METHODOLOGIES AND APPLICATION

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Information entropy risk measure applied to large group decision-making method

Xuan-hua Xu[1] · Xintong Luo[1]

Abstract

Based on specially significant emergencies, as Tianjin Port, "8·12" large fire and explosion accidents and other practical cases, we have a scientific modeling for decision-making process and identify the risk that complex large group decision-makers' preference differences lead to in the process. We propose a new risk measure combined with information entropy theory to measure risk in clustering. Risk due to the complexity of appetite caused in the decision-making process is quantificationally computed, and the size of the risk helps determine the results of the final preference information assembly, whereby the program order. Finally, numerical example illustrates the effectiveness of the method.

Keywords Risk measure · Large group · Emergency decision

1 Introduction

Major emergencies generally refer to the accidents occurring in a certain time and region and causing great losses of life and property (http://www.chinasafety.gov.cn/2007-04/20/content_232858.htm), such as the Tianjin Port "8 · 12" fire and explosion incident. In the study of the risk of major emergencies, the general focus is the risk caused by the emergency disposal taken at the incident scene. When psychological factors are considered to deal with the risk of decision-making according to the prospect theory (Kahneman and Tversky 1979), regret theory (Bell 1982), etc., it means that the impact is taken into account that individual preferences have on the results of selection. This paper considers the risk caused by multiple complex preferences in large group decision-making process. Since the major participant involved in decision-making is mainly the government, this risk is similar to the decision risk faced by government in decision-making process. Bin (2012) analyses the decision-making risk of government investment projects

from the perspective of the participants, identifies the risk factors, uses fuzzy clustering method to make the comparison among various risk factors' correlations, and finally establishes an evaluation model to measure the participant risk of government investment projects. And because of the complex preferences, great conflicts are likely to exist among decision-makers' preferences, which are one kind of potential reason of decision risk. Xuanhua et al. (2014) proposes the multi-attribute and multi-stage large group decision-making method for preference conflict optimization, which considers phase correction of decision-makers' preferences to optimize the conflict and reduce the risk; Zhanfeng (2012) sets the anti-party system, so the extreme conflict resolution plan is proposed from the macro-level system that helps decision-makers in the mutual discussion to get consistent results. Moreover, different decision-making participants may give different decision-making values. Fasolo and Costa (2014) studies the different representations of numerical and linguistic expressions of decision-making and their effects on decision-making, whereas in the actual decision-making process different forms of decision values may also pose a risk.

Obviously, as for the decision-making of large events, merely participants' complex preferences can lead to a very large number of risk factors. In general, these elements are scientific decision-making process, the clear responsibilities of decision-makers, the rationality of decision-making power distribution, the suitable structure of expert groups, the

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participants' social responsibility, the evaluation forms, the dynamic movement of decision-makers, the conflict caused by the preference and the interpersonal relationship between the participators and so on.

With so many risks, in order to control the adverse effects, we need to have an auxiliary tool to measure and evaluate it. The previous research on risk measurement was almost in the field of finance (Junshan 2007; Chengli and Yan 2014; Ye et al. 2017; Grechuk and Zabarankin 2015), because investment portfolio gains can be directly expressed in numbers to make quantitative calculation of the risk control based on risk measure model. For emergency disposal, investment projects, site selection decisions, etc., all of them involve identifying and analyzing the risk factors as well as rating the risk of the whole decision-making process (Aven 2015). In recent years, the theory of financial risk measurement has gradually matured, and other fields have begun to study the application of risk measurement (Pender et al. 2016). In this paper, we proposed a method of measuring the risk of large group decision-making which focuses on the risk resulting from distribution of the decision-making rights, by calculating the degree of uncertainty with the information entropy theory (Xinlei 2015; Fleischhacker and Fok 2015).

This paper draws lessons from the "7 · 23" Yong-Wen line large-scale railway traffic accident (http://www.chinasafety. gov.cn/newpage/Contents/Channel_21679/2011/1228/2448 74/content_244874.htm), the Tianjin Port "8 · 12" large fire and explosion incident (http://www.chinasafety.gov.cn/ newpage/newfiles/201600812baogao.pdf) and other recent relevant information of emergency disposal. And on the basis of the existing emergency decision-making and risk measurement research, a new large group decision-making method is developed based on risk measurement.

2 Methodology

2.1 Problem description

According to the emergency disposal parts of the relevant large incident investigation reports in http://www.chinasafet y.gov.cn/newpage/Contents/Channel_21679/2011/1228/24 4874/content_244874.htm and http://www.chinasafety.gov. cn/newpage/newfiles/201600812baogao.pdf, we can simplify the analysis to know that the major emergency decisions can be concluded from three aspects. First, in order to prevent more severe consequences, it is the first step to make a quick emergent decision, such as fire fighting and evacuation of the crowds. At this time, it is mainly the local government and even the relevant departments that directly make emergency decisions in a very limited time, which requires participants' high level of the dynamic decision-making capacity.
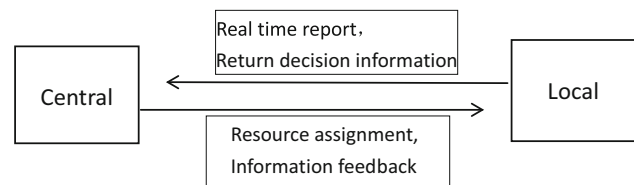

Fig. 1 Major emergencies central-local decision mode diagram

The second is the choice of rescue programs. Since the emergency scene of events may be different, the local government has prepared contingency plans as the alternatives. The third is to make decisions on medical resource scheduling, rescue compensation and other important matters. In addition, in recent years, with the increasing popularity of information technology, network public opinion (Wentao and Dachao 2011) has become a part of emergency decision-making which cannot be ignored. A part of the literature (http://www.chinasafety.gov.cn/newpage/Content s/Channel_21679/2011/1228/244874/content_244874.htm) mentioned that the misleading media reports caused the masses to mistakenly think the rescue has stopped, so the public opinion negatively affects the rescue operations. With the real-time monitoring of public opinion, the state media can announce the latest emergence plans immediately when facing some exceptional cases on the internet.

In the process of decision-making, there is generally a central leadership meeting to listen to the situation report and to make instructions. Then local government immediately establishes the accident rescue headquarters and organizes the relevant departments and experts to make emergency decision. Decision-makers of central departments contact with local headquarters through telephone or video and send representatives to the location to conduct supervision and guidance on local decisions. Therefore, a central-local decision-making model can be established, as shown in Fig. 1.

Assume that the central decision-maker decides the total number of local decision-makers is m. And decide the weight range of the local decision-makers in every decision-making process. We try to compute the weight distribution when the risk is the minimum and aggregate the preference information to sort the scheme.

For large group major emergency decision-making, basic symbols are provided as follows:

$\Omega = \{e_1, e_2, \ldots, e_i, \ldots, e_m\}$, represents a collection of m local decision participants, where $m > 20$ (Liu et al. 2014);

$A = \{a_1, a_2, \ldots, a_l, \ldots, a_p\}$, represents a collection of p alternative emergency plans;

$C = \{c_1, c_2, \ldots, c_j, \ldots, c_n\}$, represents a collection of n attributes for emergency plans;

$W = (w_1, w_2, \ldots, w_n)^T$, represents an attribute weight vector, where $\sum_{i=1}^{n} w_i = 1$.

$\boldsymbol{\omega} = (\omega_1, \omega_2, \ldots, \omega_m)^{\mathrm{T}}$, represents weight vector of decision-makers in decision group.

2.2 Information entropy risk measurement of decision participants' rights distribution

The risks caused by the decision-makers' right distribution in this paper mainly refer to the situation that the decision results cannot fully express the majority's wishes when all the participants' opinions are assembled.

Suppose that the evaluation value of the alternative a_l in attribute c_j of the member e_i is $d_{lj}^{(i)}$, where $d_{lj}^{(i)} \in [0, 1]$, then the preference matrices of m members are given as follows:

$$D^{(i)} = \begin{bmatrix} d_{11}^{(i)} & \cdots & d_{1j}^{(i)} & \cdots & d_{1n}^{(i)} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ d_{l1}^{(i)} & \cdots & d_{lj}^{(i)} & \cdots & d_{lj}^{(i)} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ d_{p1}^{(i)} & \cdots & d_{pj}^{(i)} & \cdots & d_{pn}^{(i)} \end{bmatrix}, \quad i = 1, 2, \ldots, m_o$$

Now the information entropy method is used to measure the risk of the entire decision-making group in the aggregation process, with the attribute weight vector W and the membership weights $\boldsymbol{\omega}$.

(1) As all evaluations of attribute c_j are $d_{lj}^{(i)}, i = 1, \ldots, m$; $l = 1, \ldots, p$, the interval $[0, 1]$ is equally divided into h small intervals and the size h is given by the decision-makers. And then the sth small interval is $\begin{cases} ((s-1)/h, s/h], & s > 1 \\ [0, 1/h], & s = 1 \end{cases}$. According to the membership weights, we can obtain the probability that the $d_{lj}^{(i)}$ falls in the s th interval:

$$P_{js}^l = \sum_{i=1}^{m} \omega_i S_{ij}^l, \quad \text{where } S_{ij}^l = \begin{cases} 0, & d_{lj}^{(i)} \notin ((s-1)/h, s/h] \\ 1, & d_{lj}^{(i)} \in ((s-1)/h, s/h] \end{cases}, \quad j = 1, 2, \ldots, n; \tag{1}$$

(2) In this paper, the average uncertainty degree of evaluation information is expressed by information entropy, and the risk of right distribution when the attribute c_j of all schemes' evaluation values is aggregated is calculated as follow:

$$E_j = -\frac{1}{\ln h} \sum_{l=1}^{p} \sum_{s=1}^{h} \left(P_{js}^l \ln P_{js}^l \right), \quad j = 1, 2, \ldots, n, \tag{2}$$

Then the risk vector is $E = (E_1, E_2, \ldots, E_n)^{\mathrm{T}}$;

(3) Finally, the risk entropy of the decision-making participants resulting from the uneven distribution of rights is obtained:

$$R = W^{\mathrm{T}} E. \tag{3}$$

2.3 Decision procedure

Step 1 The local command center reports the situation of the site to the central departments first. Then the central decision-maker decides the list of experts ($m > 20$) of each department involved in the decision-making and gives the attributes set C and the attribute weight W.

Step 2 Local decision-makers, according to the information given by the central departments, convened above personnel to participate in decision-making. Since the evaluation value of the alternative a_l in attribute c_j of the member e_i is $d_{lj}^{(i)}$, the preference matrices of m members are given as follows:

$$D^{(i)} = \begin{bmatrix} d_{11}^{(i)} & d_{12}^{(i)} & \cdots & d_{1n}^{(i)} \\ d_{21}^{(i)} & d_{22}^{(i)} & \cdots & d_{2n}^{(i)} \\ \cdots & \cdots & \cdots & \cdots \\ d_{p1}^{(i)} & d_{p2}^{(i)} & \cdots & d_{pn}^{(i)} \end{bmatrix} = \left(D_1^{(i)}, D_2^{(i)}, \ldots, D_n^{(i)} \right),$$
$$i = 1, 2, \ldots, m_o$$

According to the calculation formula proposed by the literature (Xuanhua et al. 2009), we can obtain the preference convergence degree between the member e_{i_1} and the member e_{i_3} of the attribute c_j:

$$r_j^{i_1 i_2} \left(D_j^{(i_1)}, D_j^{(i_2)} \right) = \frac{\left(\left| D_j^{(i_1)} - \overline{D_j^{(i_1)}} \right| \right)^{\mathrm{T}} \left(\left| D_j^{(i_2)} - \overline{D_j^{(i_2)}} \right| \right)}{\left\| D_j^{(i_1)} - \overline{D_j^{(i_1)}} \right\|_2 \left\| D_j^{(i_2)} - \overline{D_j^{(i_2)}} \right\|_2},$$

where $\| \bullet \|_2$ denotes the 2-norm of the vector, and

$$\overline{D_j^{(i)}} = \frac{1}{p} \sum_{l=1}^{p} d_{jl}^{(i)}. \tag{4}$$

And the preference convergence degree between the member e_{i_1} and the member e_{i_3} is

$$r^{i_1 i_2} = \sum_{j=1}^{n} w_j r_j^{i_1 i_2} \left(D_j^{(i_1)}, D_j^{(i_2)} \right). \tag{5}$$

Firstly, the members are randomly sorted and the first member is selected to form the aggregation Ω_1, which is compared with the left members in pairs to calculate the convergence degree of preferences. And determine appropriate threshold by previous study. Let these members, whose

degree results are greater than the threshold, join cluster Ω_1. After we find all the members to join in Ω_1, we select the top number among the remained members according to the previous ranking. Then we continue to compare the top number member with other members which did not join the former cluster Ω_1 by the same calculation. Compare the result with the threshold and members having larger results take part in the cluster Ω_2. When convergence degrees of preferences between a decision-maker and the rest of the decision-makers are all below the threshold, the separate decision-maker becomes a cluster. The previous steps mentioned in this paragraph should be repeated until all decision-makers can join their appropriate clusters. The decision group is clustered into K clusters , which is $\overline{\Omega} = \{\Omega_1, \Omega_2, \ldots, \Omega_k, \ldots, \Omega_K\}$.

Step 3 The previous results are reported back to the central departments, and the central decision-maker gives the weight interval of each expert in each cluster under the uniform standard. In other words, for any cluster Ω_k (whose number of members is denoted as n_k), the infimum set and supremum set of membership weight interval are given:

$$\text{Inf}_k = \{a_1^k, a_2^k, \ldots a_g^k, \ldots, a_{n_k}^k\}, \text{Sup}_k = \{b_1^k, b_2^k, \ldots, b_g^k, \ldots, b_{n_k}^k\},$$

$$\forall a_g^k \in [0, 1), b_g^k \in (0, 1] \text{ and } a_g^k < b_g^k, \sum_{g=1}^{n_k} a_g^k \le 1 \le \sum_{g=1}^{n_k} b_g^k,$$

Then we can randomly obtain the weight ω_g^k, $g = 1, 2, \ldots, q$, of members in cluster Ω_k, which meets the condition (1) : $\omega_g^k \in [a_g^k, b_g^k]$, $g = 1, 2 \ldots, n_k$;condition (2): $\sum_{g=1}^{n_k} \omega_g^k = 1$.

Then, the central decision-maker provides the overall weight interval's infimum set $\text{Inf} = \{a_1, a_2, \ldots, a_g, \ldots, a_K\}$ and supremum set $\text{Sup} = \{b_1, b_2, \ldots b_g, \ldots, b_K\}$ of every cluster, where $\forall a_g \in [0, 1), b_g \in (0, 1]$ and $a_g < b_g$, $\sum_{g=1}^{K} a_g \le 1 \le \sum_{g=1}^{K} b_g$. After aggregating cluster's information into a decision matrix representing each cluster correspondingly, the clusters' weights are randomly selected within the given interval, and that is $\omega_g \in [a_g b_g]$, $g = 1, 2, \ldots, K$, where $\sum_{g=1}^{K} \omega_g = 1$.

Step 4 According to the clustering result of decision group $\overline{\Omega}$, calculate the weights of experts within each cluster. For any cluster Ω_k, we use computer to generate a set of random number $X^k = (x_1^k, x_2^k, \ldots, x_g^k, \ldots, x_{n_k}^k)$, $\forall x_g^k \in [0, 1]$. According to the corresponding weight interval's infimum and supremum, let $y_g^k = (b_g^k - a_g^k)x_g^k + a_g^k$, $g = 1, 2, \ldots, n_k$, $Y^k = \{y_1^k, y_{21}^k, \ldots, y_{n_k}^k\}$, and normalized Y^k get the weight vector $\boldsymbol{\omega}^k = (\omega_1^k, \omega_2^k, \ldots \omega_{n_k}^k)^T$. Obviously it meets the condition (2), and we have to check whether $\boldsymbol{\omega}^k$

satisfies the condition(1). If not, we choose the new random numbers again, and continue to find the weight vector that matches the conditions; if satisfies, then take the $\boldsymbol{\omega}^k$ as a member weight vector. When obtain an appropriate $\boldsymbol{\omega}^k$, we can use the right distribution risk model of the decision-making participant proposed in this paper to calculate the risk under this weight vector:

(1) we have already obtained K clusters, and all the members of each cluster are in the corresponding set $I_{\Omega_k} = \{e_{1k}, e_{2k}, K, e_{nk}\}$, then the Cluster Ω_k's decision matrix for n attributes of m alternatives is as follows:

$$D^{ik} = \begin{bmatrix} d_{11}^{ik} & d_{12}^{ik} & \cdots & d_{1n}^{ik} \\ d_{21}^{ik} & d_{22}^{ik} & \cdots & d_{2n}^{ik} \\ \cdots & \cdots & \cdots & \cdots \\ d_{p1}^{ik} & d_{p2}^{ik} & \cdots & d_{pn}^{ik} \end{bmatrix}, \quad i = 1, 2, \ldots, n_k$$

(2) Members in cluster Ω_k provide the evaluation value d_{lj}^{ik}, $i = 1, \ldots, n_k$. for the alternative a_l's attribute c_j. According to formula (1), calculate the probability distributions that the d_{lj}^{ik} falls in the different intervals. Then, use the formula (2) to obtain the risk generated by the distributions mentioned above. Finally, we can get the whole risk entropy value by formula (3).

Repeat choosing random numbers for appropriate times to get teams of the weight vector, and each team's risk entropy value is calculated. Then select the optimal weight vector ω_*^k corresponding to the smallest risk entropy and use weighted average operator (Yager and Alajlan 2016) to gather decision information in cluster Ω_k. Then obtain $D_{\Omega_k} = \sum_{g=1}^{n_k} \omega_{*g}^k D(i_g)$. Apply the above method to each gathering processing to get each cluster's gathering results with the minimum risk entropy value, which is equal to obtaining decision preference matrix of the number of gathering members K.

Step 5 In each given cluster's weight interval, we select a random number to be combined, and then normalize each group of random numbers. We select multiple weight combinations that satisfy the limit interval, measure the risk of aggregating process in turn, and choose the weight vector $\boldsymbol{\omega}^* = (\omega_1^*, \omega_2^*, \ldots \omega_K^*)^T$ when the risk is the smallest, and that is to get decision-making preference matrix that aggregates all the information $D = \sum_{k=1}^{K} \omega_k^* D_{\Omega_k}$. Finally, according to the given attribute weight $\mathbf{W}$, calculate the final score $\mathbf{F} = \mathbf{W}^T D$ of all programs, and sort the scores by number, which should be sent to the central decision-makers for approval and implementation.

Table 1 Personnel scheduling scheme

Department	Decision	Scene rescue
Administration of work safety	7	224
Department of public health	5	150
Environmental Protection Department	5	123
The Meteorological Department	3	57
The people's Liberation Army	4	1353
The armed police forces	3	986
Firefighting force	5	2124
Others (Explosion-proof, anti-chemical, epidemic prevention, etc.)	8	534
Total	40	5551

3 Numerical examples

After receiving the call that a warehouse in the storage of dangerous goods broke out of fire, the Public Security Bureau 110 command center quickly sent the fire brigade to put out the fire and evacuate the crowds. Because of the rapid spread of fire and explosion, casualties and property losses continued to increase, reaching the major disaster level. The command center immediately contacted the central departments to report details of the incident.

Step 1 The central departments set up a decision-making group with four members, which led by the leader of highest level in the group to make decisions on this major incident and schedule the relevant departments to the scene to rescue personnel and make decisions (Table 1).

For 4 known different evacuation routes $A = \{a_1, a_2, a_3, a_4\}$, the central decision-making group gives five attributes which should be included in the reference based on the feedback from the site: c_1: terrain convenience, c_2: the suitable degree of local weather, c_3: the intact degree of medical facilities, c_4: the impossibility of secondary disasters, c_5: adequacy of material, that is $C = \{c_1, c_2, c_3, c_4, c_5\}$. Each member of the central group gives the recommended value of the attribute weight and then gets averages. After that the weight of each attribute of the scheme is obtained as shown in Table 2. The central decision-making group sent 40 decision-makers $\Omega = \{e_1, e_2, \ldots, e_{40}\}$ to constitute large groups of decision-making.

Step 2 Upon receiving the notice from the central government, the local command team contacted the decision-making groups to make quick evaluation on the five attributes of the four contingency plans according to the situation on site. The evaluation results are shown in Appendix 1. The degree of convergence among the decision-making preference matrices is calculated by the formula (4) and (5), and the decision-maker whose clustering degree is above the given

Table 2 Attribute weight assignment

Attribute code	c_1	c_2	c_3	c_4	c_5
Member1	0.25	0.12	0.30	0.13	0.20
Member2	0.23	0.15	0.32	0.05	0.20
Member3	0.30	0.12	0.25	0.05	0.23
Member4	0.20	0.20	0.33	0.13	0.24
Weight	0.245	0.147	0.300	0.091	0.217

threshold $\gamma = 0.8$ (Xuanhua et al. 2009) is clustered. In this paper, the degree of convergence between decision-maker e_1's and e_2's decision matrices is taken as an example (calculated by using the MATLAB programming).

The two matrices are as follows:

$$D^{(1)} = \begin{bmatrix} 0.4 & 0.5 & 0.7 & 0.1 & 0.9 \\ 0.6 & 0.5 & 0.1 & 0.7 & 0.2 \\ 0.5 & 0.9 & 0.3 & 0.2 & 0.3 \\ 0.4 & 0.5 & 0.3 & 0.6 & 0.2 \end{bmatrix}$$
$$= \left(D_1^{(1)}, D_2^{(1)}, D_3^{(1)}, D_4^{(1)}, D_5^{(1)} \right),$$

$$D^{(2)} = \begin{bmatrix} 0.7 & 0.5 & 0.3 & 0.1 & 0.8 \\ 0.6 & 0.4 & 0.2 & 0.7 & 0.6 \\ 0.5 & 0.9 & 0.5 & 0.2 & 0.3 \\ 0.4 & 0.5 & 0.1 & 0.6 & 0.2 \end{bmatrix}$$
$$= \left(D_1^{(2)}, D_2^{(2)}, D_3^{(2)}, D_4^{(2)}, D_5^{(2)} \right).$$

The preference coherence degree of decision-maker e_1 and e_2 is calculated for each attribute separately:

$$r_j^{12} \left(D_j^{(1)}, D_j^{(2)} \right)$$
$$= \frac{\left(\left| D_j^{(1)} - \overline{D_j^{(1)}} \right| \right)^{\mathrm{T}} \left(\left| D_j^{(2)} - \overline{D_j^{(2)}} \right| \right)}{\left\| D_j^{(1)} - \overline{D_j^{(1)}} \right\|_2 \left\| D_j^{(2)} - \overline{D_j^{(2)}} \right\|_2}, \quad j = 1, 2, \ldots 5,$$

where $\overline{D_j^{(1)}} = \frac{1}{4} \sum_{l=1}^{4} d_{jl}^{(1)}$, $\overline{D_j^{(2)}} = \frac{1}{4} \sum_{l=1}^{4} d_{jl}^{(2)}$. The results are shown in Table 3.

According to the attribute weight assignment given by the central group, the total degree of the two decision-makers can be obtained:

Table 3 The degree between e_1 and e_2 on each attribute

Attribute code	c_1	c_2	c_3	c_4	c_5
Degree	0.8086	0.9771	0.3684	1	0.9349

Table 4 Decision-makers clustering results

Cluster code	Number of members	Detailed list	Consistency index
Ω_1	11	$e_1, e_5, e_{10}, e_{12}, e_{13}, e_{22}, e_{31}, e_{32}, e_{36}, e_{37}, e_{38}$	0.8521
Ω_2	5	$e_2, e_9, e_{18}, e_{21}, e_{25}$	0.8925
Ω_3	7	$e_3, e_7, e_{11}, e_{17}, e_{27}, e_{30}, e_{35}$	0.9335
Ω_4	8	$e_4, e_{15}, e_{19}, e_{28}, e_{33}, e_{34}, e_{39}, e_{40}$	0.9290
Ω_5	5	$e_6, e_{14}, e_{20}, e_{23}, e_{24}$	0.8539
Ω_6	4	$e_8, e_{16}, e_{26}, e_{29}$	0.9486

Table 5 Cluster weight interval

Cluster code	Ω_1	Ω_2	Ω_3	Ω_4	Ω_5	Ω_6
Weight interval	[0.3, 0.4]	[0.1, 0.2]	[0.2, 0.3]	[0.2, 0.3]	[0, 0.1]	[0, 0.1]

Table 6 When $h = 5$, the best weighting result for each cluster

Cluster	Weight vector	Risk value
Ω_1	$(0.0912, 0.0730, 0.0311, 0.0745, 0.0880, 0.0981, 0.0984, 0.0950, 0.0655, 0.0981, 0.1872)^T$	0.5070
Ω_2	$(0.5576, 0.1075, 0.1976, 0.0601, 0.0772)^T$	0.2368
Ω_3	$(0.0881, 0.0681, 0.0938, 0.0227, 0.1251, 0.2974, 0.3047)^T$	0.9813
Ω_4	$(0.2456, 0.0052, 0.1706, 0.1188, 0.3008, 0.0123, 0.0115, 0.1352)^T$	0.5000
Ω_5	$(0.1371, 0.0493, 0.5811, 0.0293, 0.2033)^T$	0.5215
Ω_6	$(0.0787, 0.8617, 0.0181, 0.0415)^T$	0.0702

Table 7 When $h = 10$, the best weighting result for each cluster

Cluster	Weight vector	Risk value
Ω_1	$(0.0887, 0.0921, 0.0847, 0.0500, 0.0776, 0.0980, 0.0972, 0.0502, 0.0987, 0.0735, 0.1894)^T$	0.5708
Ω_2	$(0.5520, 0.1010, 0.1273, 0.0386, 0.1811)^T$	0.7886
Ω_3	$(0.0294, 0.0889, 0.0616, 0.0821, 0.1795, 0.2150, 0.3434)^T$	0.7008
Ω_4	$(0.2106, 0.0032, 0.1252, 0.1849, 0.3019, 0.0271, 0.0322, 0.1148)^T$	0.6441
Ω_5	$(0.1051, 0.0085, 0.5161, 0.1004, 0.2699)^T$	0.8766
Ω_6	$(0.0614, 0.8270, 0.0452, 0.0664)^T$	0.1656

$$r^{12} = 0.245 \times 0.8086 + 0.147 \times 0.9771 + 0.301 \times 0.3684$$
$$+ 0.091 \times 1 + 0.216 \times 0.9349 = 0.7456.$$

When $\gamma = 0.8$, we have calculation on each two decision-makers together and cluster decision-makers whose results are greater than 0.8. The results are shown in Table 4.

Step 3 The results will be reported back to the central decision-making team. Given that the central decision-makers give the interval number $h = 5$ and $h = 10$, respectively, each weight interval is gathered for internal decision-makers of each cluster. It should be ensured that all members' weights in a given range can be added to 1. The interval numbers are shown in Appendix 2.

The central decision group assigned the weight interval for each cluster according to the number of members, as shown in Table 5.

Step 4 Randomly select the numbers in the interval given in Appendix 2 and normalize the weight of each decision-maker to meet the conditions. Then measure the risk of cluster under the weight distribution and choose 10 effective risk entropy results to make comparisons. When the risk entropy is minimum, choose the weight distribution results for real clustering. Tables 6 and 7 show the best weight distribution of each cluster. The programming results of MATLAB are shown in Tables 8 and 9.

Step 5 Make a random selection from weight interval in Table 5 and ensure that the normalized weights are obtained in the weight range. Then make effective operations for over 10 times. Calculation results of risk level are shown in Tables 10 and 11. We choose a set of weights with the least risk, when $h = 5$, $\boldsymbol{\omega}^* = (0.3704, 0.1017, 0.2125, 0.2924, 0.0055, 0.0175)^T$ and $h = 10$, $\boldsymbol{\omega}^* = (0.3249, 0.1702,$

Table 8 When $h = 5$, the clustering result of each cluster

Cluster	Clustering results
Ω_1	$D_{\Omega_1} = \begin{bmatrix} 0.4183 & 0.4906 & 0.6100 & 0.1479 & 0.8797 \\ 0.6031 & 0.5144 & 0.1126 & 0.6970 & 0.2171 \\ 0.4922 & 0.8489 & 0.3000 & 0.2095 & 0.3100 \\ 0.4000 & 0.4927 & 0.3000 & 0.5804 & 0.2470 \end{bmatrix}$
Ω_2	$D_{\Omega_2} = \begin{bmatrix} 0.6450 & 0.4893 & 0.3000 & 0.1425 & 0.7678 \\ 0.6000 & 0.3802 & 0.1832 & 0.7000 & 0.5708 \\ 0.5013 & 0.8725 & 0.4893 & 0.1725 & 0.3000 \\ 0.4000 & 0.5000 & 0.1000 & 0.6000 & 0.2000 \end{bmatrix}$
Ω_3	$D_{\Omega_3} = \begin{bmatrix} 0.6137 & 0.2000 & 0.2634 & 0.3074 & 0.6297 \\ 0.8611 & 0.1726 & 0.5225 & 0.8694 & 0.4204 \\ 0.4702 & 0.8374 & 0.4695 & 0.1125 & 0.5999 \\ 0.4698 & 0.1000 & 0.5931 & 0.1305 & 0.1907 \end{bmatrix}$
Ω_4	$D_{\Omega_4} = \begin{bmatrix} 0.6905 & 0.7503 & 0.2949 & 0.6235 & 0.3395 \\ 0.6429 & 0.1971 & 0.5936 & 0.5337 & 0.2000 \\ 0.3067 & 0.2803 & 0.4120 & 0.1699 & 0.5473 \\ 0.6302 & 0.3238 & 0.7100 & 0.6005 & 0.2894 \end{bmatrix}$
Ω_5	$D_{\Omega_5} = \begin{bmatrix} 0.2029 & 0.7989 & 0.3838 & 0.4419 & 0.2279 \\ 0.7370 & 0.6677 & 0.5586 & 0.1784 & 0.6163 \\ 0.4838 & 0.4050 & 0.5030 & 0.4620 & 0.6635 \\ 0.2000 & 0.1407 & 0.2366 & 0.1000 & 0.6594 \end{bmatrix}$
Ω_6	$D_{\Omega_6} = \begin{bmatrix} 0.4805 & 0.4236 & 0.7746 & 0.2236 & 0.3847 \\ 0.6983 & 0.5291 & 0.8843 & 0.1060 & 0.1315 \\ 0.5959 & 0.1296 & 0.3157 & 0.3157 & 0.6157 \\ 0.7587 & 0.1921 & 0.5607 & 0.8370 & 0.4236 \end{bmatrix}$

Table 9 When $h = 10$, the clustering result of each cluster

Cluster	Clustering results
Ω_1	$D_{\Omega_1} = \begin{bmatrix} 0.4100 & 0.4935 & 0.6196 & 0.1436 & 0.8793 \\ 0.5970 & 0.5049 & 0.1135 & 0.6916 & 0.2190 \\ 0.4874 & 0.8496 & 0.2976 & 0.2050 & 0.3113 \\ 0.4000 & 0.4908 & 0.3000 & 0.5806 & 0.2390 \end{bmatrix}$
Ω_2	$D_{\Omega_2} = \begin{bmatrix} 0.6451 & 0.4899 & 0.3000 & 0.1306 & 0.7697 \\ 0.6000 & 0.3873 & 0.1860 & 0.7000 & 0.5617 \\ 0.4845 & 0.8759 & 0.4899 & 0.1692 & 0.3000 \\ 0.4000 & 0.5000 & 0.1000 & 0.6000 & 0.2000 \end{bmatrix}$
Ω_3	$D_{\Omega_3} = \begin{bmatrix} 0.6047 & 0.2000 & 0.2696 & 0.3104 & 0.6214 \\ 0.8613 & 0.1774 & 0.5272 & 0.8656 & 0.4194 \\ 0.4785 & 0.8359 & 0.4656 & 0.1179 & 0.5999 \\ 0.4547 & 0.1000 & 0.5910 & 0.1343 & 0.1902 \end{bmatrix}$
Ω_4	$D_{\Omega_4} = \begin{bmatrix} 0.7417 & 0.7881 & 0.2725 & 0.6874 & 0.2548 \\ 0.6468 & 0.1342 & 0.6743 & 0.5104 & 0.2000 \\ 0.2874 & 0.1626 & 0.4447 & 0.1698 & 0.5874 \\ 0.6564 & 0.3000 & 0.7574 & 0.6003 & 0.3027 \end{bmatrix}$
Ω_5	$D_{\Omega_5} = \begin{bmatrix} 0.2100 & 0.7863 & 0.3968 & 0.4484 & 0.2434 \\ 0.7475 & 0.6936 & 0.5689 & 0.1786 & 0.6032 \\ 0.4968 & 0.4008 & 0.5100 & 0.4604 & 0.6698 \\ 0.2000 & 0.1540 & 0.2302 & 0.1000 & 0.6460 \end{bmatrix}$
Ω_6	$D_{\Omega_6} = \begin{bmatrix} 0.4882 & 0.4184 & 0.7771 & 0.2184 & 0.3949 \\ 0.6859 & 0.5224 & 0.8877 & 0.1112 & 0.1246 \\ 0.5934 & 0.1296 & 0.3123 & 0.3123 & 0.6123 \\ 0.7743 & 0.1939 & 0.5693 & 0.8509 & 0.4184 \end{bmatrix}$

$0.2227, 0.2576, 0.0145, 0.0101)^T$. We get the final decision evaluation matrix and calculate the final value of each scheme

Table 10 When $h = 5$, each cluster weight distribution and its risk

W	R
$(0.3167, 0.1085, 0.2063, 0.2099, 0.0105, 0.1481)^T$	1.5208
$(0.3204, 0.1732, 0.2338, 0.2094, 0.0204, 0.0428)^T$	1.4521
$(0.3337, 0.1588, 0.2111, 0.2681, 0.0263, 0.0021)^T$	1.4291
$(0.3704, 0.1017, 0.2125, 0.2924, 0.0055, 0.0175)^T$	1.4084
$(0.3063, 0.1309, 0.2165, 0.2079, 0.0663, 0.0721)^T$	1.5405
$(0.3089, 0.1408, 0.2378, 0.2165, 0.0692, 0.0268)^T$	1.4998
$(0.3212, 0.1208, 0.2747, 0.2302, 0.0256, 0.0275)^T$	1.4415
$(0.3689, 0.1026, 0.2643, 0.2223, 0.0139, 0.0280)^T$	1.4109
$(0.3291, 0.1386, 0.2734, 0.2027, 0.0179, 0.0383)^T$	1.4329
$(0.3328, 0.1324, 0.2353, 0.2556, 0.0287, 0.0152)^T$	1.4447

Table 11 When $h = 10$, each cluster weight distribution and its risk

W	R
$(0.3045, 0.1801, 0.2401, 0.2128, 0.0613, 0.0012)^T$	2.1749
$(0.3249, 0.1702, 0.2227, 0.2576, 0.0145, 0.0101)^T$	2.0957
$(0.3435, 0.1654, 0.2064, 0.2122, 0.0259, 0.0466)^T$	2.1593
$(0.3166, 0.1243, 0.2190, 0.2426, 0.0398, 0.0577)^T$	2.2512
$(0.3101, 0.1979, 0.2134, 0.2166, 0.0051, 0.0569)^T$	2.1102
$(0.3159, 0.1150, 0.2498, 0.2360, 0.0348, 0.0485)^T$	2.1988
$(0.3009, 0.1341, 0.2152, 0.2001, 0.0992, 0.0505)^T$	2.3402
$(0.3539, 0.1678, 0.2067, 0.2218, 0.0205, 0.0292)^T$	2.1161
$(0.3449, 0.1030, 0.2685, 0.2349, 0.0001, 0.0486)^T$	2.0969
$(0.3034, 0.1580, 0.2530, 0.2033, 0.0473, 0.0350)^T$	2.1730

according to the attribute weight in Table 2. The evaluation values are shown in Tables 12 and 13.

Finally both of the two cases' ranking results are: $a_1 > a_2 > a_3 > a_4$, which are conveyed to the central decision-making group to determine the final program selection.

4 Conclusion

This paper provides a method of multi-attribute emergency decision-making for large group, calculates the risk in the decision-making by risk measurement proposed, and reduces the risk of the process of clustering, which makes the conclusion better reflect the views of decision-makers. Through the calculation of the preference convergence and the risk of the decision-maker's rights distribution, the risk caused by the preference difference and the distribution of rights are considered. When processing vast amounts of information, we often cannot use a precise number to represent all of our views. The fuzzy interval uses high-speed operation of the computer to find the result consistent with the demand and reflecting the views of most people. In fact, expansion research can be made on central decision-makers, for example, with large data method a more appropriate num-

Table 12 When $h = 5$, the final evaluation result

Alternatives/attributes	c_1	c_2	c_3	c_4	c_5	Final evaluation
a_1	0.5624	0.5052	0.4143	0.3233	0.6450	0.5055
a_2	0.6716	0.3364	0.3635	0.6730	0.2920	0.4477
a_3	0.4360	0.6676	0.3894	0.1768	0.4473	0.4349
a_4	0.4873	0.3534	0.4661	0.4945	0.2480	0.4102

Table 13 When $h = 10$, the final evaluation result

Alternatives/attributes	c_1	c_2	c_3	c_4	c_5	Final evaluation
a_1	0.5605	0.4928	0.3740	0.3143	0.5997	0.4805
a_2	0.6500	0.2999	0.3737	0.6493	0.3142	0.4428
a_3	0.4192	0.6347	0.3996	0.1684	0.4432	0.4273
a_4	0.4665	0.3323	0.4409	0.4663	0.2438	0.3910

ber of participants and distribution can be selected. Actually the number of people involved in decision-making can be dynamic. The method presented in this paper can deal with the situation of dynamic large groups, and the risk control of dynamic decision participants can be further studied on the basis of this paper.

There are also shortcomings. For instance, when there is too much limits of selection of the random number, it is difficult to find the weights that can fully meet the conditions from the random numbers in the selected range; with less range limits of random number, the risk level changes greatly. We can consider using numerical approximation and other methods to set a risk threshold, which can solve the appropriate weight interval until the interval's corresponding risk value is below this threshold.

Compliance with ethical standards

Appendix 1: Group decision evaluation

See Table 14.

Table 14 Assessment data for 40 decision makers

Member/alternative		c_1	c_2	c_3	c_4	c_5
e_1	l_1	0.4	0.5	0.7	0.1	0.9
	l_2	0.6	0.5	0.1	0.7	0.2
	l_3	0.5	0.9	0.3	0.2	0.3
	l_4	0.4	0.5	0.3	0.6	0.2
e_2	l_1	0.7	0.5	0.3	0.1	0.8
	l_2	0.6	0.4	0.2	0.7	0.6
	l_3	0.5	0.9	0.5	0.2	0.3
	l_4	0.4	0.5	0.1	0.6	0.2
e_3	l_1	0.6	0.2	0.3	0.3	0.6
	l_2	0.9	0.2	0.6	0.9	0.4
	l_3	0.5	0.9	0.5	0.1	0.6
	l_4	0.5	0.1	0.6	0.1	0.1
e_4	l_1	0.7	0.8	0.3	0.7	0.3
	l_2	0.7	0.1	0.7	0.5	0.2
	l_3	0.3	0.1	0.5	0.2	0.6
	l_4	0.7	0.3	0.8	0.6	0.3
e_5	l_1	0.5	0.5	0.7	0.1	0.9
	l_2	0.6	0.4	0.1	0.7	0.3
	l_3	0.5	0.9	0.3	0.2	0.3
	l_4	0.4	0.4	0.3	0.6	0.3
e_6	l_1	0.2	0.7	0.5	0.5	0.1
	l_2	0.8	0.9	0.7	0.1	0.5
	l_3	0.6	0.4	0.5	0.5	0.8
	l_4	0.2	0.1	0.1	0.1	0.7
e_7	l_1	0.4	0.2	0.2	0.1	0.6
	l_2	0.8	0.2	0.6	0.9	0.4
	l_3	0.5	0.9	0.5	0.1	0.6
	l_4	0.4	0.1	0.5	0.1	0.1

Table 14 continued

Member/alternative		Attribute				
		c_1	c_2	c_3	c_4	c_5
e_8	l_1	0.5	0.4	0.8	0.2	0.4
	l_2	0.6	0.5	0.9	0.2	0.1
	l_3	0.6	0.2	0.3	0.3	0.6
	l_4	0.9	0.2	0.6	0.9	0.4
e_9	l_1	0.5	0.4	0.3	0.2	0.5
	l_2	0.6	0.4	0.1	0.7	0.4
	l_3	0.4	0.7	0.4	0.2	0.3
	l_4	0.4	0.5	0.1	0.6	0.2
e_{10}	l_1	0.3	0.5	0.7	0.1	0.8
	l_2	0.4	0.5	0.2	0.6	0.2
	l_3	0.5	0.8	0.3	0.2	0.2
	l_4	0.4	0.5	0.3	0.6	0.2
e_{11}	l_1	0.7	0.2	0.3	0.2	0.6
	l_2	0.9	0.1	0.4	0.9	0.4
	l_3	0.5	0.9	0.5	0.1	0.6
	l_4	0.6	0.1	0.6	0.1	0.1
e_{12}	l_1	0.4	0.4	0.2	0.1	0.8
	l_2	0.6	0.5	0.1	0.7	0.2
	l_3	0.6	0.9	0.3	0.2	0.3
	l_4	0.4	0.5	0.3	0.6	0.6
e_{13}	l_1	0.3	0.7	0.6	0.1	0.9
	l_2	0.6	0.5	0.1	0.7	0.2
	l_3	0.4	0.8	0.3	0.2	0.3
	l_4	0.4	0.5	0.3	0.6	0.2
e_{14}	l_1	0.2	0.7	0.5	0.5	0.1
	l_2	0.7	0.9	0.6	0.1	0.5
	l_3	0.6	0.5	0.5	0.2	0.8
	l_4	0.2	0.1	0.1	0.1	0.7
e_{15}	l_1	0.4	0.7	0.3	0.7	0.3
	l_2	0.7	0.1	0.5	0.5	0.2
	l_3	0.3	0.1	0.5	0.2	0.6
	l_4	0.7	0.3	0.8	0.7	0.3
e_{16}	l_1	0.5	0.4	0.8	0.2	0.4
	l_2	0.7	0.5	0.9	0.1	0.1
	l_3	0.6	0.1	0.3	0.3	0.6
	l_4	0.8	0.2	0.6	0.9	0.4
e_{17}	l_1	0.6	0.2	0.3	0.3	0.6
	l_2	0.8	0.2	0.7	0.9	0.2
	l_3	0.5	0.8	0.5	0.1	0.6
	l_4	0.4	0.1	0.6	0.1	0.1
e_{18}	l_1	0.6	0.5	0.3	0.2	0.8
	l_2	0.6	0.3	0.2	0.7	0.6
	l_3	0.6	0.9	0.5	0.1	0.3
	l_4	0.4	0.5	0.1	0.6	0.2
e_{19}	l_1	0.7	0.8	0.3	0.6	0.2
	l_2	0.7	0.3	0.5	0.4	0.2

Table 14 continued

Member/alternative		Attribute				
		c_1	c_2	c_3	c_4	c_5
	l_3	0.2	0.6	0.3	0.2	0.5
	l_4	0.5	0.3	0.7	0.6	0.3
e_{20}	l_1	0.2	0.9	0.3	0.4	0.3
	l_2	0.7	0.5	0.5	0.2	0.7
	l_3	0.4	0.4	0.5	0.5	0.6
	l_4	0.2	0.1	0.3	0.1	0.7
e_{21}	l_1	0.6	0.5	0.3	0.3	0.8
	l_2	0.6	0.4	0.1	0.7	0.6
	l_3	0.5	0.8	0.5	0.2	0.3
	l_4	0.4	0.5	0.1	0.6	0.2
e_{22}	l_1	0.5	0.5	0.7	0.3	0.9
	l_2	0.6	0.5	0.1	0.7	0.3
	l_3	0.5	0.8	0.2	0.2	0.3
	l_4	0.4	0.5	0.3	0.6	0.2
e_{23}	l_1	0.3	0.8	0.5	0.5	0.5
	l_2	0.8	0.9	0.7	0.1	0.5
	l_3	0.6	0.4	0.6	0.4	0.8
	l_4	0.2	0.1	0.1	0.1	0.7
e_{24}	l_1	0.2	0.6	0.5	0.5	0.1
	l_2	0.8	0.9	0.6	0.2	0.5
	l_3	0.6	0.4	0.5	0.4	0.7
	l_4	0.2	0.3	0.2	0.1	0.5
e_{25}	l_1	0.6	0.5	0.3	0.1	0.8
	l_2	0.6	0.4	0.2	0.7	0.5
	l_3	0.4	0.9	0.5	0.1	0.3
	l_4	0.4	0.5	0.1	0.6	0.2
e_{26}	l_1	0.5	0.4	0.7	0.2	0.4
	l_2	0.4	0.6	0.9	0.2	0.1
	l_3	0.6	0.2	0.3	0.3	0.6
	l_4	0.9	0.2	0.6	0.9	0.4
e_{27}	l_1	0.5	0.2	0.3	0.3	0.6
	l_2	0.9	0.3	0.6	0.9	0.6
	l_3	0.5	0.9	0.5	0.2	0.6
	l_4	0.5	0.1	0.6	0.1	0.1
e_{28}	l_1	0.8	0.8	0.3	0.7	0.2
	l_2	0.7	0.1	0.7	0.5	0.2
	l_3	0.3	0.1	0.5	0.2	0.6
	l_4	0.6	0.3	0.7	0.6	0.3
e_{29}	l_1	0.6	0.4	0.8	0.2	0.6
	l_2	0.6	0.4	0.9	0.2	0.1
	l_3	0.5	0.2	0.3	0.3	0.6
	l_4	0.9	0.2	0.6	0.9	0.4
e_{30}	l_1	0.6	0.2	0.2	0.3	0.7
	l_2	0.8	0.2	0.6	0.9	0.4
	l_3	0.4	0.8	0.5	0.1	0.6
	l_4	0.5	0.1	0.6	0.1	0.2

Table 14 continued

Member/alternative		Attribute				
		c_1	c_2	c_3	c_4	c_5
e_{31}	l_1	0.5	0.4	0.7	0.1	0.9
	l_2	0.6	0.5	0.1	0.7	0.2
	l_3	0.5	0.8	0.3	0.2	0.3
	l_4	0.4	0.5	0.3	0.4	0.3
e_{32}	l_1	0.4	0.5	0.7	0.2	0.9
	l_2	0.5	0.6	0.2	0.7	0.2
	l_3	0.5	0.9	0.3	0.3	0.3
	l_4	0.4	0.5	0.3	0.6	0.2
e_{33}	l_1	0.8	0.8	0.2	0.7	0.3
	l_2	0.6	0.1	0.7	0.5	0.2
	l_3	0.3	0.1	0.4	0.1	0.6
	l_4	0.7	0.3	0.8	0.6	0.3
e_{34}	l_1	0.6	0.8	0.4	0.7	0.2
	l_2	0.7	0.2	0.7	0.5	0.2
	l_3	0.3	0.1	0.5	0.2	0.6
	l_4	0.7	0.3	0.8	0.6	0.4
e_{35}	l_1	0.7	0.2	0.3	0.4	0.6
	l_2	0.9	0.1	0.4	0.8	0.4
	l_3	0.5	0.8	0.4	0.1	0.6
	l_4	0.4	0.1	0.6	0.2	0.3
e_{36}	l_1	0.3	0.5	0.6	0.1	0.9
	l_2	0.6	0.4	0.1	0.7	0.2
	l_3	0.4	0.9	0.3	0.2	0.5
	l_4	0.4	0.5	0.3	0.6	0.2
e_{37}	l_1	0.5	0.4	0.7	0.1	0.8
	l_2	0.6	0.5	0.1	0.7	0.2
	l_3	0.5	0.7	0.4	0.2	0.3
	l_4	0.4	0.5	0.3	0.6	0.2
e_{38}	l_1	0.4	0.5	0.5	0.2	0.9
	l_2	0.7	0.6	0.1	0.7	0.2
	l_3	0.5	0.9	0.3	0.2	0.3
	l_4	0.4	0.5	0.3	0.6	0.2
e_{39}	l_1	0.6	0.8	0.3	0.7	0.3
	l_2	0.7	0.3	0.7	0.5	0.2
	l_3	0.3	0.1	0.5	0.2	0.6
	l_4	0.7	0.3	0.8	0.6	0.3
e_{40}	l_1	0.7	0.7	0.3	0.7	0.2
	l_2	0.5	0.1	0.7	0.7	0.2
	l_3	0.3	0.1	0.5	0.2	0.6
	l_4	0.7	0.3	0.7	0.6	0.3

Appendix 2: Each cluster's weight distribution

See Table 15, 16, 17, 18, 19 and 20.

Table 15 Cluster Ω_1 weight distribution

Member	e_1	e_5	e_{10}	e_{12}	e_{13}	e_{22}	e_{31}	e_{32}	e_{36}	e_{37}	e_{38}
Weight interval	[0, 0.1]	[0, 0.1]	[0, 0.1]	[0, 0.1]	[0, 0.1]	[0, 0.1]	[0, 0.1]	[0, 0.1]	[0, 0.1]	[0, 0.1]	[0.1, 0.2]

Table 16 Cluster Ω_2 weight distribution

Member	e_2	e_9	e_{18}	e_{21}	e_{25}
Weight interval	[0.5, 0.6]	[0.1, 0.2]	[0.1, 0.2]	[0, 0.1]	[0, 0.1]

Table 17 Cluster Ω_3 weight distribution

Member	e_3	e_7	e_{11}	e_{17}	e_{27}	e_{30}	e_{35}
Weight interval	[0, 0.1]	[0, 0.1]	[0, 0.1]	[0, 0.1]	[0.1, 0.2]	[0.2, 0.3]	[0.3, 0.4]

Table 18 Cluster Ω_4 weight distribution

Member	e_4	e_{15}	e_{19}	e_{28}	e_{33}	e_{34}	e_{39}	e_{40}
Weight interval	[0.2, 0.3]	[0, 0.1]	[0.1, 0.2]	[0.1, 0.2]	[0.3, 0.4]	[0, 0.1]	[0, 0.1]	[0.1, 0.2]

Table 19 Cluster Ω_5 weight distribution

Member	e_6	e_{14}	e_{20}	e_{23}	e_{24}
Weight interval	[0.1, 0.2]	[0, 0.1]	[0.5, 0.6]	[0, 0.1]	[0.2, 0.3]

Table 20 Cluster Ω_6 weight distribution

Member	e_8	e_{16}	e_{26}	e_{29}
Weight interval	[0, 0.1]	[0.8, 0.9]	[0, 0.1]	[0, 0.1]

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