there are 61 adults (49.2%) who are one hundred percent match subjects ranking order compared with ranking order by using Wu and Chen 2011's method and 49 adults (39.5%) whose S.C.C. are between 0.8 and 0.9 and rest of 14 adults (11.3%) whose S.C.C. are less than or equal to 0.7. The details of S.C.C. of 4 kinds of product categories applied Wu and Chen 2011's method are shown in Table IV. From Tables III and IV, the highest of mean of S.C.C. is 0.92 for bank service by using the proposed method, and the second highest of mean of S.C.C. is 0.91 which also for bank service by using Wu and Chen 2011's method. The lowest of mean of S.C.C. is 0.80 for both chocolate and digital cameras which also using Wu and Chen 2011's method. All the mean values of S.C.C. by using the proposed method are higher than the mean values of S.C.C. by using Wu and Chen 2011's method expect that the product of amusement parks with the same mean of S.C.C. values.

VII. DISCUSSION AND CONCLUSIONS

There are many meticulous type-2 Fuzzy ELECTRE methods which are proposed by outstanding authors to solve decision making problems. In this study, a simple type-2 Fuzzy ELECTRE method is proposed because of its simple logic but can predict customers' alternatives ranking order even without customers their own candidate ranking order. Moreover, the results of this study show that the mean value of S.C.C. which compared the ranking order by using the proposed method with customers' their own ranking order are higher than 80% for each product individually and even higher than 90% at bank service products item as well. In this study, decision makers utilize IFS data instead of single values in the evaluation process of IF ELECTRE method to fit real life and uncertain situations. This new approach integrates the concept of the outranking relationship of ELECTRE method with IFS data.

Furthermore, the proposed method and Wu and Chen 2011's study are applied for the ranking order of alternatives based on subjects' evaluation information in different criteria and alternatives. This study also compared both methods on their S.C.C. of 4 kinds of product categories. The proposed method only uses score function to distinguish different evaluated information with IFS data, on the other hand, Wu and Chen 2011's study uses both of score and accuracy functions.

Additionally, from Tables III and IV, all the mean values of S.C.C. by using the proposed method are higher than the mean values of S.C.C. by using Wu and Chen 2011's method expect that the product of amusement parks with the same mean of S.C.C. values. The proposed method's results are closer to customer candidate alternatives ranking order than Wu and Chen 2011's study, even the proposed method only use score function alone to classify the IFS data. On the other hand, from Tables III and IV, the highest of mean of S.C.C. is 0.92 for bank service by using proposed method, and the second highest of mean of S.C.C. is 0.91 which also for bank service by using Wu and Chen 2011's method. The reason could be bank service belonged in the utilitarian product category that people treat the evaluation more seriously or more preciously on the questionnaire than rest of product categories, and the utilitarian product category will be chosen in the future study to test the proposed method effectually.

To control the educational level, 124 college students are recruited to participate in this study, and therefore the selected product categories are not expensive for most students can afford them. In the near future, we will focus on the utilitarian and higher unit price product categories by using the same proposed method, and to compare the results with current study. Another topic will be participator; we can choose higher income group except student group to compare the results with current study. We can also apply the proposed method in other fields to check the method more productively. This paper is a real case by using the proposed method which can predict consumers' alternatives ranking order easily and use this method to solve real MCDM problems in consumer predicition case for decision making. We will simulate masses of data sets to test the proposed method for its ranking regularity as well. We will also develop ELECTRE methods with different kinds of type-2 fuzzy data to solve MCDM problems.

The detail S.C.C. data are shown in Appendix A and B. Appendix A is the Spearman rank order correlation coefficients for the products calculated by using the proposed method. Appendix B is the Spearman rank order correlation coefficients for the products calculated by using Wu and Chen 2011's method.

APPENDIX

APPENDIX A: THE SPEARMAN RANK ORDER CORRELATION COEFFICIENTS FOR THE PRODUCTS CALCULATED USING THE PROPOSED METHOD

	Frequency			
S.C.C.	*DC	**P	***C	****B
-0.6	2	0	0	0
-0.5	2	0	0	0
-0.3	2	2	0	1
-0.2	0	0	0	1
-0.1	0	1	0	1
0.5	0	0	11	0
0.6	0	0	8	0
0.7	28	18	31	4
0.8	7	8	12	7
0.9	39	50	35	41
1	*****44	45	27	69
Sum	124	124	124	124

There are124 Spearman rank order correlation coefficients (S.C.C.) which are the subjects ranking order compare with the ranked order by using the proposed method in each product category.

*"DC" stands for digital cameras
**"P" stands for amusement parks
***"C" stands for chocolate
****"B" stands for bank service

*****For example, there are 44 cases on digital cameras and their Spearman rank order correlation coefficients are 1.

APPENDIX B: THE SPEARMAN RANK ORDER CORRELATION COEFFICIENTS FOR THE PRODUCTS CALCULATED USING WU AND CHEN 2011'S METHOD

	Frequency			
S.C.C.	*DC	**P	***C	****B
-0.6	1	0	0	0
-0.3	3	0	0	1
-0.2	1	0	0	0
-0.1	3	4	0	1
0.5	0	0	14	0
0.6	5	0	10	0
0.7	22	17	28	12
0.8	8	11	12	8
0.9	uc3	44	36	41
1	*****38	48	24	61
Sum	124	124	124	124

There are124 Spearman rank order correlation coefficients (S.C.C.) which are the subjects ranking order compare with the ranked order by using Wu and Chen 2011's method in each product category.

*"DC" stands for digital cameras
**"P" stands for amusement parks
***"C" stands for chocolate
****"B" stands for bank service

*****For example, there are 38 cases on digital cameras and their Spearman rank order correlation coefficients are 1.

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