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Dynamic DEMATEL Group Decision Approach Based on Intuitionistic Fuzzy Number

Hui Xie*, Wanchun Duan, Yonghe Sun, Yuanwei Du
Faculty of Management and Economics, Kunming University of Science and Technology, Kunming, 650093, China
*Corresponding author, e-mail: zhubing811109@126.com

Abstract

With respect to the problems of aggregation about group experts' information and dynamic decision in DEMATEL (decision making trial and evaluation laboratory), a dynamic DEMATEL group expert decision-making method on intuitionistic fuzzy number (IFN) is presented. Firstly using IFN instead of original point estimates to reflect the experts' preference, the group experts' information are integrated horizontally at each period. Then the aggregation information at different periods are aggregated vertically again by dynamic intuitionistic fuzzy weighted averaging (DIFWA) operator so as to obtain the dynamic intuitionistic fuzzy DEMATEL total relation matrix. Thirdly, through the analysis of center and reason degree, the positions of the various factors in the system are clear and definite, and the inner structure of system has been revealed. Finally, the feasibility and practicability of the proposed method is shown through an illustrative example of a process of course selection in a school.

Keywords: *DEMATEL, intuitionistic fuzzy numbers, dynamic intuitionistic fuzzy weighted averaging operator*

1. Introduction

A kind of complex system factor analysis method, called Decision Making Trial and Evaluation Laboratory method (DEMATEL) was first conceived by George Washington university center in Geneva Battelle association in 1973 [1]. This kind of method is a tool based on graph theory and matrix to analyze the importance of the factors of system. The method constructs the direct influence matrix(DIM) through the experts' qualitative judgment of the logical relationship and influence between each other in the complex system factors analysis. Then it can calculate the degree of reason and center, so as to reveal the intrinsic causal relationship and find out the key factors of the system. Because of its practicability and convenience the method itself, DEMATEL receive high attention by scholars both at home and abroad, and it has been widely applied in many field [2]-[3]. However, through a lot of practical application, many scholars have found experts' judgment is subjective and arbitrary in the process of decision-making. Therefore the improvement of DEMATEL method becomes research hotspot in recent years. Several literatures respectively propose using grey number, triangular fuzzy number in DIM construction in order to make the experts' judgment more objective and scientific such as Tseng (2009), Don& Hshiung (2012) and Wu (2011) [4]-[6]. But these methods above are still failed to solve the science problem of experts' judgment building mechanism. We have put forward using intuitionistic fuzzy number to express experts' preference information in DEMATEL decision-making, which is based on the system intuition thinking of academician Wang Zhongtuo [7], and fully considering the expert information such as cognitive ability, personal preferences and situational characteristics. The extended method results by intuitionistic fuzzy numbers, improve the DEMATEL evaluation model. However, the vast majority literatures of DEMATEL decision-making are only focused on the judgment of the relationship between system factors by one single expert at the same period. But the relationship between the factors is complicated and diverse at different periods, also and the experts' knowledge and individual experience has certain limitation in many situations. It is necessary to develop some approaches to deal with these issues. At this point of view, when the complexity of system increases, the scientific decision making process often needs evaluation of multi-person and multi-rounds. In this paper, we shall take time dimension into decision making process, and aggregate experts' information of different periods effectively. It can reflect the DEMATEL method more scientifically and precisely.

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Currently dynamic decision-making problems have been more widely used in multi-criteria decision-making, but there not existing research about dynamics DEMATEL group decision-making proposed by scholars. Therefore, based on applying the intuitionistic fuzzy numbers (IFN) to express experts' preferences , this paper constructs the initial intuitionistic fuzzy relation matrix to implement the pairwise comparison judgment between two factors .Then the experts' judgement information at the same period is integrated horizontally. Next the group experts' information at different periods are vertically integrated through the dynamic intuitionistic fuzzy weighted average(DIFWA) operators in the following part, resulting in dynamic intuitionistic fuzzy DEMATEL total -relation matrix. Finally the new DEMATEL decision-making method is proposed and an example was applied to illustrate the presented method to be practicality and feasibility.

2. The traditional DEMATEL method

The traditional DEMATEL method specific steps are as follows[8]:

Step1: Suppose the system contains a set of elements $G=\{g_i \mid i=1,2,\cdots n\}$.

Step2: Draw directed graph about all links between the influencing factors. With the arrow from g_i to g_j means that g_i has direct impact to g_j, and the numbers on the arrows illustrate the direct influence strength between factors. And rate on a scale of 0 to 4 where, 0: no effect, 1: low effect, 2:medium effect, 3: high effect, 4: very high effect.

Step3: Construct the initial direct-relation matrix. Based on the pair-wise comparisons in terms of influence and directions by experts, a matrix $A=\left[a_{ij}\right]_{n\times n}$ is obtained, which is an $n\times n$ matrix. Here $a_{ij}=\theta_{i\to j}$ $(i=1,2,\cdots,n;\ j=1,2,\cdots,n; i\neq j)$ is denoted as the degree to which the factor g_i affects the factor g_j ,i.e. If there is no relationship between g_i and g_j, $a_{ij}=0$

$$A=\begin{bmatrix} 0 & a_{12} & \cdots & a_{1n} \\ a_{21} & 0 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 0 \end{bmatrix} \tag{1}$$

Step4: Normalize the initial direct-relation matrix. Normalize the matrix A and form a normalized matrix $B=\left[b_{ij}\right]_{n\times n}$, where $b_{ij}=a_{ij}/\max\sum\{a_{ij} \mid 1\le i\le n\}$.

Step5: **C**alculate the total-relation matrix. The total relation matrix T is defined as $T=B(I-B)^{-1}=[t_{ij}]_{n\times n}$, where I is denoted as the identity matrix.

Step6: The sum of rows and columns, within the total relation matrix T is separately denoted as f_i and e_i, using the formulate: $f_i=\sum_{j=1}^{n}t_{ij}$, $e_i=\sum_{j=1}^{n}t_{ji}$, Where f_i and e_i denote the sum of rows and columns respectively. Now f_i summarizes both direct and indirect effects given by g_i to the other factors. So e_i shows both direct and indirect effects given by g_j from the other factors. The sum of $r_i=f_i+e_i$ indicates the degree of importance for factor g_i in the entire system. On the contrary ,the difference $u_i=f_i-e_i$ represents the net effect that factor g_i contributes to system. Specifically, if u_i is positive , factor g_i is a net cause, while factor g_i is a net receiver if u_i is negative.

Step7: Set up a threshold value to obtain digraph. Since matrix T provides information on how one factor affects another, it is necessary for a decision maker to set up a threshold value to filter out some negligible effects. In doing so, only the effects greater than the threshold value would be chosen and shown in digraph.

3. Preliminaries

3.1 Definition of intuitionistic fuzzy Set (IFS)

Bulgarian scholars Atanassov expands Zadeh's fuzzy theory whose basic component is only a membership fuction. The intuitionistic fuzzy sets is characterized by a membership fuction and a non- membership fuction [9]. Since intuitionistic fuzzy sets adds new parameters into the fuzzy sets, and thus IFS can describe "neither this nor that" vague concept, therefore the theory have been a very suitable tool to be used to describe the imprecise or uncertain decision information. In many complex decision making field, a lot of scholars used intuitionistic fuzzy sets and have achieved fruitful results [10]-[11]. Domestic scholar Professor Xu Zeshui gives relevant concepts of intuitionistic fuzzy judgment matrix.

Definition1: Let a set X be a universe of discourse. An A-IFS is an object having the form:

$$A=\left\{\left\langle x,\mu_A(x),v_A(x)\right\rangle \middle| x\in X\right\} \tag{2}$$

Where the function $\mu_A : X \to [0,1]$ defines the degree of membership and $v_A : X \to [0,1]$ defines the degree of non-membership in of the element $x \in X$ to A ,respectively, and for every $x \in X$,

$$0 \le \mu_A(x)+v_A(x) \le 1 \tag{3}$$

For any A-IFS A and $x \in X$, $\pi_A(x)=1-\mu_A(x)-v_A(x)$ is called the degree of indeterminacy or hesitancy of x to A.

For convenience of computation, we call $\alpha=(\mu_\alpha, v_\alpha, \pi_\alpha)$ an intuitionistic fuzzy number(IFN), where $\mu_\alpha \in [0,1],\ v_\alpha \in [0,1],\ \mu_\alpha + v_\alpha \le 1,\ \pi_\alpha = 1-\mu_\alpha - v_\alpha.$

Definition2: Let a set of $Y=\{y_1, y_2, \cdots, y_n\}$ be n alternatives which are compared pare-wise by decision makers, then the intuitionistic fuzzy preference matrix is defined as $B=(b_{ij})_{n\times n}$, $b_{ij}=(\mu_{ij}, v_{ij}, \pi_{ij}),\ \ i, j=1,2,\cdots,n,$ where μ_{ij} indicates the intensity degree to which y_i is preferred to y_j, v_{ij} indicates the intensity degree to which y_i is not preferred to y_j, π_{ij} indicates the intensity degree of uncertainty, and all of them should satisfy the condition: $\mu_{ij}+v_{ij} \le 1,\quad \mu_{ij}=v_{ij},\quad \mu_{ij}=v_{ij}=0.5,\quad \pi_{ij}=1-\mu_{ij}-v_{ij},\ i, j=1,2,\cdots,n.$ We call B the intuitionistic fuzzy judgment matrix.

3.2 Description of dynamic DEMATEL group decision problem

The dynamic intuitionistic fuzzy DEMATEL group decision problem which has n factors at p different periods ($t_k(k=1,2,\cdots,p)$) can be defined as:

$$A^{(t_k)}=\begin{bmatrix} 0 & a_{12}^{(t_k)} & \cdots & a_{1n}^{(t_k)} \\ a_{21}^{(t_k)} & 0 & \cdots & a_{2n}^{(t_k)} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1}^{(t_k)} & a_{n2}^{(t_k)} & \cdots & 0 \end{bmatrix} \tag{4}$$

$$\omega(t) = (\omega(t_1), \omega(t_2), \cdots, \omega(t_p)) \quad (5)$$

In Eq (4)&(5), $A^{(t_k)}$ is the initial intuitionistic fuzzy relation matrix at $t_k (k = 1, 2, \cdots, p)$. And we use IFN $a_{ij}^{t_k} = (\mu_{\alpha_{ij}^{t_k}}, \nu_{\alpha_{ij}^{t_k}}, \pi_{\alpha_{ij}^{t_k}})$ to express experts' preference. μ_{ij} indicates the intensity degree the expert gives which i is preferred to j at t_k period. ν_{ij} indicates the intensity degree the expert gives which i is not preferred to j at t_k period. π_{ij} indicates the intensity degree of uncertainty. They meet the conditions: $\mu_{\alpha_{ij}^{t_k}} \in [0,1]$, $\nu_{\alpha_{ij}^{t_k}} \in [0,1]$, $\mu_{\alpha_{ij}^{t_k}} + \nu_{\alpha_{ij}^{t_k}} \le 1$, $\pi_{\alpha_{ij}^{t_k}} = 1 - \mu_{\alpha_{ij}^{t_k}} - \nu_{\alpha_{ij}^{t_k}}$, $(i, j = 1, 2, \cdots, n)$. $\omega(t_k)$ is the weight vector of t_k, $\omega(t_k) > 0$, $\sum_{k=1}^{p} \omega(t_k) = 1$; Therefore, for an intuitionistic fuzzy variable $a_{ij}^{t_k} = (\mu_{a_{ij}^{t_k}}, \nu_{a_{ij}^{t_k}}, \pi_{a_{ij}^{t_k}})$, if $t = t_1, t_2, \cdots, t_p$, then $a_{ij}^{t_1}, a_{ij}^{t_2}, \cdots, a_{ij}^{t_p}$, indicate p IFNs collected at p different periods.

Dynamic intuitionistic fuzzy DEMATEL group decision making problem can be expressed as simply: According to the initial intuitionistic fuzzy direct relation matrix which is given by each expert at different times, the new method integrates these matrix horizontally and vertically, so that we can sort the system factors, determine the importance and relevance of complex system.

3.3 Transformation of the intuitionistic fuzzy function

Each participating decision making expert has his own risk preference, and different risk preference will lead to different decision results. The most striking feature of IFS reflects the fuzziness and uncertainty of experts in reality through the comprehensive description of the degree of membership, non-membership and hesitancy. The degree of hesitancy shows experts' uncertainty about the decision making problems, while the person who tend to adventure think most of the decision makers who hesitate would support risk appetite, and people who dislikes risk consider most of the decision makers who hesitate would against the risk. People who is risk neutral believe the hesitating decision makers who support or against are half and half. Therefore we introduce the coefficient of risk preference $\beta \in [0,1]$ which is the proportion of hesitant person choose to support, so $1-\beta$ is the proportion of hesitant person choose to against. If $\beta > 0.5$, we consider the expert is risk appetite, and the greater β is , the strength of risk preference is greater. If $\beta < 0.5$, we think the expert is risk avoidance, and the smaller β is , the strength of risk preference is smaller. When $\beta = 0.5$, the expert is risk neutral. In this paper, we let 1 denote the membership, and let -1 denote the non-membership, so the weight vector of hesitation is $\beta - (1-\beta) = 2\beta - 1$. At last we get the intuitionistic fuzzy function based on the coefficient of risk preference as follows: $\overline{r_{ij}} = \mu_{ij} - \upsilon_{ij} + (2\beta - 1)\pi_{ij}$, $\beta \in [0,1]$.

3.4 Dynamic intuitionistic fuzzy weighted averaging (DIFWA) operator

Information aggregation is an essential process and is also an important research topic in the field of information fusion. If time is taken into account, for example , the argument information may be collected at different periods, then the aggregation operators and their associated weights should not be kept constant.

Definition3: Let t be a time variable, and let $a^{(t_1)}, a^{(t_2)}, \cdots, a^{(t_p)}$ be a collection of IFNs collected at different periods $t_k (k = 1, 2, \cdots, p)$, and $\omega(t) = (\omega(t_1), \omega(t_2), \cdots, \omega(t_p))$ be the weight vector of the periods $\{t_k\}(k=1,2,\cdots,p)$, and $\omega(t_k)>0(k=1,2,\cdots,p)$, $\sum_{k=1}^{p}\omega(t_k)=1$, then we call a dynamic intuitionistic fuzzy weighted averaging(DIFWA) operator.

4. Dynamic DEMATEL group decision approach based on intuitionistic fuzzy number

Based on the above theory, this section shows a dynamic DEMATEL group decision method based on IFN. Firstly, the extended method gives the initial intuitionistic fuzzy direct-relation matrix by each expert at different periods, then we aggregate the group experts' initial intuitionistic fuzzy direct-relation matrix horizontally at each period by certain way. On that basis, the aggregation matrix of intuitionistic fuzzy direct-relation at different periods are aggregated vertically again by DIFWA operator when the time vector is already know. We get the intuitionistic fuzzy total-relation matrix. Finally, we can calculate the degree of center and reason and find the key influence factors of system. The specific flow and steps of the method are as follows.

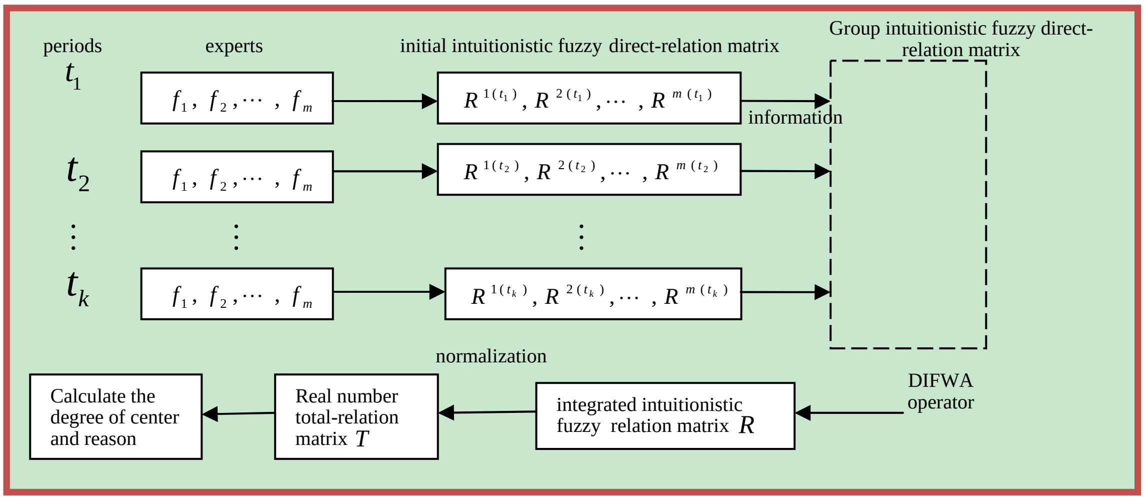

Figure 1. The flow chart of dynamic DEMATEL group decision-making method

Step1: Suppose a set of system factors $G=\{g_i|i=1,2,\cdots n\}$.

Step2: Construct the directed graph by the experts who give their judgment between the factors. If g_i has direct impact to g_j, we mark an arrow from the former to the latter. And so on, direct graph among all factors is given out.

Step3: Construct the initial intuitionistic fuzzy direct-relation matrix by single expert at p different periods. Suppose there are m experts in the decision making team, which are represented as the set: $F=\{f_1,f_2,\cdots,f_m\}$. Let the expert f_φ give his judgement between any two factors $(g_i,g_j)=(i,j=1,2,\cdots,n), i\neq j$. The result can be expressed: $r_{ij}^{\varphi(t_k)}=(\mu_{ij}^{\varphi(t_k)},\nu_{ij}^{\varphi(t_k)},\pi_{ij}^{\varphi(t_k)})$. $\mu_{ij}^{\varphi(t_k)}$ indicates that the expert f_φ think g_i is more important than g_j and the value gives the degree of importance when he compares them at t_k period. $\nu_{ij}^{\varphi(t_k)}$ indicates that g_j is prefered to g_i and $\pi_{ij}^{\varphi(t_k)}$ reflects the expert's hesitancy. $\mu_{ij}^{\varphi(t_k)},\nu_{ij}^{\varphi(t_k)},\pi_{ij}^{\varphi(t_k)}$ satisfy the condition of

Definition 1. Then we can obtain the initial intuitionistic fuzzy direct-relation matrix $R^{\varphi(t_k)} = (r_{ij}^{\varphi(t_k)})_{n\times n}$ by expert f_φ at $t_k (k=1,2,\cdots,p)$ period.

$$R^{\varphi(t_k)} = \begin{bmatrix} (\mu_{11}^{\varphi(t_k)}, v_{11}^{\varphi(t_k)}, \pi_{11}^{\varphi(t_k)}) & \cdots & (\mu_{1n}^{\varphi(t_k)}, v_{1n}^{\varphi(t_k)}, \pi_{1n}^{\varphi(t_k)}) \\ (\mu_{21}^{\varphi(t_k)}, v_{21}^{\varphi(t_k)}, \pi_{21}^{\varphi(t_k)}) & \cdots & (\mu_{2n}^{\varphi(t_k)}, v_{2n}^{\varphi(t_k)}, \pi_{2n}^{\varphi(t_k)}) \\ \vdots & \vdots & \vdots \\ (\mu_{n1}^{\varphi(t_k)}, v_{n1}^{\varphi(t_k)}, \pi_{n1}^{\varphi(t_k)}) & \cdots & (\mu_{nn}^{\varphi(t_k)}, v_{nn}^{\varphi(t_k)}, \pi_{nn}^{\varphi(t_k)}) \end{bmatrix}$$

Step4: Aggregate intuitionistic fuzzy direct-relation matrix of single expert at $t_k (k=1,2,\cdots,p)$ period. The weight vector of every expert is λ, and $\lambda = \{\lambda_1, \lambda_2, \cdots, \lambda_m\}$ is the set of all the experts' weight vector. The set of experts is $f_\varphi \{\varphi = 1,2,\cdots,m\}$. So the aggregation of intuitionistic fuzzy direct-relation matrix is $R^{(t_k)} = \sum_{\varphi=1}^{m} \lambda_\varphi R^{\varphi(t_k)} = (r_{ij}^{(t_k)})_{n\times n}$. And $r_{ij}^{t_k} = (\mu_{ij}^{t_k}, v_{ij}^{t_k}, \pi_{ij}^{t_k}), i,j = 1,2,\cdots,n, \mu_{ij}^{t_k} = \sum_{\varphi=1}^{m} \lambda_\varphi \mu_{ij}^{\varphi(t_k)}$,
$v_{ij}^{t_k} = \sum_{\varphi=1}^{m} \lambda_\varphi v_{ij}^{\varphi(t_k)}, \pi_{ij}^{t_k} = \sum_{\varphi=1}^{m} \lambda_\varphi \pi_{ij}^{\varphi(t_k)} . i,j = 1,2,\cdots,n.$

Step5: We aggregate the aggregation of intuitionistic fuzzy relation matrix $R^{(t_k)} = (r_{ij}^{(t_k)})_{n\times n}$ into integrated intuitionistic fuzzy relation matrix $R = (r_{ij})_{n\times n}$ at p different periods by the DIFWA operator:

$$DIFWA_{\omega(t)}(a^{(t_1)}, a^{(t_2)}, \cdots, a^{(t_p)}) = \sum_{k=1}^{p} \omega(t_k) a^{(t_k)} = (1 - \prod_{k=1}^{p} (1-\mu_{a^{(t_k)}})^{\omega(t_k)}, \prod_{k=1}^{p} v_{a^{(t_k)}}{}^{\omega(t_k)}, \prod_{k=1}^{p} (1-\mu_{a^{(t_k)}})^{\omega(t_k)} - \prod_{k=1}^{p} v_{a^{(t_k)}}{}^{\omega(t_k)})$$

$r_{ij} = (\mu_{r_{ij}}, v_{r_{ij}}, \pi_{r_{ij}}), \mu_{r_{ij}} = 1 - \prod_{k=1}^{p} (1-\mu_{r_{ij}^{(t_k)}})^{\omega(t_k)}, \ v_{r_{ij}} = \prod_{k=1}^{p} v_{r_{ij}^{(t_k)}}{}^{\omega(t_k)}$,
$\pi_{r_{ij}} = \prod_{k=1}^{p} (1-\mu_{r_{ij}^{(t_k)}})^{\omega(t_k)} - \prod_{k=1}^{p} v_{r_{ij}^{(t_k)}}{}^{\omega(t_k)}, \ (i,j = 1,2,\cdots,n)$.

Step6: Convert the integrated intuitionistic fuzzy relation matrix. It is very important to convert the matrix which is constituted by IFNs from fuzzy number into real number. We take risk preference coefficient β into the process of conversion, whose value is in section3.3. After conversion the real number matrix is generated: $\overline{R} = (\overline{r_{ij}})_{n\times n}$, $\overline{r_{ij}} = \mu_{ij} - \upsilon_{ij} + (2\beta - 1)\pi_{ij}$, $\beta \in [0,1]$. $\overline{r_{ij}}$ means determinate degree of experts' preference which is converted from hesitancy.

Step7: Calculate total-relation matrix. According to the formula $T = B(I-B)^{-1} = [t_{ij}]_{n\times n}$, we measure the combined impact of every factor which is effected by other factors directly and indirectly. And we get the total relation matrix T, where I is the identity matrix. It is the normalized direct-relation matrix $B = \left[b_{ij}\right]_{n\times n}$, where $b_{ij} = r_{ij} / \max \sum \{r_{ij} | 1 \le i \le n\}$.

Step8: Calculate the degree of center and reason. We add the factors of rows respectively to get the degree of centre: $f_i = \sum_{j=1}^{n} t_{ij}$. In the same way, we get the degree of reason:

$e_i = \sum_{j=1}^{n} t_{ji}$ .Thus it is infered the degree of centre about g_i in all factors: $r_i = f_i + e_i, (i = 1, 2, \cdots, n)$, as well as the degree of reason about g_i which can indicate the internal structure of it : $u_i = f_i - e_i, (i = 1, 2, \cdots, n)$.

Step9: Determine the key influence factors. We rank all the factors based on their importance by the degree of center r_i . We need to choose the key influence factors according to the practical environment and resource conditions. In addition, we can also put forward related management suggestions to the key factors by the degree of reason u_i .

5. Application example

In this section, we will offer an example to illustrate our procedure and prove the feasibility of the method. The postgraduate about economics must complete two professional elective course in third grade according to the training plan in M university. The teacher who is in charge of the course arrangement should give out the course scheduling at the end of grade two. In order to arrange the course reasonably, we choose three postgraduates to be the decision makers who gives their choice about three courses that can be offered in the beginning of the grade two and at the end of the semester respectively. The three courses are: a_1 , western economics; a_2 , game theory; a_3 , financial engineering.

First determine the set of system factors $G = \{a_1, a_2, a_3\}$. Three postgraduates f_1, f_2, f_3 (whose weight vector is λ_1 : 0.3, λ_2 : 0.3, λ_3 : 0.4) compare the three courses by using IFN at two times t_1, t_2 (whose weight vector is t_1 : 0.3, t_2 : 0.7). The postgraduates $f_k(k = 1, 2, 3)$ provide their initial intuitionistic fuzzy direct relation matrix $R^{\varphi(t_k)} = (r_{ij}^{\varphi(t_k)})_{3\times3}(\varphi = 1, 2, 3; k = 1, 2)$ respectively, as listed below:

$$R^{1(t_1)} = \begin{bmatrix} (0.5,0.5,0) & (0.4,0.6,0) & (0.5,0.4,0.1) \\ (0.6,0.4,0) & (0.5,0.5,0) & (0.3,0.4,0.3) \\ (0.4,0.5,0.1) & (0.4,0.3,0.3) & (0.5,0.5,0) \end{bmatrix}, R^{1(t_2)} = \begin{bmatrix} (0.5,0.5,0) & (0.2,0.8,0) & (0.9,0.1,0) \\ (0.8,0.2,0) & (0.5,0.5,0) & (0.3,0.5,0.2) \\ (0.1,0.9,0) & (0.5,0.3,0.2) & (0.5,0.5,0) \end{bmatrix}$$

$$R^{2(t_1)} = \begin{bmatrix} (0.5,0.5,0) & (0.5,0.5,0) & (0.2,0.6,0.2) \\ (0.5,0.5,0) & (0.5,0.5,0) & (0.3,0.4,0.3) \\ (0.6,0.2,0.6) & (0.4,0.3,0.3) & (0.5,0.5,0) \end{bmatrix}, R^{2(t_2)} = \begin{bmatrix} (0.5,0.5,0) & (0.3,0.7,0) & (0.1,0.8,0.1) \\ (0.7,0.3,0) & (0.5,0.5,0) & (0.5,0.5,0) \\ (0.8,0.1,0.1) & (0.5,0.5,0) & (0.5,0.5,0) \end{bmatrix}$$

$$R^{3(t_1)} = \begin{bmatrix} (0.5,0.5,0) & (0.3,0.5,0.2) & (0.3,0.7,0) \\ (0.5,0.3,0.2) & (0.5,0.5,0) & (0.1,0.9,0) \\ (0.7,0.3,0) & (0.9,0.1,0) & (0.5,0.5,0) \end{bmatrix}, R^{3(t_2)} = \begin{bmatrix} (0.5,0.5,0) & (0.4,0.5,0.1) & (0.6,0.3,0.1) \\ (0.5,0.4,0.1) & (0.5,0.5,0) & (0.4,0.4,0.2) \\ (0.3,0.6,0.1) & (0.4,0.4,0.2) & (0.5,0.5,0) \end{bmatrix}$$

Then we use step 4 to aggregate the matrix $R^{1(t_1)}, R^{2(t_1)}, R^{3(t_1)}$ and $R^{1(t_2)}, R^{2(t_2)}, R^{3(t_2)}$ horizontally into matrix $R^{(t_k)} = (r_{ij}^{(t_k)})_{3\times3}$:

$$R^{(t_1)} = \begin{bmatrix} (0.5,0.5,0) & (0.39,0.53,0.08) & (0.33,0.58,0.09) \\ (0.53,0.39,0.08) & (0.5,0.5,0) & (0.22,0.6,0.18) \\ (0.58,0.33,0.09) & (0.6,0.22,0.18) & (0.5,0.5,0) \end{bmatrix}, R^{(t_2)} = \begin{bmatrix} (0.5,0.5,0) & (0.31,0.65,0.04) & (0.54,0.39,0.07) \\ (0.65,0.31,0.04) & (0.5,0.5,0) & (0.4,0.46,0.14) \\ (0.39,0.54,0.07) & (0.46,0.4,0.14) & (0.5,0.5,0) \end{bmatrix}$$

By DIFWA , we fuse the $R^{(t_1)}, R^{(t_2)}$ again into integrated intuitionistic fuzzy relation matrix R :

$$R=\begin{bmatrix}(0.5,0.5,0) & (0.34,0.61,0.05) & (0.49,0.44,0.07)\\(0.62,0.33,0.05) & (0.5,0.5,0) & (0.35,0.56,0.09)\\(0.45,0.47,0.08) & (0.51,0.33,0.16) & (0.5,0.5,0)\end{bmatrix}$$

Next we utilize step 6 to convert matrix R into real number matrix $\overline{R}$. Here we let $\beta=0.5$, so the real number matrix $\overline{R}$ is:

$$\overline{R}=\begin{bmatrix}0 & -0.27 & 0.05\\0.29 & 0 & -0.21\\-0.02 & 0.18 & 0\end{bmatrix}$$

In the same way, according to the step 7&8, we calculate the center and reason degree as shown in table 1.

Table1. The rank information of every optional curriculum

curriculum	f_i	e_i	f_i+e_i	f_i-e_i	rank
a_1	-0.37	0.3	-0.07	-0.67	2nd
a_2	-0.38	-0.65	-1.03	0.27	3rd
a_3	0.37	-0.03	0.34	0.4	1st

From the comparison of data in Table 1 clearly, we can select the curriculum as the sequence of $a_3 \succ a_1 \succ a_2$ in the process of academic curriculum arrangement. That is to say, the decision makers who is responsible for the course arrangement should opt to the alternative in accordance with the above order when the option is limited. Through the above analysis, the dynamic DEMATEL decision approach that this paper present fully consider the limitations of expert cognition. As the application of IFN, the method also completely express experts' judgment on decision making problems integrally. At the same time, by the means of the judgment of multi-person and multi-rounds, and using DIFWA operator to integrate the decision-makers' judgment of different moment, the approach is more coincident with the actual decision situation. Through the practical application of this instance, it can be seen that the presented method has the application feasibility for the objective actual situation.

6. Conclusions

Since DEMATEL was introduced, it has been applied in many areas, such as in social life, economic management, and many other fields by its strong practicality and convenience. However, in the application of DEMATEL method, present literature always ignores the influence of subjective factors of decision makers. And the vast majority of scholars take account into only one single expert's judgment about the factors relationship of the complex system at a single period, who ignore the complexity of the decision-making process. Therefore, this paper proposes a method called dynamic DEMATEL group decision method based on IFN. The method has two following advantages. Firstly, using IFNs instead of the traditional point estimates, can reflect the experts' overall perception of complex decision problems more objectively and accurately. It is also more delicately portray the fuzziness and uncertainty of the complex system in real world. Secondly, through many experts in multiple rounds of scientific decision making, bringing the time dimension into DEMATEL in dynamic decision, and integrating group information effectively, will be more in line with the complex issue of practical decision making situations. Finally, an example of verification results shows that this approach is feasible, which can effectively solve dynamic DEMATEL group decision problem in practice.

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