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Article

Risk Assessment of Technology Projects “Unveiling and Commanding” System Based on Multiple Combination Weighting Two-Dimensional Cloud Model

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Abstract: There are many uncertainties in the process of technology projects “Unveiling and Commanding” system which can easily lead to the risk of failing to achieve the expected effect of technology quality. In order to ensure that the implementation of the system can achieve the expected results, the indicator system for risk assessment of technology projects “Unveiling and Commanding” system is established on the basis of expert interviews and field research. The improved game theory multiple combination weighting method is used to weight the indicators to reduce error risk of the weight results. This paper makes a comprehensive risk assessment of technology projects “Unveiling and Commanding” system from the two dimensions of risk possibility and risk impact degree based on two-dimensional cloud model, so as to reduce the subjectivity, randomness and fuzziness of assessment results. The example verifies that the model is reasonable and effective, and has a certain guiding role in the improvement of technology projects “Unveiling and Commanding” system.

Keywords: technology projects; “Unveiling and Commanding” system; two-dimensional cloud model; risk assessment; multiple combination weighting

1. Introduction

The “Unveiling and Commanding” system is a kind of scientific research incentive mechanism that stimulates innovation vitality with market competition, in essence, it is a technology reward system¹. This system is a mechanism to cash in scientific research funding investment with scientific research achievements, and a non-periodic scientific research funding arrangement organized by government to openly collect scientific and technological innovation achievements for the whole society². The “Unveiling and Commanding” system is a new mode of scientific research organization that deepens the reform of scientific and technological system, strengthens the innovation and research organization, and solves the problem of disconnection between scientific research and achievement application in the process of industrial technology research organization. The system helps to mobilize the intellectual potential of all sectors of society to the greatest extent and find practical solutions at the fastest speed for the most urgent scientific research problems in the form of open innovation.

Although there are a large number of existing “Unveiling and Commanding” lists and the amount of the list is relatively large, a series of problems are gradually emerging in the specific practice process, such as the failure to set the list, the failure to select the candidate, the failure to tackle key problems, and the failure to honor the award list. In addition, the innovation of science and technology projects itself has the characteristics of high difficulty, high investment and high risk. The risk of technology projects “Unveiling and Commanding” has become increasingly apparent, which seriously affects the expected effect of this system and also restricts the breakthrough of key

core technologies³. At present, there are few studies on the “Unveiling and Commanding” system, which mainly focus on its connotation, operation mechanism and process optimization, and almost no studies have discussed the risks related to the “Unveiling and Commanding” system. Therefore, it is necessary to study the risk of the technology projects “Unveiling and Commanding” system to ensure that the implementation of the system can achieve the expected effect.

The methods of risk assessment can be divided into two categories: qualitative assessment methods and quantitative assessment methods^{4,6}. The former mainly includes expert scoring method⁷, risk matrix method⁸, Delphi method⁹, fuzzy analytic hierarchy process (FAHP) and so on¹⁰. The latter includes Monte Carlo simulation¹¹, system dynamics model¹², exponential creation, entropy weight method (EW) and so on^{13,14}. At present, the more advanced risk assessment methods mainly include BP neural network assessment method¹⁵, hierarchical variable weight theory¹⁶, improved EW method¹⁷, grey correlation analysis method¹⁸, improved CRITIC method and so on¹⁹. These methods improve the objectivity and accuracy of risk assessment results to a certain extent. However, there is a large risk of error when using a single assessment method, so the combination of multiple methods has become a more popular assessment method. The game theory combination weighting method can effectively integrate weights obtained from different assessment methods, but this method cannot ensure that the linear combination coefficient is greater than zero, which limits the application of this method^{20,21}. In order to overcome this problem, we can consider improving the existing game theory combination weighting method, and propose an improved game theory multiple combination weighting method to fuse the weights obtained by multiple weighting methods, thereby reducing the error of indicator weight calculation.

The two-dimensional cloud model is an extension of the one-dimensional cloud model, which uses the transformation between qualitative concepts and quantitative data to comprehensively evaluate the uncertainty and randomness under the joint action of two dimensions²². The risk of technology projects “Unveiling and Commanding” system is determined by the risk possibility occurrence and risk impact degree, which conforms to the application conditions of the two-dimensional cloud model. Therefore, it is scientific and effective to use the two-dimensional cloud model to establish the risk assessment model of technology projects “Unveiling and Commanding” system.

In summary, this paper constructs the risk assessment indicator system according to the characteristics of technology projects “Unveiling and Commanding” system. The indicators weights are calculated using the improved game theory multiple combination weighting method. The risk possibility and risk impact degree are taken as the basic variables of assessment, and substituted into the two-dimensional cloud model to complete the risk assessment of technology projects “Unveiling and Commanding” system.

2. Construction of Risk Assessment Indicator System of Technology Projects “Unveiling and Commanding” System

Through the sorting of previous relevant literature and field research, it is found that the process of technology projects “Unveiling and Commanding” system is roughly the same, which can be summarized into three stages: unveiling the list and selecting the candidate, tackling the key technical problems, and awarding the list. The stage of unveiling the list and selecting the candidate can be subdivided into setting the list, publishing the list, and selecting the candidate. Therefore, this study divides the risks of technology projects “Unveiling and Commanding” system into five categories: setting the list risk, publishing the list risk, selecting the candidate risk, tackling the key technical problems risk and awarding the list risk²³.

(1) Setting the list risk. The quality of the list itself directly affects the effect of “Unveiling and Commanding”, which is mainly reflected in the failure to focus on major scientific and technological bottlenecks, resulting in the failure to accurately collect key core technical requirements, and the inadequate assessment of projects in the list. On the one hand, due to insufficient collection channels or insufficient mobilization of collection personnel and collection objects, some lists are mainly

derived from the common scientific and technological problems put forward by local enterprises or the technical problems of individual enterprises themselves, and their overall situation, frontier and driving force are not enough, so that the key core technology needs cannot be accurately collected. On the other hand, the positioning of the technical indicators of the projects in the list is not accurate enough or the relevant requirements are not clear enough, resulting in the projects that are not suitable for "Unveiling and Commanding" are not eliminated, resulting in the low rate of unveiling the list and even the consequences of "flowing the list". At the same time, the review of the qualifications and scientific research capabilities of the demand side is not in place, and the expert diagnosis, peer review, field research and other measures taken during the review have not been truly put into practice, which will affect the smooth development of the follow-up process of "Unveiling and Commanding".

(2) Publishing the list risk. First of all, the publishing the list plan is not in place, which is manifested as insufficient attraction and weak operability. The relevant plan setting is similar to the general scientific research plan. Similar to general scientific research planning, some provisions are not enough incentive to effectively attract talented candidate, and the program's research and development timeliness, bonus amount and other settings are not reasonable enough to cause the talented candidate to participate in the enthusiasm is not high. Secondly, the publicity of publishing the list is not enough. It is mainly reflected in that the platform of the list is not wide enough and the way of the list is not rich enough, which leads to a small range of communication and narrow range of awareness, resulting in fewer participants, resulting in a low rate of listing disclosure or a low quality of listing disclosure.

(3) Selecting the candidate risk. The risk is mainly due to the imperfect selection mechanism of the handsome talents, which is manifested in three aspects: the qualification restrictions of the handsome talents still exist, the lack of competition among the candidates, and the lack of standardization of the selection process. Compared with the traditional vertical commissioned scientific research declaration system, the biggest difference is that the open innovation model without threshold is constructed, but in reality, this model has not been well practiced, and education background and qualifications are still the implicit screening conditions for the selection of candidates. In addition, according to the survey, at present, there is still a single revealer, with few parallel studies conducted by multiple revealers. The lack of competition leads to the revealer being easy to slack off in the research and development process, thus increasing the risk of research and development failure. Finally, there may be collusion to defraud government funds in the process of selecting commanders such as the qualification review of the revealers and the assessment of the revealers' plan. At the same time, when experts are organized to review the qualifications of the list revealers, they often organize a review meeting without conducting a field and comprehensive investigation of the list revealers, so that experts cannot deeply understand the scientific research literacy, innovation ability and other qualifications of the list revealers, which may lead to the poor adaptability of the selected talents to the technical requirements of the list.

(4) Tackling the key technical problems risk. The risk is mainly reflected in both external and internal aspects. The external risk aspect refers to the failure of the revealers to fully integrate the superior resources such as industry, university and research, which leads to the failure of technological research. At the same time, the fault tolerant mechanism, compensation mechanism, risk sharing mechanism and other collaborative research mechanisms are not perfect, which leads to the difficulty of tackling the problem, and then chooses to withdraw. The internal risk aspect refers to the problems existing in the revealers themselves, including inadequate project management (such as change of project management team, lack of leadership ability of project leaders, unreasonable work planning, etc.), insufficient cost identification of the project, resulting in excess of later costs, insufficient capacity of research and development personnel and difficulty in meeting the technical requirements of the list.

(5) Awarding the list risk. The risk is also divided into internal and external aspects. The internal risk performance includes: First, it fails to effectively combine the process assessment and the result

assessment, resulting in the mismatch between the results of the disclosure and the task or scheme of the disclosure. Second, the ownership of intellectual property rights and honors finally formed by “Unveiling and Commanding” is not clear, resulting in difficulties in ranking. The external risks are mainly manifested in the lack of funds on the demand side and the list maker side, which makes it difficult to meet the funds agreed on the list, as well as the promised research and development subsidies, talent support, financial support are not provided as promised.

According to the above analysis, the indicator system for risk assessment of technology projects “Unveiling and Commanding” system is constructed, as shown in Figure 1.

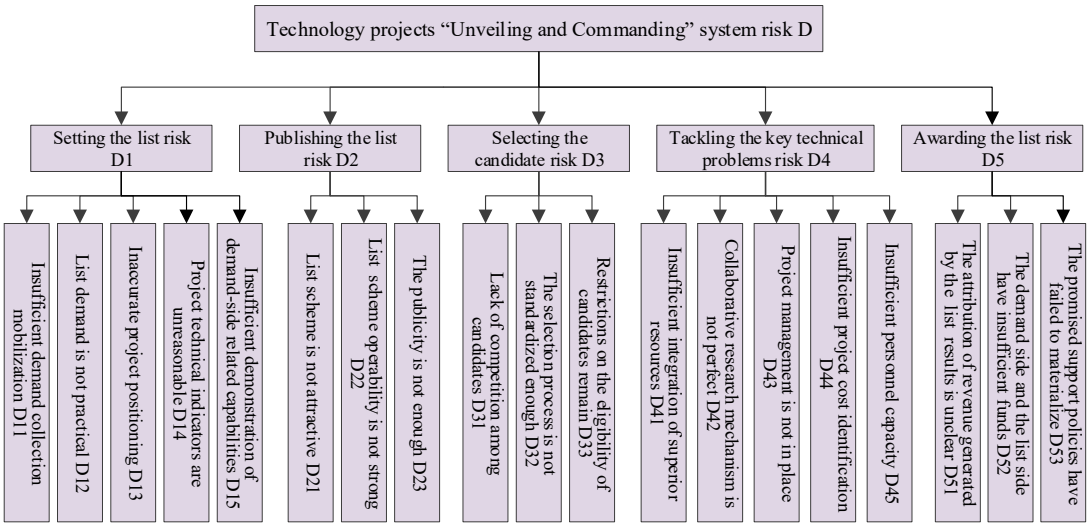


Figure 1. Risk assessment indicator system of technology projects “Unveiling and Commanding” system.

Risk is the overall reflection of the occurrence possibility of a certain foreseeable emergency situation and the severity of its consequences. Risk is widespread in the technology projects “Unveiling and Commanding” system. The complexity of science and technology projects and the uncertainty of internal and external conditions make the technology projects “Unveiling and Commanding” system with great risks. Through the analysis, it can be seen that the above indicators have an impact on the “Unveiling and Commanding” system from the two dimensions of the risk possibility and risk impact degree. Therefore, the risk possibility and the risk impact degree are selected as the basic variables of assessment, and the assessment is more comprehensive from two dimensions.

3. Multiple Combination Weighting of Risk Assessment Indicator System of Technology Projects “Unveiling and Commanding” System

At present, the research on indicator weighting is relatively mature. The subjective weighting method can well reflect the intention of the evaluator, but the human subjective factors have a greater impact. The objective weighting method can make good use of objective data, but it may cause the situation that the indicators with greater impact occupy a smaller weight. In order to make effective use of objective data and consider expert opinions and suggestions, the method of multiple combination weighting is generally adopted to make the indicator weights more scientific and reasonable. In this regard, four latest research weighting methods, including hierarchical variable weight theory, improved EW method, grey correlation analysis method and improved CRITIC weight method, are selected to calculate indicator weights respectively. The improved game theory method is used to combine the weight results calculated by these four methods to obtain multiple combination weights.

3.1. Hierarchical Variable Weight Theory

The analytic hierarchy process (AHP) theory only considers the relative importance of each influencing factor in decision making, and ignores the preference for state equilibrium. Variable weight theory is essentially a dynamic modeling principle. Considering that the indicator weight should change with the change of the state of the indicator value, in order to eliminate the bias effect of the constant weight on the actual decision making in the case of extreme state value. The expert judgment matrix $A = (z_{ij})_{a \times a}$ is obtained through the analytic hierarchy process, and then the judgment matrix is processed by formulas (1) and (2) to obtain the constant weight of each indicator. The process of solving the weight is as follows:

$$w_i^0 = \frac{\sqrt[a]{\prod_{j=1}^a z_{ij}}}{\sum_{i=1}^a \sqrt[a]{\prod_{j=1}^a z_{ij}}} \quad (1)$$

$$\begin{cases} \lambda_{\max} = \sum_{i=1}^a \frac{(AW)_i}{aW_i} \\ CR = ((\lambda_{\max} - a) / (a - 1)) / RI \end{cases} \quad (2)$$

Combined with the existing research on variable weight theory and the research content of this paper, the variable weight formula suitable for the risk assessment of technology projects "Unveiling and Commanding" system is obtained, as shown in formula (3).

$$w_i(x_1, x_2, \dots, x_a) = \frac{w_i^0 x_i^{\alpha-1}}{\sum_{k=1}^a w_k^0 x_k^{\alpha-1}} \quad (3)$$

In the formula, w_i^0 , x_i , a and w_i are the constant weight, state value, exponential number and variable weight of each indicator respectively. α is the equilibrium coefficient, and α is generally 0.2 ~ 0.3 in engineering.

3.2. Improved EW Method

The improved EW method is based on data analysis and calculation to solve the indicator weight, which can reflect the differences and importance between different indicators, and has the characteristics of consistency and stability, which is suitable for solving the assessment system with more underlying indicators. The improved EW method can ensure the objectivity of indicator weights. The process of solving the weight is as follows:

The improved EW method is used to determine the objective importance of the indicator quantity in the sample set, and the decision matrix of sample set is used to standardize the indicators of the evaluated scene. Let the sample set have J objects and M assessment indicators, and its initial decision matrix B is:

$$B = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1M} \\ b_{21} & b_{22} & \cdots & b_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ b_{J1} & b_{J2} & \cdots & b_{JM} \end{bmatrix} \quad (4)$$

In the formula, $b_{\alpha\beta}$ represents the value of the β th assessment indicator of the α th object in the initial decision matrix B .

The indicators are standardized, and all the indicators are very small indicators with positive values, which are converted into very large indicators by formula (5), which are expressed as:

$$c_{\alpha\beta} = (\max(b_{\beta}) - b_{\alpha\beta}) / \sqrt{\sum_{\alpha=1}^J (\max(b_{\beta}) - b_{\alpha\beta})^2} \quad (5)$$

In the formula, $\max(b_{\beta})$ is the maximum value of the β th assessment indicator column, $c_{\alpha\beta}$ is the standardized value of the β th assessment indicator of the α th object.

The information entropy of each indicator in the sample set is calculated, and the information entropy e_{β} of the β th assessment indicator is as follows:

$$e_{\beta} = -\frac{1}{\ln J} \sum_{\alpha=1}^J q_{\alpha\beta} \ln(q_{\alpha\beta}) \quad (6)$$

$$q_{\alpha\beta} = \frac{c_{\alpha\beta}}{\sum_{\alpha=1}^J c_{\alpha\beta}} \quad (7)$$

In the formula, $q_{\alpha\beta}$ is the proportion of the α th object in the β th assessment indicator column.

Because the method in this paper needs to calculate EW weights of a large number of objects, and the boundaries of the secondary indicators involved are subjective division, it may lead to the dispersion of some indicators is too small. In order to adapt to the application scenario of this paper, the improved EW weight calculation method is used to solve the weight ω_{β}^{eW} of the β th assessment indicator as an example, as follows:

$$\begin{cases} \omega_{\beta}^{eW} = \frac{\tau - e_{\beta}}{\sum_{\beta=1}^J (\tau - e_{\beta})}, \tau \geq 1 \\ s.t. \frac{\max(\omega_{\beta}^{eW})}{\min(\omega_{\beta}^{eW})} \leq \varepsilon \end{cases} \quad (8)$$

In the formula, τ is the correction coefficient of information entropy redundancy, and the larger the value, the smaller the dispersion of the improved EW weight. ε is a constant to limit the dispersion of the indicator from the improved EW weight. In this paper, the value of ε is 2, which means that the maximum value of the improved EW weight in the indicator does not exceed 2 times of the minimum value.

3.3. Grey Correlation Analysis

Grey correlation analysis can determine the degree of similarity or dissimilarity between two sets of system vectors. According to the grey correlation analysis, the correlation coefficient between the score vector of each indicator and the score vector of the relatively optimal indicator can be calculated. Then calculate the correlation degree of each indicator, and finally normalize the correlation degree to the weight of each indicator. The process of solving the weight is as follows:

The judgment matrix $E = (e_{ij})_{a \times b}$ is sorted to determine the reference data column X_0 .

$$X_0 = (X_0(1), X_0(2), \dots, X_0(b)) \quad (9)$$

Calculate the absolute difference C_{ij} between the evaluated object sequence and the reference sequence, and determine the maximum value using formulas (10) and (11).

$$C_{ij}(\min) = \min_{i=1}^a \min_{k=1}^b |X_0(k) - X_i(k)| \quad (10)$$

$$C_{ij}(\max) = \max_{i=1}^a \max_{k=1}^b |X_0(k) - X_i(k)| \quad (11)$$

Using formula (12), the correlation coefficients of the corresponding values of each comparison object sequence and reference sequence are calculated respectively.

$$\xi_i(k) = \frac{\min_{i=1}^a \min_{k=1}^b |X_0(k) - X_i(k)| + \rho \max_{i=1}^a \max_{k=1}^b |X_0(k) - X_i(k)|}{|X_0(k) - X_i(k)| + \rho \max_{i=1}^a \max_{k=1}^b |X_0(k) - X_i(k)|} \quad (12)$$

In the formula, ρ is the resolution coefficient. If ρ is large, the difference between the correlation coefficients is small, and the discriminant ability is weak. In general, ρ takes 0.5.

According to the formula (13), the correlation degree of each indicator is calculated respectively, and the grey correlation analysis weight of each indicator in the formula (14) is used.

$$r_i^0 = \frac{1}{b} \sum_{k=1}^b \xi_i(k) \quad (13)$$

$$w_i = r_i^0 / \sum_{i=1}^a r_i^0 \quad (14)$$

3.4. Improved CRITIC Weight Method

CRITIC method is an objective weighting method to determine the weight of assessment indicators by calculating the correlation between them. This method cannot overcome the information conflict between indicators when calculating the weights. Therefore, the improved CRITIC weight method is proposed, and the conflict coefficient is introduced to represent the information conflict between indicators. The process of solving the weight is as follows:

Firstly, the judgment matrix $E = (e_{ij})_{a \times b}$ is transposed, and then standardized to obtain the standardized matrix $H = (h_{ij})_{b \times a}$, where formula (15) is used for cost indicator and formula (16) is used for benefit indicator.

$$h_{ij} = (\max(e_{ij}) - e_{ij}) / (\max(e_{ij}) - \min(e_{ij})) \quad (15)$$

$$C_{ij}(\max) = \max_{i=1}^a \max_{k=1}^b |X_0(k) - X_i(k)| \quad (16)$$

The improved CRITIC method uses the coefficient of variation to measure the discrimination of indicator information, and its calculation formula is shown in formula (17).

$$v_j = \left(\sqrt{\frac{1}{b} \sum_{i=1}^b (h_{ij} - \frac{1}{b} \sum_{i=1}^b h_{ij})^2} \right) / \left(\frac{1}{b} \sum_{i=1}^b h_{ij} \right) = \frac{\sigma_j}{h_j} \quad (17)$$

The conflict between indicators is expressed by the conflict coefficient, and the calculation formula is shown in formula (18).

$$C_j = \sum_{i=1}^b (1 - \rho_{ij}) \quad (18)$$

In the formula, $j=1,2,\dots,a$.

ρ_{ij} is the correlation coefficient between indicators, and its calculation formula is shown in formula (19).

$$\rho_{ij} = \text{cov}(H'_i, H'_j) / (\sigma_i, \sigma_j) \quad (19)$$

The information quantity Q_j of each indicator is calculated. According to the principle that the larger the information quantity is, the greater the weight of the corresponding indicator is, the corresponding weight is calculated by formulas (20) and (21).

$$Q_j = \sigma_j \sum_{i=1}^b (1 - \rho_{ij}) \quad (20)$$

$$W_j = Q_j / \sum_{j=1}^a Q_j \quad (21)$$

3.5. Improved Game Theory Multiple Combination Weighting Method

In order to overcome the shortcomings of the traditional combination weighting method, the improved game theory method is used to scientifically and reasonably couple the hierarchical variable weight theory weight w_1 , the improved EW method weight w_2 , the grey correlation analysis weight w_3 , and the improved CRITIC method weight w_4 . The combination weighting process is as follows:

(1) Construct weight factor vectors set $w = \{w_1, w_2, w_3, w_4\}$.

(2) The sub-target weight factor vectors w_1 , w_2 , w_3 and w_4 are linearly combined.

$$W = \sum_{s=1}^4 \alpha_s w_s^T \quad (22)$$

In the formula, W is the comprehensive weight factor vector of the sub-target. α_s is the linear combination coefficient. w_s is the sub-target weight factor vector calculated by the single weighting method.

(3) Based on the idea of game aggregation model, the weight factor vectors of each sub-target are linearly combined to minimize the deviation between the comprehensive weight factor vector and vectors w_1 , w_2 , w_3 and w_4 , so as to seek the comprehensive weight compromise solution W^* . Construct a game model to optimize the linear combination coefficient α_s :

$$\min_{\alpha_s} \left\| \sum_{s=1}^4 \alpha_s w_s^T - w_k \right\|_2 \quad (23)$$

In the formula, $k=1,2,3,4$.

(4) The optimal first derivative condition of formula (23) is:

$$\sum_{s=1}^4 \alpha_s w_k w_s^T = w_k w_k^T \quad (24)$$

The traditional game theory method cannot ensure that the linear combination coefficient α_s is greater than zero. If it is not regular, it is contrary to the assumption. Therefore, combining formula (24) and optimizing the game model to establish a new objective function.

$$\min_{\alpha_r} \sum_{m=1}^4 \left| \left(\sum_{r=1}^4 \alpha_r \mathbf{w}_m \mathbf{w}_r^T \right) - \mathbf{w}_m \mathbf{w}_m^T \right| \quad (25)$$

(5) The constraint function of formula (26) is established by referring to the constraint conditions of objective weighting method of maximizing deviation.

$$\sum_{r=1}^4 \alpha_r^2 = 1 \quad (26)$$

In the formula, $\alpha_r > 0$.

(6) Combined with formulas (25) and (26), the optimization model of multiple combination weighting strategy of improved game theory is established as follows:

$$\begin{aligned} \min_{\alpha_r} \sum_{m=1}^4 \left| \left(\sum_{r=1}^4 \alpha_r \mathbf{w}_m \mathbf{w}_r^T \right) - \mathbf{w}_m \mathbf{w}_m^T \right| \\ s.t. \quad \alpha_r > 0 \quad (r = 1, 2, 3, 4) \\ \sum_{r=1}^4 \alpha_r^2 = 1 \end{aligned} \quad (27)$$

(7) In order to solve the above optimization model, the Lagrange function is established. The partial derivative is obtained to get the linear combination coefficient α_r , and then it is normalized to get the combination coefficient solution α_r^* :

$$\alpha_r^* = \frac{\sum_{m=1}^4 \mathbf{w}_m \mathbf{w}_r^T}{\sum_{r=1}^4 \sum_{m=1}^4 \mathbf{w}_m \mathbf{w}_r^T} \quad (28)$$

(8) Finally, the multiple combination weighting vector $\mathbf{W}^*$ is expressed as:

$$\mathbf{W}^* = \sum_{r=1}^4 \alpha_r^* \mathbf{w}_r^T \quad (29)$$

The calculation process of the improved game theory multiple combination weighting method is shown in Figure 2.

Based on the above assessment indicator system and multiple combination weighting methods, a number of experts in related fields of risk assessment of technology projects "Unveiling and Commanding" system are invited to judge the importance of risk from two dimensions of risk possibility and risk impact degree in this system. The weights of all indicators are calculated by the above weight calculation formula, and the results are shown in Table 1 and Table 2.

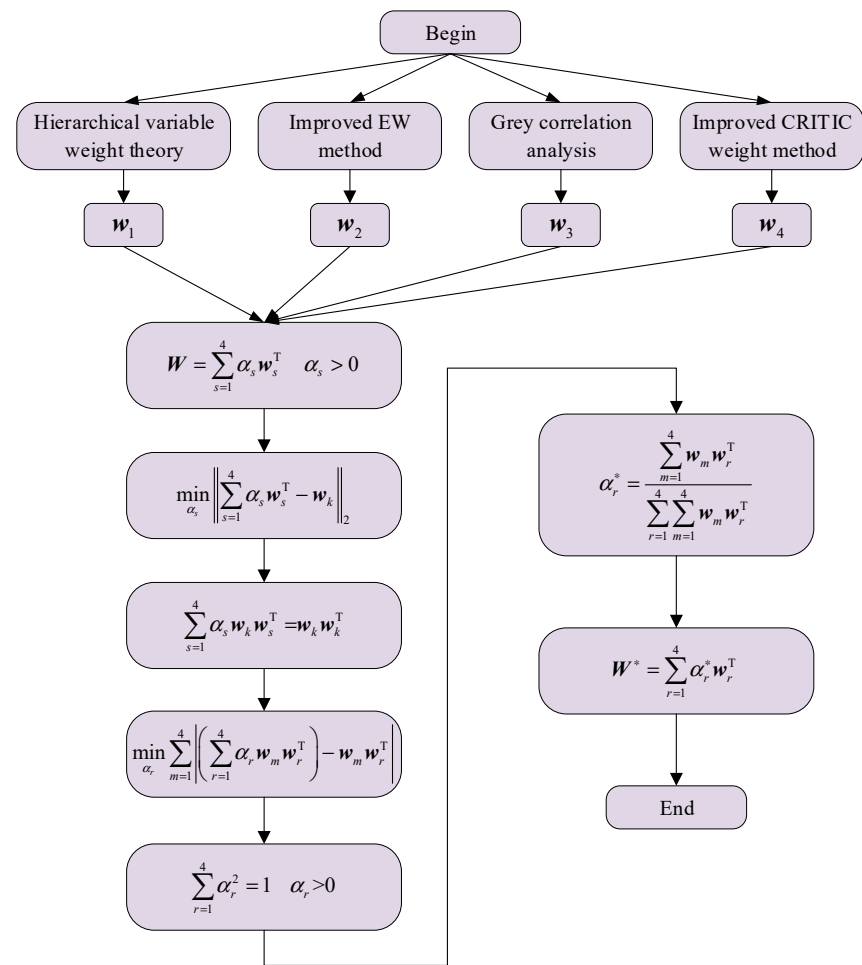


Figure 2. The calculation process of the improved game theory multiple combination weighting method.

Table 1. Indicators weights of risk probability of technology projects “Unveiling and Commanding” system.

		Indicators weights				
		Hierarchical variable weight theory w_1	Improved EW method w_2	Grey correlation analysis w_3	Improved CRITIC weight method w_4	Improved game theory multiple combination weighting method w
Level 2 indicators	D11	0.082673	0.065644	0.042711	0.065772	0.066192
	D12	0.063305	0.072181	0.045975	0.058942	0.061629
	D13	0.081533	0.052265	0.03968	0.056894	0.059454
	D14	0.056164	0.022022	0.031734	0.046904	0.039183
	D15	0.085082	0.047609	0.052953	0.050933	0.060585
	D21	0.02107	0.04535	0.082191	0.059169	0.048198
	D22	0.053012	0.048566	0.033617	0.036986	0.044594
	D23	0.066207	0.050691	0.068571	0.056833	0.06015
	D31	0.048508	0.070914	0.08234	0.057538	0.063802
	D32	0.07288	0.056284	0.033625	0.066475	0.05877
	D33	0.052044	0.027382	0.061276	0.04163	0.044409
	D41	0.043563	0.070101	0.038545	0.056033	0.053015

	D42	0.020879	0.068974	0.051903	0.06938	0.051212
	D43	0.052477	0.059396	0.046487	0.041737	0.051207
	D44	0.020774	0.040185	0.066107	0.063858	0.044281
	D45	0.036325	0.0491	0.055553	0.025486	0.041835
	D51	0.02825	0.046151	0.036261	0.06993	0.043559
	D52	0.045174	0.041925	0.065475	0.022331	0.043691
	D53	0.07008	0.065259	0.064995	0.053169	0.064234
Level 1 indicators	D1	0.368757	0.259721	0.213053	0.279445	0.287043
	D2	0.140289	0.144607	0.184379	0.152988	0.152942
	D3	0.173432	0.154581	0.177242	0.165643	0.166981
	D4	0.174019	0.287756	0.258595	0.256493	0.24155
	D5	0.143504	0.153335	0.166731	0.145431	0.151484

Table 2. Indicators weights of risk impact degree of technology projects “Unveiling and Commanding” system.

		Indicators weights				
		Hierarchical variable weight theory w_1	Improved EW method w_2	Grey correlation analysis w_3	Improved CRITIC weight method w_4	Improved game theory multiple combination weighting method w
Level 2 indicators	D11	0.050013	0.052936	0.048529	0.0602	0.052631
	D12	0.062904	0.04746	0.066163	0.079884	0.062318
	D13	0.04793	0.041001	0.062069	0.050205	0.049134
	D14	0.053133	0.076029	0.054463	0.071758	0.063993
	D15	0.043729	0.020783	0.05003	0.032218	0.035803
	D21	0.051841	0.060068	0.037766	0.066673	0.054461
	D22	0.061684	0.052807	0.052644	0.048453	0.054566
	D23	0.061146	0.082014	0.072434	0.072508	0.071936
	D31	0.03926	0.079598	0.041356	0.061238	0.056176
	D32	0.058953	0.024566	0.065013	0.036759	0.04541
	D33	0.033604	0.024267	0.071557	0.038906	0.039454
	D41	0.057268	0.025993	0.038627	0.036374	0.039978
	D42	0.038976	0.04471	0.058365	0.047794	0.046338
	D43	0.063016	0.055908	0.034878	0.075344	0.057722
	D44	0.049016	0.070795	0.048542	0.048335	0.055319
	D45	0.065148	0.05994	0.063965	0.030607	0.056441
	D51	0.071641	0.05955	0.056413	0.055372	0.061714
	D52	0.040402	0.087547	0.021615	0.022587	0.047225
	D53	0.050337	0.034029	0.055571	0.064788	0.049381
Level 1 indicators	D1	0.257708	0.238208	0.281254	0.294264	0.263879
	D2	0.174671	0.194889	0.162844	0.187634	0.180963
	D3	0.131817	0.128432	0.177927	0.136902	0.14104
	D4	0.273424	0.257346	0.244377	0.238453	0.255797

D5	0.16238	0.181125	0.133598	0.142747	0.158321
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The indicators weights distribution of risk assessment of technology projects “Unveiling and Commanding” system, as shown in Figures 3 and 4.

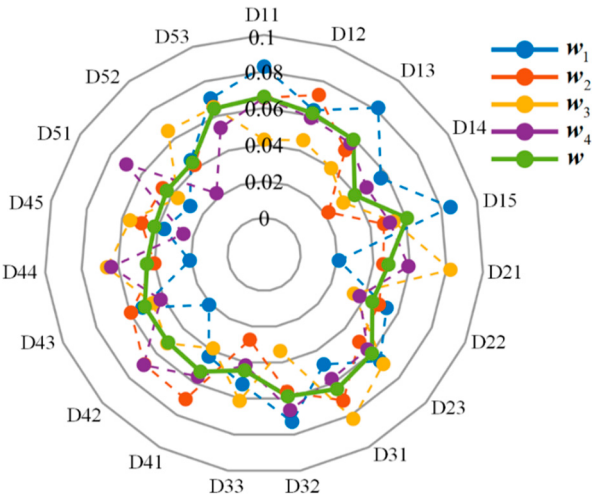


Figure 3. Indicators weights distribution of risk probability of technology projects “Unveiling and Commanding” system.

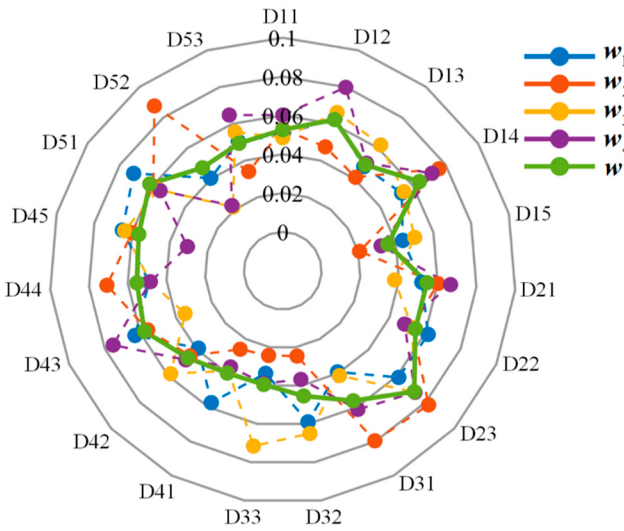


Figure 4. Indicators weights distribution of risk impact degree of technology projects “Unveiling and Commanding” system.

4. Risk Assessment of Technology Projects “Unveiling and Commanding” System Based on Two-Dimensional Cloud Model

4.1. Two-Dimensional Cloud Model Theory of Risk Assessment

The two-dimensional cloud model is improved on the basis of the one-dimensional cloud model. It expands from one assessment dimension to two assessment dimensions, and assesses advantages and disadvantages of uncertainty problem by transforming the qualitative concepts and quantitative

data of the two dimensions. The model has advantages in dealing with the comprehensive assessment of uncertainty under the joint influence of two factors²⁴.

Assuming that in the random function F of two-dimensional normal distribution, E_x and E_y are the expected values in X and Y directions respectively, E_{n_x} and E_{n_y} are the standard deviations in X and Y directions respectively, H_{e_x} and H_{e_y} are the standard deviations of E_{n_x} and E_{n_y} respectively, then the cloud model of cloud droplet $drop(x_i, y_i, \mu_i)$ satisfying formula (30) is two-dimensional cloud model:

$$\begin{aligned}(x_i, y_i) &= F(E_x, E_y, E_{n_x}, E_{n_y}) \\ (P_{x_i}, P_{y_i}) &= F(E_{n_x}, E_{n_y}, H_{e_x}, H_{e_y}) \\ u_i &= \exp \left[-\frac{1}{2} \left[\frac{(x_i - E_x)^2}{P_{x_i}^2} + \frac{(y_i - E_y)^2}{P_{y_i}^2} \right] \right]\end{aligned}\quad (30)$$

In the formula, (x_i, y_i) is the cloud droplet coordinate, u_i is the membership degree.

The two-dimensional cloud model is obtained by combining two one-dimensional cloud models, as shown in Figure 5.

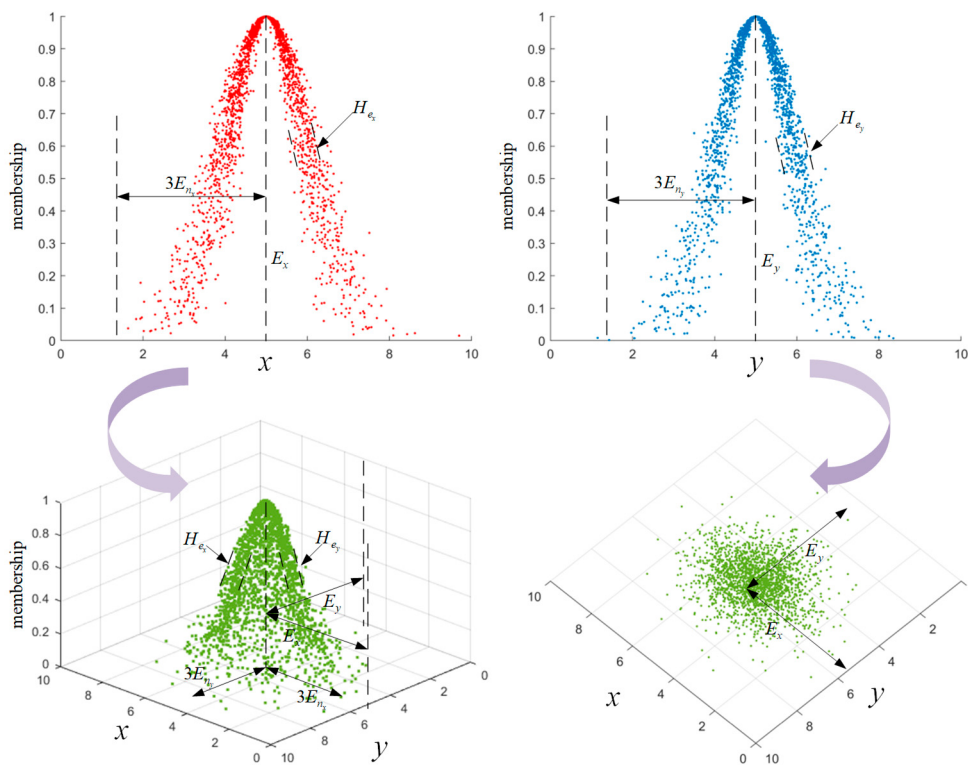


Figure 5. Schematic diagram of two-dimensional cloud model.

4.2. Risk Assessment of Two-Dimensional Standard Cloud

In order to make the scoring results more intuitive, the risk level of technology projects “Unveiling and Commanding” system is divided into five standard intervals, which are respectively expressed by minimal risk (level I), low risk (level II), medium risk (level III), high risk (level IV) and great risk (level V). Considering the habit of expert scoring, the improved golden section method is used to determine the five standard cloud eigenvalues²⁵. The calculation formula is as follows:

$$\begin{cases} E_{x0} = \frac{x_{\max} - x_{\min}}{2} \\ E_{x+2} = x_{\max} \\ E_{x-2} = x_{\min} \\ E_{x-1} = E_{x0} - 0.382(E_{x0} - x_{\min}) \\ E_{x+1} = E_{x0} + 0.382(x_{\max} - E_{x0}) \end{cases} \quad (31)$$

$$\begin{cases} E_{n-1} = E_{n+1} = \frac{0.382(x_{\max} - x_{\min})}{6} \\ E_{n0} = 0.618E_{n+1} \\ E_{n-2} = E_{n+2} = \frac{E_{n+1}}{0.618} \end{cases} \quad (32)$$

$$\begin{cases} H_{e-1} = H_{e+1} = \frac{H_{e0}}{0.618} \\ H_{e-2} = H_{e+2} = \frac{H_{e+1}}{0.618} \end{cases} \quad (33)$$

In the formula, E_{x0} , E_{n0} and H_{e0} are the expectation, entropy and super entropy of the intermediate standard cloud, respectively. E_{x-2} and E_{x-1} are the expectations of the standard cloud on the left. E_{x+1} and E_{x+2} are the expectations of the standard cloud on the right. Suppose the domain value is [0,10] and the value of H_{e0} is 0.1. The eigenvalues of standard cloud are calculated according to formulas (31)~(33), as shown in Table 3. The standard cloud images are generated by combining the cloud generator, as shown in Figures 6 and 7.

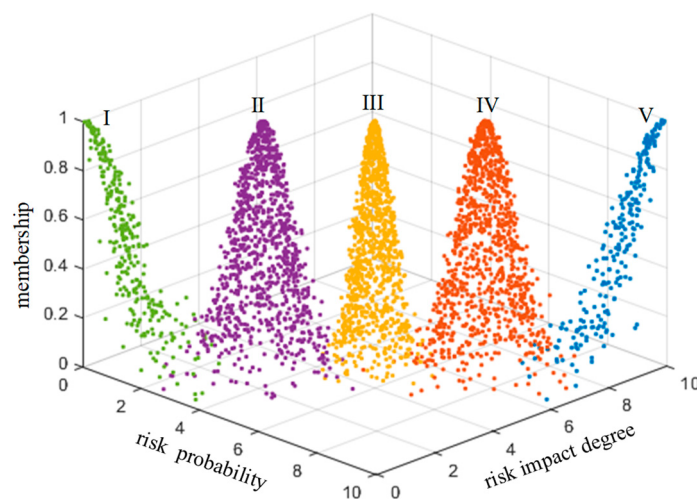


Figure 6. Standard cloud image of risk assessment of technology projects “Unveiling and Com-manding” system.

Table 3. Standard cloud eigenvalues of risk assessment of technology projects “Unveiling and Commanding” system.

Scale	Risk level description	Risk possibility	Risk impact degree	(E_{x0}, E_{n0}, H_{e0})
I	minimal risk	minimal possibility	minimal degree	(0,1.030,0.2618)
II	low risk	low possibility	low degree	(3.09,0.6367,0.1618)
III	medium risk	medium possibility	medium degree	(5,0.3935,0.1)
IV	high risk	high possibility	high degree	(6.91,0.6367,0.1618)
V	great risk	great possibility	great degree	(10,1.030,0.2618)

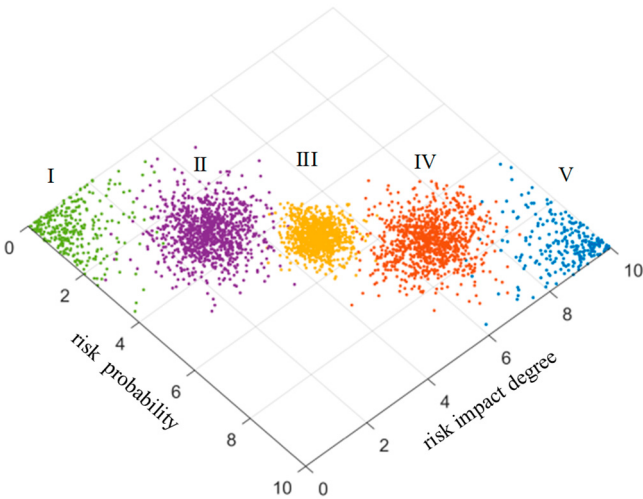


Figure 7. Top view of standard cloud image of risk assessment of technology projects “Unveiling and Commanding” system.

4.3. Two-Dimensional Comprehensive Cloud of Risk Assessment of Technology Projects “Unveiling and Commanding” System

Aiming at the problem of risk assessment of technology projects “Unveiling and Commanding” system, this paper analyses the risk possibility and risk impact degree from two dimensions, and selects two dimensional eigenvalues of each assessment indicator as two groups of basic variables of two-dimensional cloud. The risk possibility and risk impact degree of each assessment indicator form a cloud droplet, which constitutes the risk possibility assessment cloud and risk impact degree assessment cloud of the indicator, collectively referred to as the secondary cloud. The reverse cloud generator is used to generate the eigenvalues of risk possibility assessment cloud and risk impact degree assessment cloud²⁶:

$$\begin{cases} E_x = (1 / m) \sum_{j=1}^m x_j \\ E_n = \sqrt{\pi / 2} \times (1 / m) \sum_{j=1}^m |x_j - E_x| \\ H_e = \sqrt{|S^2 - E_n^2|} \\ S^2 = (1 / (m - 1)) \sum_{j=1}^m (x_j - E_x)^2 \end{cases} \tag{34}$$

In the formula, S^2 is the sample variance.

The cloud matrix of the second-level risk possibility and the cloud matrix of the second-level risk impact degree are combined with the second-level weight matrix to obtain the cloud eigenvalues of the first-level risk possibility and the first-level risk impact degree, and further obtain the cloud eigenvalues of the comprehensive risk possibility and the comprehensive risk impact degree:

$$C = (w_1, w_2, \dots, w_n) \begin{pmatrix} E_{x_1} & E_{n_1} & H_{e_1} \\ \vdots & \vdots & \vdots \\ E_{x_n} & E_{n_n} & H_{e_n} \end{pmatrix} \quad (35)$$

$$= (E_{x'}, E_{n'}, H_{e'})$$

In the formula, $E_{x'}, E_{n'}, H_{e'}$ are higher-level cloud eigenvalues.

Because of the similarity between the comprehensive risk cloud image and the standard cloud image, there are some visual errors in the three-dimensional view observation. In order to determine the risk level more accurately, the closeness degree is used to reflect the degree of fit between the two. The greater the closeness degree, the closer the comprehensive risk cloud to be evaluated is to the corresponding standard cloud level. The calculation formula of closeness degree is as follows²⁷:

$$N = \frac{1}{\sqrt{(E_x - \overline{E}_x)^2 + (E_y - \overline{E}_y)^2}} \quad (36)$$

In the formula: N is the closeness degree; E_x and E_y are the expected values of the two basic variables of comprehensive risk cloud; $\overline{E_x}$ and $\overline{E_y}$ are the expected values of two basic variables of standard cloud.

5. Experimental Analysis

Ten experts in related fields were invited to score the risk possibility and risk impact degree of each indicator, which were recorded as x_i and y_i respectively. The maximum score is 10 points, and the higher the score is, the greater the risk possibility or risk impact of the indicator is. In the early stage, according to the opinions of experts in related fields, the indicators weights of risk assessment of technology projects “Unveiling and Commanding” system were determined, as shown in Table 1 and Table 2. The cloud eigenvalues of the two basic variables can be obtained by substituting the expert scores of the secondary indicators into formula (34). The above results are combined with their corresponding weights through formula (35) to finally obtain the eigenvalues of the comprehensive risk cloud. The calculation results are shown in Table 4.

Table 4. Cloud eigenvalues of risk assessment of technology projects “Unveiling and Commanding” system.

Comprehensive risk cloud eigenvalues			First-level cloud eigenvalues			Second-level cloud eigenvalues		
Item	Risk possibility	Risk impact degree	Indicator s	Risk possibility	Risk impact degree	Indicator s	Risk possibility	Risk impact degree
D	(5.613, 0.703, 0.165)	(5.988, 0.711, 0.163)	D1	(3.859, 0.742, 0.161)	(4.155, 0.726, 0.153)		(3.146,	(3.378,
							0.612,	0.728,
							0.110)	0.137)
							(4.157,	(4.514,
						D12	0.685,	0.821,
							0.176)	0.155)

			D13	(3.428, 0.983, 0.132)	(4.106, 0.715, 0.123)
			D14	(5.553, 0.827, 0.197)	(5.222, 0.663, 0.154)
			D15	(3.028, 0.583, 0.182)	(3.445, 0.676, 0.188)
D2	(5.919, 0.827, 0.163)	(6.053, 0.788, 0.168)	D21	(5.432, 0.824, 0.191)	(6.177, 0.733, 0.183)
			D22	(6.246, 0.705, 0.153)	(6.521, 0.744, 0.170)
			D23	(6.288, 0.942, 0.136)	(5.501, 0.881, 0.152)
D3	(8.729, 0.715, 0.171)	(8.816, 0.768, 0.157)	D31	(8.317, 0.844, 0.176)	(8.701, 0.748, 0.153)
			D32	(9.147, 0.763, 0.184)	(8.911, 0.902, 0.159)
			D33	(8.682, 0.557, 0.147)	(8.813, 0.667, 0.161)
D4	(3.216, 0.711, 0.156)	(3.102, 0.641, 0.168)	D41	(3.212, 0.588, 0.134)	(2.885, 0.524, 0.149)
			D42	(3.188, 0.718, 0.158)	(3.007, 0.592, 0.165)
			D43	(2.715, 0.844, 0.168)	(3.111, 0.795, 0.177)
			D44	(3.413, 0.555, 0.145)	(3.225, 0.644, 0.163)
			D45	(3.554, 0.787, 0.175)	(3.276, 0.621, 0.181)
D5	(6.842, 0.479, 0.170)	(6.936, 0.617, 0.172)	D51	(6.634, 0.427, 0.177)	(7.144, 0.601, 0.188)
			D52	(7.334, 0.521, 0.154)	(6.944, 0.666, 0.161)
			D54	(6.615, 0.516, 0.178)	(6.889, 0.585, 0.165)

Through MATLAB forward cloud generator input the eigenvalues of risk assessment cloud of technology projects “Unveiling and Commanding” system in table 4, and the first-level indicators

assessment cloud images and comprehensive assessment cloud images of risk of technology projects “Unveiling and Commanding” system are obtained, as shown in Figures 8–19.

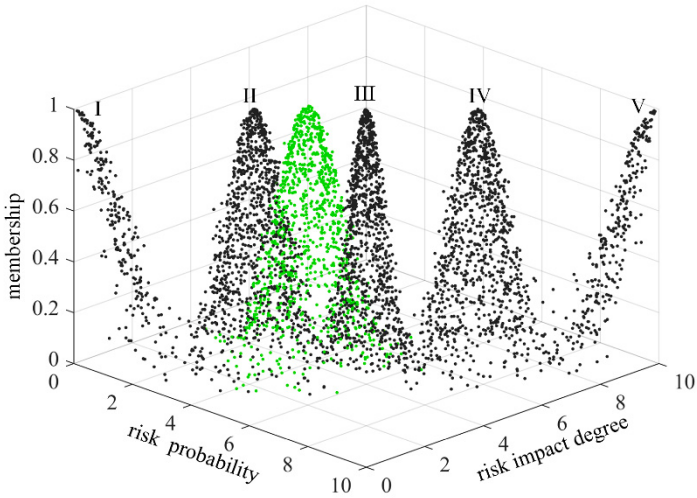


Figure 8. Risk assessment cloud image of setting the list.

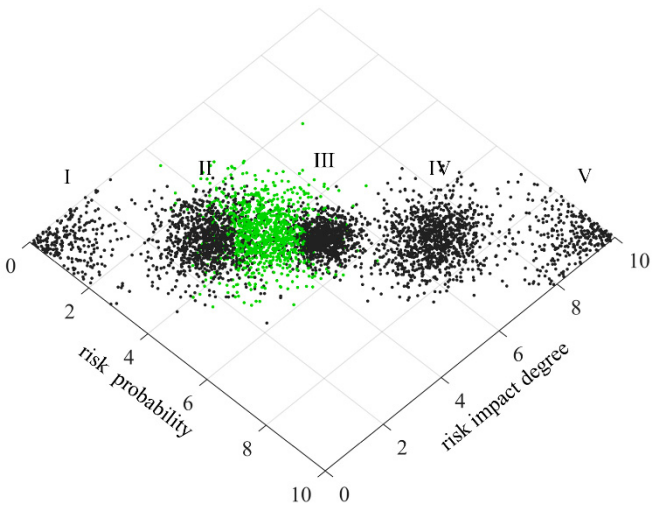


Figure 9. Top view of risk assessment cloud image of setting the list.

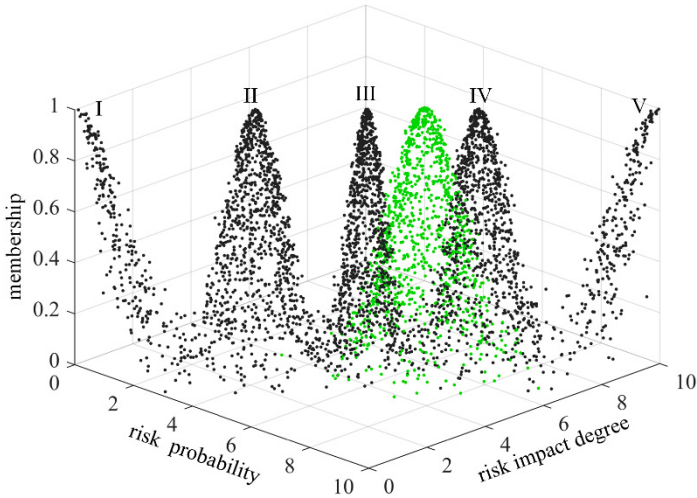


Figure 10. Risk assessment cloud image of publishing the list.

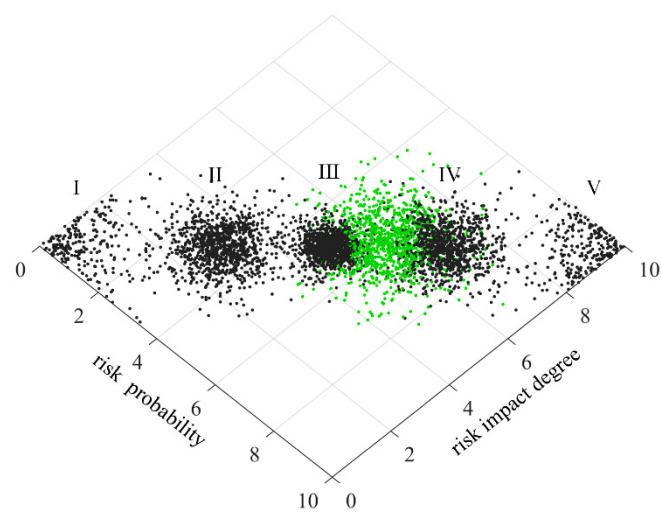


Figure 11. Top view of risk assessment cloud image of publishing the list.

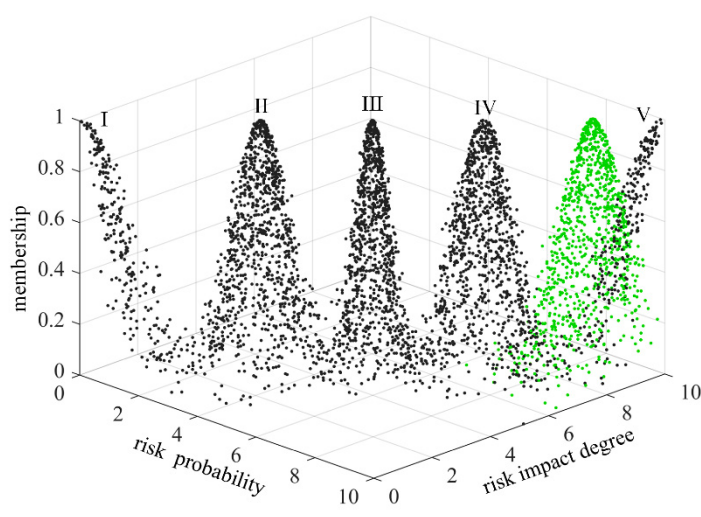


Figure 12. Risk assessment cloud image of selecting the candidate.

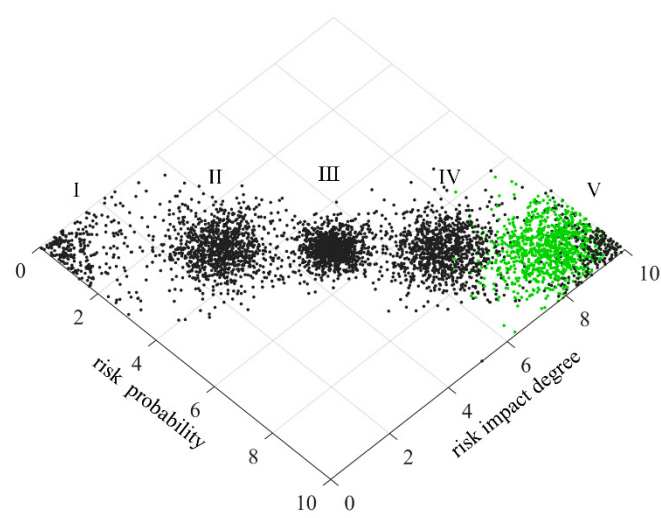


Figure 13. Top view of risk assessment cloud image of selecting the candidate.

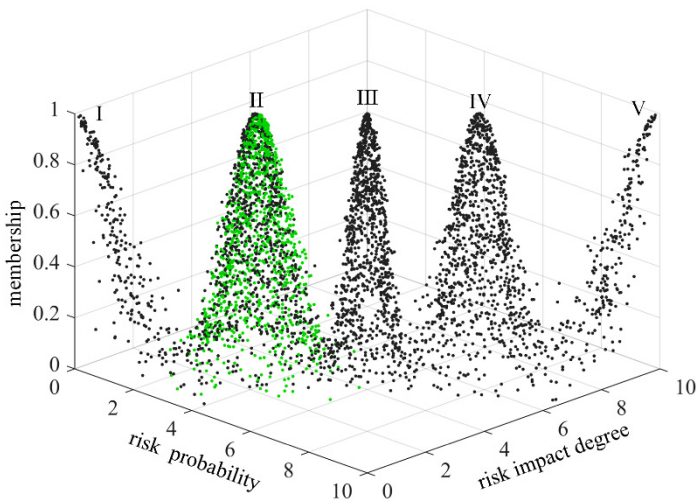


Figure 14. Risk assessment cloud image of tackling the key technical problems.

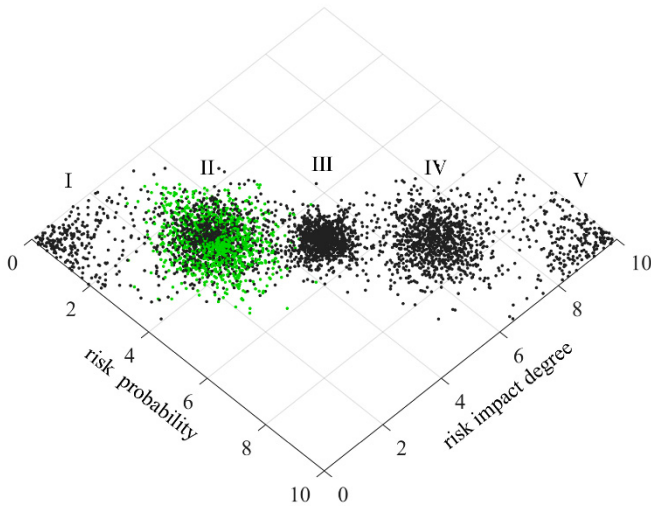


Figure 15. Top view of risk assessment cloud image of tackling the key technical problems.

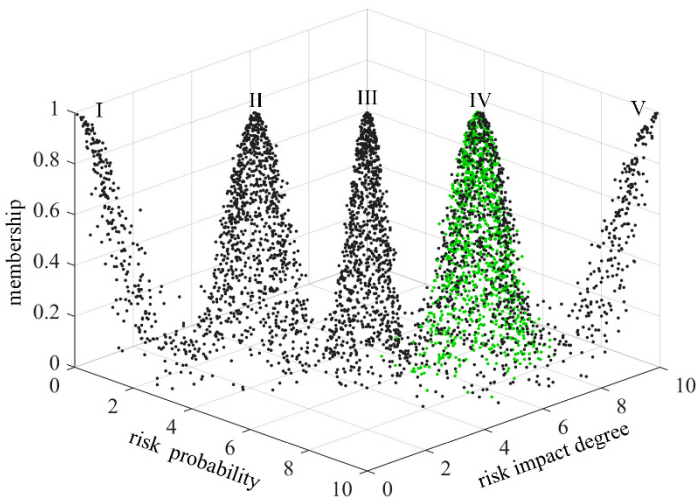


Figure 16. Risk assessment cloud image of awarding the list.

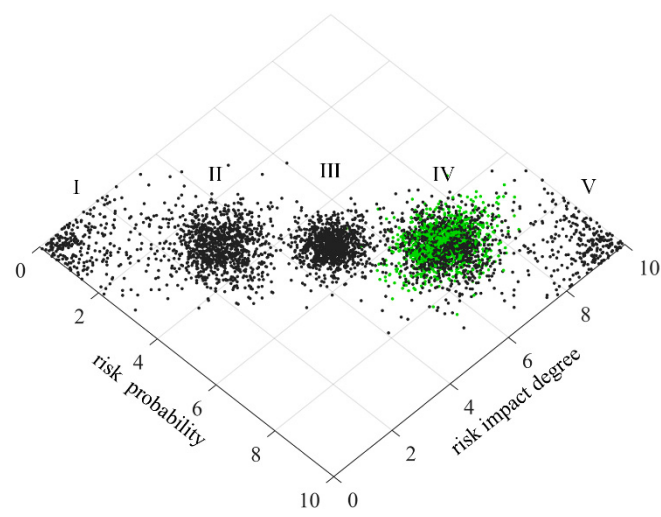


Figure 17. Top view of risk assessment cloud image of awarding the list.

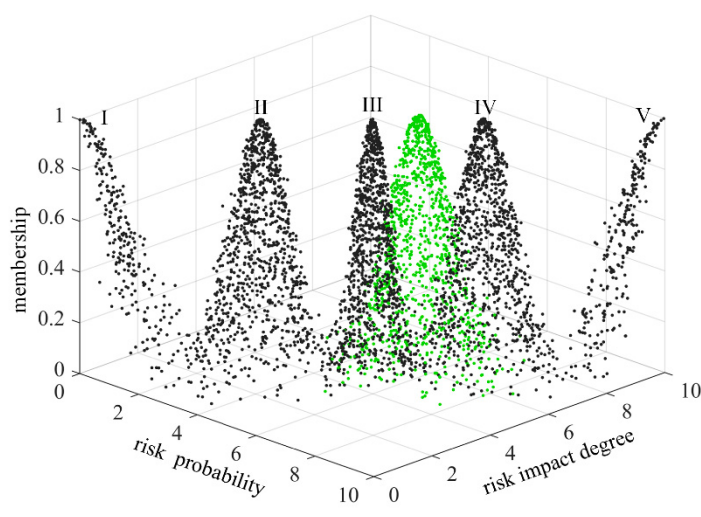


Figure 18. Risk assessment cloud image of technology projects "Unveiling and Commanding" sys-tem.

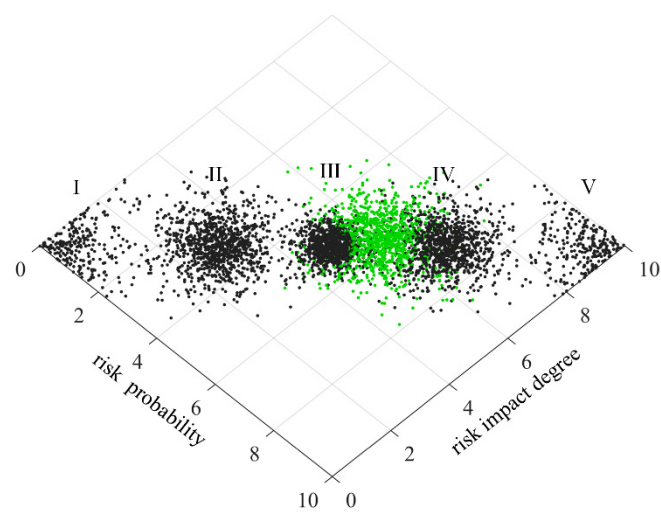


Figure 19. Top view of risk assessment cloud image of technology projects "Unveiling and Com-manding" system.

From Figures 8–19, it can be seen that setting the list risk is between level II and level III, and the closeness degree is similar to level II and level III. The publishing the list risk is between level III and level IV, and the closeness degree is similar to level III and level IV. The selecting the candidate risk is between level IV and level V, but closer to level V. The tackling the key technical problems risk is at level II. The awarding the list risk is at level IV. The technology projects “Unveiling and Commanding” system risk is between level III and level IV, but it is closer to level III. It can be found that the selecting the candidate risk is the highest, and the tackling the key technical problems risk is the lowest. It is necessary to focus on strengthening the research of selecting the candidate risk and reducing its risk.

6. Conclusion

This paper proposes the risk assessment method of technology projects “Unveiling and Commanding” system based on multiple combination weighting two-dimensional cloud model. The advantages compared with the existing methods are as follows:

- 1) The subjectivity and randomness of weight calculation are reduced by improved game theory multiple combination weighting method.
- 2) The risk of technology projects “Unveiling and Commanding” system is subdivided into two basic variables: risk probability and risk impact degree, which can reflect the system risk characteristics more comprehensively and objectively.
- 3) Combined with two-dimensional cloud model to assess the risk of technology projects “Unveiling and Commanding” system, effectively solve the problem of high ambiguity in risk assessment, and help to improve the objectivity of assessment results.

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