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Dynamic Intuitionistic Fuzzy Multiple Attributes Decision Making Method Based on Prospect Theory and VIKOR

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ABSTRACT

Most intuitionistic fuzzy multiple attribute decision making methods are proposed based on the expected utility theory under the premise of "full rationality", but this paper constructs a dynamic intuitionistic fuzzy multiple attribute decision making method based on prospect theory under the premise of "limited rationality" and VIKOR method. First we introduced the related concepts of intuitionistic fuzzy sets, dynamic operators, prospect theory and VIKOR method, then constructed the decision-making process of dynamic intuitionistic fuzzy multiple attribute decision making method based on prospect theory and VIKOR, at last made an empirical research on the analysis and evaluation about the problem of multi-stage supplier selection. The result shows that the method proposed in this paper is different from the traditional intuitionistic fuzzy method based on VIKOR. The former can better reflect the psychological characteristics of the decision makers at different risks, so it has a greater advantage, can be extended to the investment, location, personnel selection, and more widely used in decision-making areas.

1. INTRODUCTION

Multi-attribute decision-making problem usually refers to the multi-criteria decision-making problem that has discrete type decision variables, limited alternatives, and the research methods include the ascertaining type, the random type and the fuzzy decision method. After the concept of intuitionistic fuzzy sets [1, 2] based on the fuzzy theory [3], multiple attribute decision making has gradually extended to the field of intuitionistic fuzzy multiple attribute decision making. Having considered the information of the membership, the non-membership and the hesitation, the intuitionistic fuzzy set is more exquisite and profound in describing the objective phenomenon.

So far, many scholars have studied the problem of intuitionistic fuzzy multiple attribute decision making. Some authors gave the definition of intuitionistic fuzzy weighted geometric operator (IFWG), intuitionistic fuzzy ordered weighted geometric operator (IFOWG), intuitionistic fuzzy hybrid geometric operator (IFHG) and applied them to the field of intuitionistic fuzzy multiple attribute decision making [4]. The aggregation operator and the score function can be used in sorting and selection in Multi attribute decision making problem with the attribute values noted by intuitionistic fuzzy numbers, and the classic multi attribute decision making method also has been widely developed and applied in intuitionistic fuzzy filed. The papers combined the intuitionistic fuzzy set with the TOPSIS method to solve the ranking problem and the alternative selection [5-7]. The compromise solution of the dynamic intuitionistic fuzzy decision-making problem was obtained by using the VIKOR method in paper [8]. DEMATEL and AHP method were combined to solve the decision problem whose attribute value is expressed in the form of triangular intuitionistic fuzzy numbers [9]. However, the research methods above are all based on the expected utility theory.

In fact, the psychological behavior change of people in the decision-making process usually affects the decision results [10], and people tend to overlook the precondition when making decisions. With the development of the behavioral decision theory, multiple attribute decision making method based on prospect theory [11, 12] has been widely applied. Some authors applied prospect theory to the risk fuzzy decision [13]. The other authors combined the cumulative prospect theory with the set pair analysis theory adding new ideas for decision-making method [14]. The cumulative prospect theory was applied to the interval valued intuitionistic fuzzy decision, and the score function was also improved [15]. The method of evidence deduction was combined with the prospect theory [16], and selected the optimal scheme of multi attribute decision making with trapezoidal intuitionistic fuzzy information according to the principle of maximum value. Some authors applied TODIM method in multiple attribute decision making, made decision simulation and found the decision result vary with the program amount and decision attribute value [17]. In a word, prospect theory based on the psychological behavior of decision makers has been more and more widely used in the field of multi attribute decision making including Intuitionistic fuzzy decision today.

In summary, Intuitionistic fuzzy theory and multi attribute decision making method based on prospect theory research have made some progress, but the combination and the focuses on the theories and methods is still little from the non-rational perspective to study the intuitionistic fuzzy decision problem. In the decision-making by using intuitionistic fuzzy number, the uncertainty of the evaluation of data can be reduced to the greatest extent, and the study on decision making problems from the non-rational perspective can better fit the psychological and behavioral characteristics of decision makers, better improve decision-making information, make decisions more objective and reasonable, so as to better carry out comprehensive decision. Therefore, it is very important to combine the two and apply it to the actual management decision, whether to improve the theory and method of decision-making, or to expand the field of practice.

This paper researches and improves the existing achievements, building dynamic intuitionistic fuzzy multiple attribute decision making method based on prospect theory and VIKOR. Firstly, the dynamic decision-making process introduces the intuitionistic fuzzy numbers, considering the uncertainty in the decision-making process and decision making expert scoring hesitancy level, then upgrades the traditional static evaluation to dynamic evaluation, which makes the rationality of attribute evaluation values enhanced and more in line with the actual work requirements. Secondly, the VIKOR decision-making method is used for comprehensive evaluation, which is based on the ideal point and the basic idea of which is to maximize the group utility and to minimize the individual regret, then sort and select the alternatives as the optimum according to the approaching degree of the evaluation alternatives to the ideal ones, meanwhile taking the preference influence of the decision makers into account, in order to get a more reasonable decision effect. Thirdly, combining with the relevant knowledge of cumulative prospect theory to construct the decision model and assuming the decision makers have "limited rationality" and can better describe the psychological behaviors of the decision-makers than the traditional decision method based on expected utility theory, which makes the decision result more likely to be accepted.

Because the prospect theory can better describe behavior characteristics and the VIKOR method can obtain the compromise solution advantages more easily, this paper applies prospect theory and VIKOR method, aiming at solving the risk type intuitionistic fuzzy multi criteria decision making problems, puts forward a VIKOR-extended method based on prospect theory, and illustrates with a calculation example. Therefore, the new method built in this paper, both from the field of decision, and from the angle of psychology, will better fit the characteristics of decision makers, will get accurate decision results. This new method can be widely applied to the decision-making practice field related to people's psychological behavior such as the investment and financing decisions, satisfaction evaluation and path selection.

2. RELATED THEORETICAL BASIS

2.1 Intuitionistic fuzzy and dynamic operator

Definition 1. Assume X is a non-empty set, then the intuitionistic fuzzy set on the domain X can be noted as

$$A = \{\langle x, \mu_A(x), \nu_A(x)\rangle | x \in X\} \quad (1)$$

where, $\mu_A(x)$ and $\nu_A(x)$ are membership and non-membership degrees that element X in X belongs to A, $\mu_A: X \to [0,1]$, $x \in X \to \mu_A(x) \in [0,1]$, $\nu_A: X \to [0,1]$, $x \in X \to \nu_A(x) \in [0,1]$, and $0 \le \mu_A(x) + \nu_A(x) \le 1$; then $\pi_A = 1 - \mu_A(x) - \nu_A(x)$ is called the degree of hesitation or uncertainty that element X belongs to A on X. Obviously, for any $x \in X$, $0 \le \pi_A(x) \le 1$.

Let $\alpha = (\mu_\alpha, \nu_\alpha)$ be an intuitionistic fuzzy number, and Θ be the set of the whole intuitionistic fuzzy numbers. Apparently, $\alpha^+=(1,0)$ is the maximum number and $\alpha^-=(0,1)$ is the minimum number. Some basic operations of intuitionistic fuzzy sets are shown in definition 2:

Definition 2. If $\alpha_1 = (\mu_{\alpha_1}, \nu_{\alpha_1})$, $\alpha_2 = (\mu_{\alpha_2}, \nu_{\alpha_2})$ are both intuitionistic fuzzy numbers, then

(1) $\overline{\alpha} = (\nu_\alpha, \mu_\alpha)$;

(2) $\alpha_1 \wedge \alpha_2 = \{min(\mu_{\alpha_1}, \mu_{\alpha_2}), max(\nu_{\alpha_1}, \nu_{\alpha_2})\}$;

(3) $\alpha_1 \vee \alpha_2 = \{\max(\mu_{\alpha_1}, \mu_{\alpha_2}), \min(\nu_{\alpha_1}, \nu_{\alpha_2})\}$;

(4) $\alpha_1 \oplus \alpha_2 = (\mu_{\alpha_1} + \mu_{\alpha_2} - \mu_{\alpha_1}\mu_{\alpha_2}, \nu_{\alpha_1}\nu_{\alpha_2})$;

(5) $\alpha_1 \otimes \alpha_2 = (\mu_{\alpha_1}\mu_{\alpha_2}, \nu_{\alpha_1} + \nu_{\alpha_2} - \nu_{\alpha_1}\nu_{\alpha_2})$;

(6) $\lambda\alpha = (1 - (1 - \mu_\alpha)^\lambda, {\nu_\alpha}^\lambda)$, $\lambda > 0$;

(7) $\alpha^\lambda = ({\mu_\alpha}^\lambda,\ 1 - (1 - \nu_\alpha)^\lambda)$, $\lambda > 0$.

Definition 3. Assume $\alpha_j = (\mu_{\alpha_j}, \nu_{\alpha_j})$, $(j = 1,2,\cdots,n)$ is an intuitionistic fuzzy number, let IFWA: $\Theta^n \to \Theta$, if

$$IFWA_{\varpi}(\alpha_1, \alpha_2, \cdots \alpha_n) = \omega_1\alpha_1 \oplus \omega_2\alpha_2 \oplus \cdots \oplus \omega_n\alpha_n \quad (2)$$

then IFWA is called the intuitionistic fuzzy weighted averaging operator, where $\omega = (\omega_1, \omega_2, \cdots, \omega_n)^T$ is the weighted vector of $\alpha_j (j = 1,2,\cdots,n)$, $\omega_j \in [0,1]$, $(j = 1,2,\cdots,n)$, $\sum_{j=1}^{n} \omega_j = 1$.

Theorem 1. Assume $\alpha_j = (\mu_{\alpha_j}, \nu_{\alpha_j})$ $(j = 1,2,\cdots,n)$ is an intuitionistic fuzzy number, then

$$IFWA_\omega(\alpha_1, \alpha_2, \cdots, \alpha_n) = (1 - \prod_{j=1}^{n}(1 - \mu_{\alpha_i})^{\omega_i}, \prod_{j=1}^{n}{\nu_{\alpha_j}}^{\omega_i}) \quad (3)$$

and the obtained value from IFWA is also an intuitionistic fuzzy number.

If $\omega = (\frac{1}{n}, \frac{1}{n}, \cdots, \frac{1}{n})^T$, then the intuitionistic fuzzy weighted averaging operator (IFWA) will degrade to the intuitionistic fuzzy averaging operator (IFA):

$$IFA_{\frac{1}{n}}(\alpha_1, \alpha_2, \cdots, \alpha_n) = (1 - \prod_{j=1}^{n}(1 - \mu_{\alpha_i})^{\frac{1}{n}}, \prod_{j=1}^{n}{\nu_{\alpha_j}}^{\frac{1}{n}}) \quad (4)$$

If $\alpha_1 = (\mu_{\alpha_1}, \nu_{\alpha_1})$ and $\alpha_2 = (\mu_{\alpha_2}, \nu_{\alpha_2})$ are two intuitionistic fuzzy numbers, then

$$d(\alpha_1, \alpha_2) = \frac{1}{2}(|\mu_{\alpha_1} - \mu_{\alpha_2}| + |\nu_{\alpha_1} - \nu_{\alpha_2}| + |\pi_{\alpha_1} - \pi_{\alpha_2}|) \quad (5)$$

is the distance of α_1 and α_2.

A dynamic intuitionistic fuzzy multiple attribute decision making problem can be described: in period t_k $(k=1,2,...,r)$, decision-making experts provide the evaluation information that contains the intuitionistic fuzzy numbers from a series of alternatives A_i $(i=1,2,\cdots,m)$ according to the evaluation criteria $C_j=(j=1,2,\cdots,n)$, and select the optimum alternative. Let ω^k be the weight of each period t_k, and ζ_j^k be the weight of each indicator C_j in period t_k, then in period t_k the decision-making matrix can be noted as follows (Table 1):

Table 1. Intuitionistic fuzzy decision-making matrix in period t_k

t_k	C_1	C_2	...	C_n
A_1	(μ_{11}^k, ν_{11}^k)	(μ_{12}^k, ν_{12}^k)	...	(μ_{1n}^k, ν_{1n}^k)
A_2	(μ_{21}^k, ν_{21}^k)	(μ_{22}^k, ν_{22}^k)	...	(μ_{2n}^k, ν_{2n}^k)
⋮	⋮	⋮	...	⋮
A_m	(μ_{m1}^k, ν_{m1}^k)	(μ_{m2}^k, ν_{m2}^k)	...	(μ_{mn}^k, ν_{mn}^k)

where, (μ_{mn}^k, ν_{mn}^k) denotes the intuitionistic fuzzy evaluation value of the alternative A_i under the indicator C_j in period t_k given by the decision-makers, μ_{mn}^k and ν_{mn}^k respectively denote the membership degree and the non-membership degree of the evaluation value, and $\mu_{mn}^k \in [0,1]$, $\nu_{mn}^k \in [0,1]$; $\sum_{k=1}^r \omega^k = 1, \sum_{j=1}^n \zeta_j^k = 1$.

By further extending the formula (2) and (3), we can obtain the dynamic intuitionistic fuzzy weighted averaging operator (DIFWA). Let $\alpha^1, \alpha^2, \cdots, \alpha^r$ denote r intuitionistic fuzzy numbers in $t_k (k = 1,2 \cdots, r)$ periods, and ω^k be the weight for each t_k, $\omega^k > 0, \sum_{k=1}^r \omega^k = 1$, then we call

$$DIFWA_{\omega^t}(\alpha^1, \alpha^2, \cdots \alpha^r) = \omega^1\alpha^1 \oplus \omega^2\alpha^2 \oplus \cdots \oplus \omega^r\alpha^r = (1 - \prod_{k=1}^r (1-\mu_{\alpha^k})^{\omega^k}, \prod_{k=1}^r \nu_{\alpha^k}{}^{\omega^k}) \quad (6)$$

the dynamic intuitionistic fuzzy weighted averaging operator (DIFWA).

2.2 The prospect theory

Prospect theory was proposed by Kahneman and Tversky in 1979. They found a common phenomenon in the risk condition of people's actual decision-making behavior deviating from the expected utility theory through the experimental research, such as the reference dependence effect, reflection effect and isolation effect. In order to interpret and describe these behavioral biases properly, they introduce the research results of psychology into economics, and then put forward the prospect theory. Since then, the research on the prospect theory has aroused widespread concern in the academic circles, and has made a lot of research results. Kahneman also won the Nobel prize in economics in 2002 for his great contributions to the prospect theory.

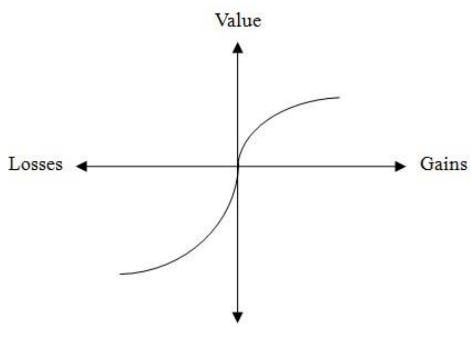

Figure 1. The prospect value function

The prospect theory uses two functions of value function and probability weight function to describe the choice behavior of people in the decision-making process. The value function is used to describe the psychological behavior such as the reference dependence, the decrease of sensitivity and the loss aversion. The probability weight function is used to describe the behavior characteristics of overestimating the low probability and underestimate the high probability. Under normal circumstances, the formula for calculating the foreground value is:

$$V = \sum v(x)\pi(p) \quad (7)$$

In the formula above, A denotes the value function whose presentation of the "S" type as shown in Figure 1:

$$v(x) = \begin{cases} x^\alpha, & x \geq 0 \\ -\delta(-x)^\beta, & x < 0 \end{cases} \quad (8)$$

Among them, α and β, respectively, denote the concave and convex degree of the value function in the income region (the first quadrant) and the loss region (the third quadrant), and δ reflects the degree of decision maker's sensitivity to decline.

In formula (7), $\pi(p)$ denotes the probability weight function which is calculated as follows:

$$\pi(p) = \begin{cases} \pi^+(p) = \dfrac{p^\xi}{(p^\xi + (1-p)^\xi)^{\frac{1}{\xi}}} \\ \pi^-(p) = \dfrac{p^\tau}{(p^\tau + (1-p)^\tau)^{\frac{1}{\tau}}} \end{cases} \quad (9)$$

where, p denotes the occurrence probability of the event, $\pi(p)$ denotes the probability of weight. ξ and τ denote the change degree of the weight function, but also reflects the different attitudes of decision makers to treat income and risk. The low probability event is usually overestimated, that is, when the occurrence probability of the event is very low, the probability weight is usually higher than the probability value, which is consistent with the behavior pattern of the decision maker with incomplete rationality. To sum up, in the theory of the decisive formula (7), there are 5 parameters, whose empirical values are: α=0.88, β=0.88, δ=2.25, ξ=0.61 and τ=0.69.

2.3 The VIKOR method

VIKOR method is a kind of compromise ranking method based on the development of the TOPSIS method, which has good ability of neutralizing the incompatibility between the properties as the biggest feature. As shown in Figure 2, the compromise solution F^C obtained by VIKOR method is the closest feasible solution to the positive solution.

VIKOR method has a great advantage in solving the incommensurability problem of the data and in obtaining the optimal solution. At present, some researchers have used VIKOR method to study the decision problem. Compared with the traditional TOPSIS method, this method is able to maximize the group value and minimize the individual regret.

About the calculation steps of VIKOR, we will introduce the details in the following part of the dynamic intuitionistic fuzzy multiple attribute decision making process based on prospect theory and VIKOR.

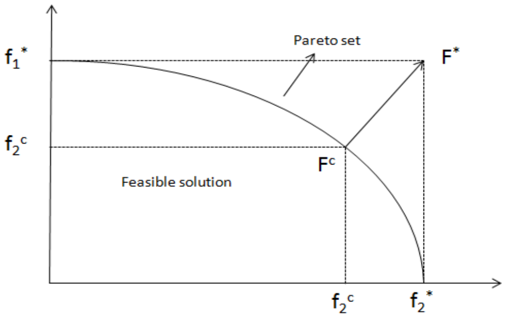

Figure 2. Compromise solution of VIKOR

3. DYNAMIC INTUITIONISTIC FUZZY MULTIPLE ATTRIBUTES DECISION MAKING BASED ON PROSPECT THEORY AND VIKOR

In this paper, the general idea of the dynamic intuitionistic fuzzy multiple attribute decision making model based on prospect theory and VIKOR is as follows: Firstly, the experts collect the relevant information of the alternatives in stages and score in intuitionistic fuzzy numbers according to the indicators. As the intuitionistic fuzzy numbers have the good nature that the membership and non-membership values are both between 0 and 1, they don't need to be standardized. Secondly, according to the DIFWA operator, the evaluation information and indicator weights of each period of time are aggregated, and the intuitionistic fuzzy matrix of the comprehensive evaluation is obtained, which is used as a reference point for the value function. Thirdly, combine the formulas (7-9) to calculate the value of the various alternatives under different indicators and construct the prospect value matrix. At last, we introduce VIKOR method into decision-making model, calculate the group benefit value S_i and individual regret R_i, and thus calculate the compromise sort value Q_i which is used to compare the alternatives.

Step 1. According to intuitionistic fuzzy score matrix by the decision-making experts, the evaluation information and indicator weights of each period of time are aggregated by using the DIFWA operator, and the intuitionistic fuzzy matrix of the comprehensive evaluation is obtained, which is used as a reference point for the value function.

Step 2. Combined formulas (7-9) to calculate the prospect value of each alternative in different indicator conditions, forming the prospect value matrix V.

Step 3. Separately define the positive ideal solution $\alpha_j{}^+$ and the negative solution $\alpha_j{}^-$in prospect value matrix V.

$$\alpha_j^+ = \{\alpha_{i1}^+, \alpha_{i2}^+, \cdots, \alpha_{in}^+\},(i = 1,2,\cdots,m) \quad (10)$$

$$\alpha_j^- = \{\alpha_{i1}^-, \alpha_{i2}^-, \cdots, \alpha_{in}^-\}, (i = 1,2,\cdots,m) \quad (11)$$

Step 4. Calculate the group benefit value S_i and individual regret R_i, the formulas are as follows:

$$S_i = \sum_{j=1}^{n}\left\{\omega_j\left(\frac{d\left(\alpha_j^+,\alpha_{ij}\right)}{d\left(\alpha_j^+,\alpha_j^-\right)}\right)\right\}, (i = 1,2,\cdots,m) \quad (12)$$

$$R_i = \max_j\left\{\omega_j\left(\frac{d\left(\alpha_j^+,\alpha_{ij}\right)}{d\left(\alpha_j^+,\alpha^-\right)}\right)\right\}, (i = 1,2,\cdots,m) \quad (13)$$

Step 5. Calculate the compromise sort value Q_i *i*n each alternative.

$$Q_i = \varepsilon\left(\frac{S^+ - S_i}{S^+ - S^-}\right) + (1-\varepsilon)\left(\frac{R^+ - R_i}{R^+ - R^-}\right), (i = 1,2,\cdots,m) \quad (14)$$

In the formula above, + denotes the maximum value and – denotes the minimum value; ε is the compromise sorting coefficient and $\varepsilon \in [0,1]$. If $\varepsilon>0.5$, then the proportion of the group benefit of the alternatives is greater than that of the individual regret, and vice versa. Usually, let $\varepsilon=0.5$.

Step 6. Sort the alternatives according to the decision-making criteria of VIKOR method. The greater Q_i value, the worse the alternative; the smaller Q_i value, the better the alternative. Meanwhile if $Q' - Q\frac{1}{(m-1)}_{min}$, then the alternative with the minimum solution is the optimum where Q' is the second minimum solution, Q_{min} is the minimum solution and m is the number of the alternatives.

4. AN ILLUSTRATED EXAMPLE

An enterprise selects the optimal supplier from 5 potential alternatives $A_i(A_1, A_2, \cdots, A_5)$ through three stages including the qualification revi (t_1), the preliminary communication (t_2) and the in-depth research (t_3). The experts evaluate and score according to 5 indicators, such as the financial (C_1), customer servic (C_2), transport capacity (C_3), storage capacity (C_4) and response capacity (C_5). The evaluation values are given in the form of intuitionistic fuzzy number, and let ω^k be the weight of each period t_k, where $\omega=[0.20,0.30,0.50]$; ζ_j^k denotes the weight of the indicator C_j at period t_k, where $\zeta=[0.30,0.17,0.13,0.26,0.14]$. The evaluation values of the expert group at each stage of the five suppliers are shown in Table 2-Table 4: Then, according to the DIFWA operator (6), the evaluation information and the indicator weight information of the experts in each period of time are aggregated, and the intuitionistic fuzzy matrix is obtained, as shown in Table 5.

Table 5 can be used as the reference point matrix for the prospect value calculation, then according to the formulas (7-9) the prospect value of each alternative can be calculated. The matrix is shown in Table 6.

The positive solutions of prospect value of alternatives and the negative solutions can be noted as

$$\alpha_j^+ = \{0.0269, 0.0322, 0.2344, -0.1230, 0.0311\}^T$$

$$\alpha_j^- = \{-0.4549, -0.1901, -0.3578, -0.2205, -0.2708\}^T$$

Table 2. The evaluation information matrix of the expert at period t_1

t_1	C_1	C_2	C_3	C_4	C_5
A_1	(0.30,0.50)	(0.40,0.40)	(0.50,0.30)	(0.40,0.10)	(0.50,0.40)
A_2	(0.50,0.20)	(0.60,0.30)	(0.50,0.40)	(0.70,0.20)	(0.60,0.30)
A_3	(0.70,0.10)	(0.60,0.40)	(0.70,0.20)	(0.60,0.30)	(0.70,0.20)
A_4	(0.60,0.40)	(0.70,0.20)	(0.80,0.10)	(0.40,0.50)	(0.30,0.60)
A_5	(0.60,0.30)	(0.30,0.60)	(0.70,0.20)	(0.40,0.60)	(0.50,0.30)

Table 3. The evaluation information matrix of the expert at t_2

t_2	C_1	C_2	C_3	C_4	C_5
A_1	(0.50,0.40)	(0.40,0.20)	(0.40,0.20)	(0.40,0.50)	(0.20,0.30)
A_2	(0.50,0.30)	(0.50,0.20)	(0.60,0.30)	(0.40,0.30)	(0.40,0.60)
A_3	(0.70,0.10)	(0.70,0.30)	(0.50,0.40)	(0.60,0.40)	(0.30,0.10)
A_4	(0.50,0.30)	(0.60,0.30)	(0.60,0.30)	(0.40,0.30)	(0.70,0.30)
A_5	(0.60,0.20)	(0.70,0.10)	(0.70,0.20)	(0.40,0.50)	(0.50,0.40)

Table 4. The evaluation information matrix of the expert at t_3

t_3	C_1	C_2	C_3	C_4	C_5
A_1	(0.50,0.10)	(0.50,0.20)	(0.40,0.30)	(0.40,0.50)	(0.30,0.60)
A_2	(0.40,0.40)	(0.50,0.30)	(0.60,0.20)	(0.50,0.40)	(0.50,0.40)
A_3	(0.80,0.20)	(0.70,0.30)	(0.80,0.10)	(0.50,0.50)	(0.80,0.10)
A_4	(0.50,0.30)	(0.70,0.20)	(0.40,0.30)	(0.60,0.20)	(0.70,0.10)
A_5	(0.60,0.30)	(0.60,0.40)	(0.30,0.50)	(0.70,0.20)	(0.60,0.20)

Table 5. Intuitionistic fuzzy matrix of comprehensive evaluation

	C_1	C_2	C_3	C_4	C_5
A_1	(0.465,0.209)	(0.452,0.230)	(0.421,0.266)	(0.400,0.362)	(0.391,0.449)
A_2	(0.452,0.319)	(0.522,0.266)	(0.582,0.259)	(0.523,0.319)	(0.495,0.426)
A_3	(0.755,0.141)	(0.682,0.318)	(0.714,0.174)	(0.553,0.422)	(0.684,0.115)
A_4	(0.522,0.318)	(0.673,0.226)	(0.574,0.241)	(0.510,0.271)	(0.645,0.199)
A_5	(0.600,0.266)	(0.590,0.286)	(0.542,0.316)	(0.576,0.328)	(0.553,0.267)

Table 6. The prospect value matrix of the alternatives

V	C_1	C_2	C_3	C_4	C_5
A_1	0.3130	0.0094	0.0322	0.1878	0.0311
A_2	0.0269	0.0322	0.0063	0.1436	0.0200
A_3	0.0038	0.0032	0.2344	0.1230	0.2663
A_4	0.4549	0.0015	0.1325	0.2205	0.2708
A_5	0.2718	0.1901	0.3578	0.1980	0.1539

Table 7. S_i R_i Q_i and the ranking of the suppliers in this paper

New method	S_i	R_i	Q_i	Rank
A_1	0.3304	0.2328	0.2816	2
A_2	0.0206	0.0122	0.0164	1
A_3	0.4058	0.3535	0.3976	3
A_4	0.7818	0.3600	0.5709	5
A_5	0.6975	0.2400	0.4688	4

The group benefit value S_i and the individual regret R_i of each alternative can be calculated according to formulas (12-13), and the compromise sorting value Q_i according to the formula (14). When $\varepsilon=0.5$, the result is shown in Table 7.

According to the compromise sorting coefficient, we can obtain the sensitivity analysis of the illustrated example, as shown in Table 8.

From Table 8 we can see the alternative sorting result in this example hardly changes with the compromise sorting coefficient ε, but shows some stability, which means the new method constructed based on prospect theory and VIKOR method is not so sensitive to the compromise sorting coefficient, that is, the decision result is relatively stable.

Besides, according to the decision-making mechanism of VIKOR method, the compromise solution is A_2 by using the method constructed in this paper and the result of the same problem by using the traditional VIKOR method is shown in Table 9.

According to the results of Table 7 and 9, we construct a model with different ranking results of suppliers from the traditional VIKOR method in this paper. The main reason is that we introduce prospect theory into this paper, transform the traditional utility value function into prospect value function, and rank with VIKOR method and the reference points aggregated from the dynamic intuitionistic fuzzy number, which can fully reflect the risk preference of the decision makers in the face of the loss and the benefit, more close to the real situation of people's decision-making process. Consequently, the result is more convincing.

Table 8. Sensitivity analysis

	ε =0.05		ε=0.20		ε=0.35		ε=0.50		ε=0.65		ε=0.80		ε=0.95	
	Q_i	rank	Q_i	rank	Q_i	rank	Q_i	rank	Q_i	rank	Q_i	rank	Q_i	rank
A_1	0.24	2	0.25	2	0.27	2	0.28	2	0.30	2	0.31	2	0.33	2
A_2	0.01	1	0.01	1	0.02	1	0.02	1	0.02	1	0.02	1	0.02	1
A_3	0.36	4	0.36	4	0.37	3	0.38	3	0.39	3	0.40	3	0.40	3
A_4	0.38	5	0.44	5	0.51	5	0.57	5	0.63	5	0.70	5	0.76	5
A_5	0.26	3	0.33	3	0.40	4	0.47	4	0.54	4	0.61	4	0.67	4

Table 9. S_i R_i Q_i and the supplier ranking by using traditional VIKOR

VIKOR	S_i	R_i	Q_i	Rank
A_1	0.0000	0.0000	0.0000	1
A_2	0.3351	0.7528	0.5440	2
A_3	1.0000	1.0000	1.0000	5
A_4	0.5823	0.8176	0.6999	3
A_5	0.6191	0.9528	0.7859	4

5. CONCLUSIONS

In this paper, we construct a dynamic intuitionistic fuzzy multiple attribute decision making method based on prospect theory and VIKOR, and prove its validity and feasibility by numerical examples. The innovation is mainly reflected in the following aspects: Firstly, the risk preference and subjective feeling of the decision makers are considered, and the prospect theory is applied to the decision analysis; Secondly, this paper uses dynamic intuitionistic fuzzy decision-making method, which fully reflects the uncertainty and dynamic of the decision maker in the process of scoring; Finally, the improved VIKOR decision method is introduced into the decision model to find the satisfactory solution of the decision problem, rather than the optimal solution, which is exactly the same as the original intention of the group utility maximization. In short, this paper constructs the dynamic intuitionistic fuzzy multiple attribute decision making method based on prospect theory and VIKOR, which can be applied to the fields of the investment, location selection, personnel selection and so on. However, in the future, we hope to find out more practical methods for determining the reference point of the prospect value when we study the theory of multiple attribute decision making problems.

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