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Retraction

Retracted: Analysis and Design of the Project Risk Management System Based on the Fuzzy Clustering Algorithm

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] P. Zhong, H. Yin, and Y. Li, "Analysis and Design of the Project Risk Management System Based on the Fuzzy Clustering Algorithm," *Journal of Control Science and Engineering*, vol. 2022, Article ID 9328038, 8 pages, 2022.

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Research Article

Analysis and Design of the Project Risk Management System Based on the Fuzzy Clustering Algorithm

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In order to effectively control the cost risk of power grid construction projects, the author proposes a cost risk management system for power grid construction projects based on the fuzzy clustering algorithm. The system introduces the fuzzy clustering maximum tree algorithm, and by constructing a mathematical model, combined with the empirical analysis, the key risk factors in the cost risk of power grid construction projects are identified. Through the analysis, it can be concluded that the key risks in the cost risk of power grid construction projects are the planning risks of infrastructure projects, the research risks of infrastructure projects, and the cost risks of infrastructure projects. Experimental results show that combined with expert experience and the actual situation of power grid engineering, the classification result at threshold $\lambda = 0.785$ becomes more realistic. At this λ level, 6 risk factors are grouped into 4 categories as follows: class I $\{x_1, x_2, x_4\}$, class II $\{x_3\}$, class III $\{x_5\}$, and class IV $\{x_6\}$. Through research, the identification of key risks can enable project managers to control the cost of power grid construction projects, targeted, so that risks can be minimized and investment returns can be improved.

1. Introduction

With the deepening of the reform of China's economic system and power system, the requirements for the construction of power grid projects are getting higher and higher, so the cost of investing in the construction cost of power grid projects has increased accordingly. At the same time,the changes in the macroenvironment have caused complex and unpredictable risk factors in the engineering cost of power grid projects, and the factors affecting the engineering cost have increased. During the construction of power grid projects, potential risk events affect the safety of project construction. If a safety accident occurred during the construction process, it may lead to the extension of the project construction period or it may shutdown for rectification, so the research on the cost risk of the power grid project is becoming more and more important considering the new situations [1]. Effective and reasonable risk management can not only suppress the occurrence of risk events at the source but also prepare management strategies in advance for the risks that have not occurred; in order to achieve the purpose of reducing the probability of risk events, for the risk factors that have occurred, measures can be taken to act on the key factors of the risk event to achieve the purpose of reducing losses, as shown in Figure 1 [2]. Therefore, evaluating the risk on the basis of effectively identifying the project cost risk factors of the power grid project and formulating a sound economic risk management strategy is a problem that project managers need to focus on. The core content of power grid project cost risk management is to adopt appropriate, economical, and efficient risk management strategies to avoid, reduce, or transfer risks, thereby reducing the impact of risk factors on the project cost. The general power grid project construction has the characteristics of large investment and long construction period; in addition, most of the power grid projects are public utilities involving public electricity consumption; therefore, under the premise of strictly guaranteeing the

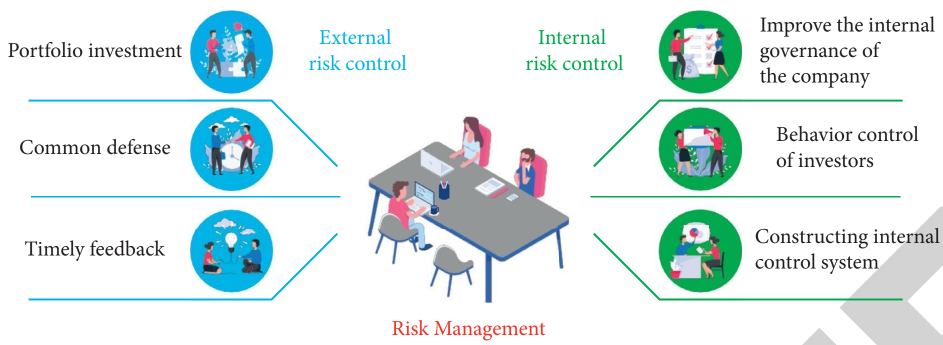

Figure 1: Risk management system.

quality and construction period of the project, the cost of the power grid project should be reasonably controlled. Generally, in the construction and implementation of power grid projects, unexpected emergencies will occur; as a result, the dynamics and uncertainty of the project cost of the power grid project are generated, so a complete set of risk management scheme is required to carry out risk identification, evaluation, management, and control the whole process of power and network project cost, and through the combination strategy management of risk factors, unforeseen costs of grid projects can be reduced [3]. Therefore, combined with the characteristics of power grid project engineering cost, it is particularly important to systematically study the risk management theory and management strategy of power grid project engineering cost.

2. Literature Review

The development of China's engineering cost management has gone through four stages: the former Soviet Union's cost management model marked by "standard quota;" the chaotic state of cost management during the cultural revolution; from the reform and opening up to the period of restoration, rectification, and development of cost management in the 1990s; and from the late 1990s to the present, the marketization and international development of cost management. Since the mid-1980s, many Chinese researchers have put forward the idea of cost management in the whole process of engineering projects. Liu et al. proposed the idea of integrating the uncertainty cost and project risk of construction projects [4]. Yang et al. analyzed the construction project cost risk management theory [5]. Wang and Srikantha used quantitative evaluation methods to construct a fuzzy comprehensive evaluation model of engineering project cost risk, thereby, quantitatively assessing the impact of risk factors on the cost of highway engineering projects [6]. Wang et al. used Monte Carlo simulation and crystal ball software to analyze the risk level of engineering project cost [7]. Guo et al. established a combined distribution model based on the actual and extreme event risk theory of engineering cost risk analysis and this model integrated the left-tailed distribution, the original distribution, and the right-tailed distribution model; therefore, a weighed optimization model based on parameter estimation of the combined distribution model is established to predict the risk of engineering cost [8]. In order to effectively predict the final cost and duration of the project, Ibrahim and Elshwadfy used the DE-ANN risk prediction model [9]. Shaikh et al. compared the multiple cost forecasting methods, and a grey correlation model for cost risk prediction of large-scale scientific research projects is established [10]. Huang et al. used an actual and extreme event risk theory for engineering cost risk analysis and an extreme value distribution (GPD) based on the POT model is proposed, and the corresponding VAR (value at risk) estimated value was calculated to realize the calculation of the project cost risk [11]. Isah and Kim studied the issues of project cost risk management with regard to the EPC model, mainly focussing on the identification and assessment of the project cost risks under the EPC model [12]. From the perspective of whole process management, Xie et al. pointed out that power grid engineering cost risk management includes power grid engineering project approval, project completion, and commissioning and final accounting management; for project cost risk management, it is necessary to systematically control investment estimates, design estimates, construction drawing budgets, contract prices, project settlement prices, and final accounts [13].

The identification of key factors of cost risk of power grid construction projects is a clustering problem often involved in the fields of management and scientific research; the fuzzy clustering analysis is an effective mathematical method to describe and solve clustering problems with the principle of fuzzy mathematics. The methods of fuzzy clustering analysis mainly include the following: the dynamic clustering method based on fuzzy equivalence relation, the method based on fuzzy partition (namely, the fuzzy c-means method), the maximum tree method, the weaving net method, and so on. Among them, the largest tree method is a more representative method and its steps are simple, the ideas are easy to understand, and it has good scientific generalizability. On the basis of the current research, the author establishes a fuzzy clustering maximum tree algorithm model; combined with empirical analysis, the risk factors existing in the cost of power grid construction projects are classified, and the key risk factors affecting its cost are effectively identified, providing effective decision-making information for the cost risk control of power grid construction projects.

3. Research Methods

3.1. Cost Risk Analysis of Power Grid Construction Projects

3.1.1. Identification of Cost Risk of Power Grid Construction Projects. According to the implementation process of the power grid construction project, the project cost risk is identified from each stage of the power grid construction project, including the investment decision-making stage, the design stage, the bidding stage, the implementation stage, and the completion settlement audit stage. The risk in the investment decision-making stage comes from insufficient feasibility study. The risk in the engineering design stage comes from ignoring economic rationality, and the design standard cannot be controlled according to the cost index. The risk in the bidding stage lies in the selection of units. The risk in the construction and implementation stage comes from the imperfect management system and the risk in the completion audit stage lies in the imperfect postproject evaluation.

By consulting relevant literature in China and abroad, combined with the actual situation of power grid construction projects, the risk factors affecting the cost of power grid construction projects are comprehensively analyzed and the cost risk of power grid construction projects is obtained, which mainly includes two types of risk factors: planned development risk and engineering construction risk [14]. Among them, planned development risks include infrastructure project planning risks, infrastructure project research risks, infrastructure project approval risks, and infrastructure project change risks. Engineering construction risks include infrastructure project cost risks and engineering cost risks.

(1) Plan Development Risks. The planned development risk mainly includes the planning risk of the infrastructure project, the research risk of the infrastructure project, the approval risk of the infrastructure project, and the change risk of the infrastructure project. Some explanations are as follows:

① Risk of scarcity of infrastructure land resources: due to the scarcity of available land and line corridor resources, there is a risk of scarcity of land resources in power grid (planning) projects

② Risk of cross-departmental coordination of project planning: due to the approval of multidepartment and separate projects (such as independent approval of new access projects, grid capacity expansion projects, and asset modification projects), the investment plan may not be fully coordinated and may affect the return on investment

③ Planning risk of supporting infrastructure projects: due to the untimely planning, adjustment, and construction of supporting projects, the overall normal operation of the project may be affected

④ Risk of compensation for young crops in infrastructure projects: due to insufficient estimates of compensation for land acquisition and young crops in the feasibility study, the estimated budget gap is large, which may increase the construction cost of the project and affect the construction progress of the project

⑤ Risk of financial participation in the review of infrastructure projects: due to insufficient financial data provided by the finance department and insufficient participation in the process of project review and decision-making, the economic factors related to the project are not included in the substantive review system, resulting in scientific analysis of project feasibility and other factors' influence

⑥ Risk of fluctuation in the purchase price of infrastructure equipment: due to the large fluctuation in the price of engineering equipment, it may lead to inaccurate estimates of feasibility studies and preliminary estimates

⑦ Infrastructure project approval cycle risk: because experts participate in project evaluation for too short time and are influenced by too many subjective opinions from owners, experts are unable to put forward objective evaluation opinions, thus reducing the quality of feasibility study or project design [15]

⑧ Risk of personnel allocation for infrastructure project approval: due to the large number of project approvals and insufficient approval personnel, the overall speed of project approval is affected

In addition to the above risks, planning development risks also include risks such as approval policy risks, imperfect design risks, engineering change monitoring risks, and lack of strict functional management of engineering changes.

(2) Engineering Construction Risks. Engineering construction risk includes capital construction cost risk and engineering cost risk. Some explanations are as follows:

① Infrastructure project settlement audit quality risk: during the project settlement process, the cost of the project may be unreasonable due to the lack of understanding of the relevant clauses of the project contract by the cost audit agency and insufficient understanding of national policies and quota standards

② Construction project settlement risk: since the capital construction project is settled according to the budgeted amount, the settlement amount may include unrealized engineering expenditures, resulting in economic losses of the enterprise.

③ Risk of project settlement review: in the process of project settlement review, because the two bills have not been confirmed by the construction unit, the construction unit has disputes over the settlement review results, affecting the project settlement progress or causing legal disputes [16]

④ Risk of project cost consulting and settlement audit: when determining cost consulting service providers, due to the failure to implement effective selection procedures, the best cost consulting service provider may not be entrusted to conduct project preaudits and settlement audits, which may affect the results of project settlement audits accuracy

⑤ Risk of separation of "quantity and price" auditing of project settlement: implemented in the process of project cost auditing, the project quantity is audited by the implementation department and the price audit department only audits the "quota" according to the project volume signed by the implementation department, which may lead to inaccurate settlement of some projects.

In addition to the above risks, engineering construction risks also include risks such as scientific research of infrastructure projects and selection of design units.

3.1.2. Establishment of the Cost Risk Analysis Index System for Power Grid Construction Projects. Based on the principles of scientificity, systematicness, comparability, and operability and comprehensively considering the risk factors mentioned above, the author established a cost risk analysis index system for power grid construction projects [17]. The index system consists of 6 first-level indexes and 18 second-level indexes, which comprehensively and objectively reflect the basic connotation of the cost risk of power grid construction projects. Its structure is shown in Figure 2.

3.2. Principle of Fuzzy Clustering Maximum Tree Algorithm. Fuzzy cluster analysis is a multivariate analysis method in mathematical statistics, which quantitatively determines the relationship between samples by mathematical methods, so as to objectively divide the types. There are many kinds of clustering methods, such as the fuzzy equivalent matrix clustering method, the direct clustering method, and so on. The author uses the maximum tree method in the fuzzy matrix direct clustering method, that is, the fuzzy clustering maximum tree algorithm to classify the importance of each risk factor; combined with the actual situation, we can distinguish key risk factors and noncritical risk factors. The flowchart of the general clustering algorithm is shown in Figure 3.

3.2.1. Establishment of Index System Matrix. Suppose the universe of discourse $X = \{x_1, x_2, \ldots, x_n\}$ is the object to be classified, and each object is composed of m indicators. Several experienced experts in the field were invited to form a judging panel, and the importance of each indicator was scored according to the expert scoring method. The importance degree evaluation set $V = \{V_1, V_2, \ldots, V_n\}$ was established, the importance degree ranked from low to high from 1 to p, and the evaluation values were recorded as 1, 3, 5, . . ., $2p - 1$. Therefore, the original data matrix is obtained as

$$\mathbf{A} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix}_{n\times m}. \tag{1}$$

The main purpose of the fuzzy clustering maximum tree algorithm is to classify the n elements in $X = \{x_1, x_2, \ldots, x_n\}$ according to the index characteristics [18].

3.2.2. Steps of Fuzzy Clustering Maximum Tree Algorithm

Step 1. Standardization of indicator data.

The author adopts the translation-range variation method, as shown in the following formula:

$$x_{ij}' = \frac{x_{ij} - \min\{x_{ij} | 1 \le i \le n\}}{\max\{x_{ij} | 1 \le i \le n\} - \min\{x_{ij} | 1 \le i \le n\}}. \tag{2}$$

In the formula, $x_{ij}\,(i = 1, 2, \ldots, n;\ j = 1, 2, \ldots, m)$ represents the scoring value of the importance of the jth index of the ith classified object.

Step 2. Establish a fuzzy similarity matrix.

According to the actual situation, the author chooses the Hamming distance method to find the similarity coefficient r_{ij} between x_i and x_j and establishes the fuzzy similarity matrix $\mathbf{R} = (r_{ij})_{n\times n}$.

The Hamming distance method can be expressed by the following equations:

$$d(x_i, x_j) = \sum_{k=1}^{m} \left| x_{ik} - x_{jk} \right|, \tag{3}$$

$$r_{ij} = 1 - c d(x_i, x_j). \tag{4}$$

In the formula, the coefficient c is a properly selected parameter, so that the similarity coefficient $r_{ij} \in [0, 1]$.

Step 3. Use the max tree algorithm for classification [19].

The idea of the maximum tree algorithm is to take the classified object $x_i\,(i = 1, 2, \ldots, n)$ as the vertex according to the fuzzy similarity matrix $\mathbf{R} = (r_{ij})_{n\times n}$ established earlier and to draw the branches according to the value of the element r_{ij} in the fuzzy similarity matrix R in descending order, and to mark the threshold value, it is required that no loop is generated, until all the vertices are connected and a maximum tree is obtained. In the interval [0, 1], the threshold value λ is taken and the branches whose threshold value is less than λ are cut off to obtain a disconnected graph, and each connected branch constitutes the classification at the λ level.

Step 4. According to the above results, draw a graph of the results of cluster analysis of risk factors at different value levels.

According to the result of risk cluster analysis, combined with the analysis of the actual situation of the impact of

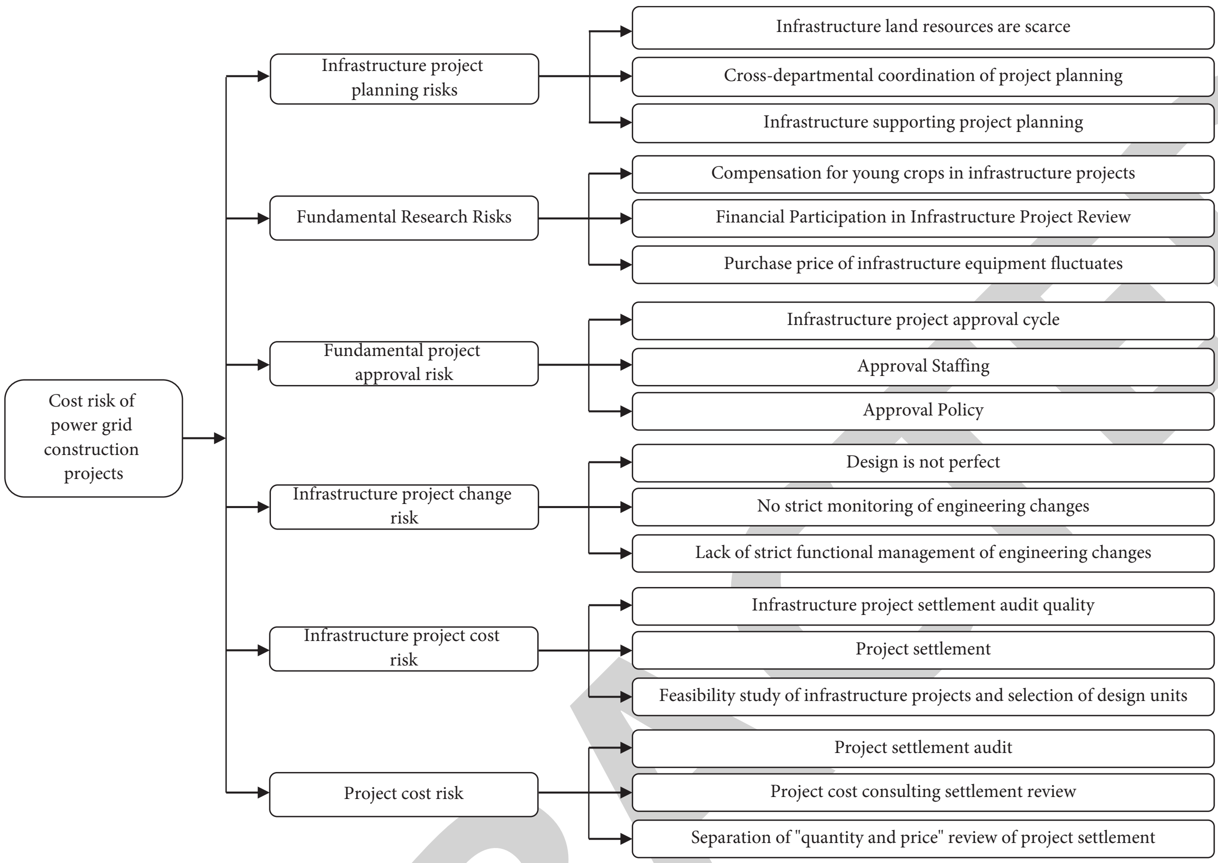

Figure 2: Cost risk composition of power grid construction projects.

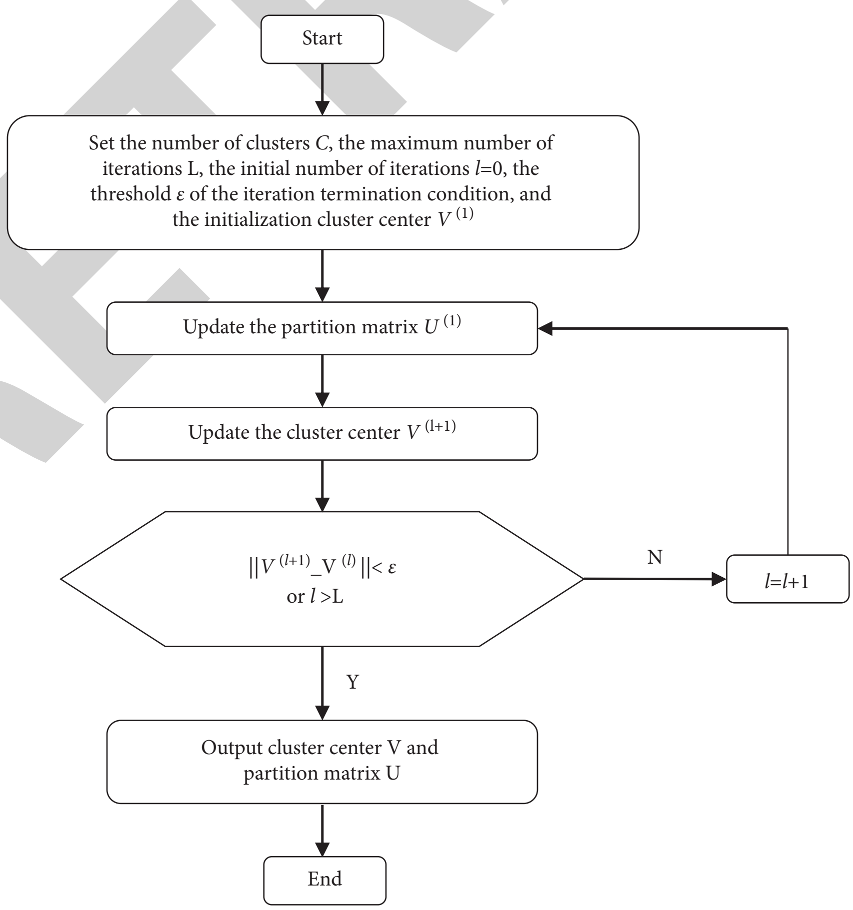

Figure 3: Flowchart of a general clustering algorithm.

various types of risks in power grid construction project cost, the main and secondary risk factors, the so-called key risk factors and nonkey risk factors, are distinguished.

4. Analysis of Results

The evaluation set $V = \{V_1, V_2, \ldots, V_5\}$ is recorded, indicating that the importance of each risk factor index is low, low, medium, high, and high and the evaluation value is 1, 3, 5, 7, and 9 in turn. The scoring by experts at different levels in different regions may have an impact on the final evaluation results, but due to the similarity of power grid construction projects, the evaluation results will not change significantly [20]. Here, taking a power company as an example, the key factors of cost risk of its power grid construction project are identified.

A judging group composed of 6 experts is selected to score the importance of each risk factor indicator according to their own experience and the information obtained, and then, take the weighted average to obtain the sample data matrix as

$$\mathbf{A} = \begin{bmatrix} 7 & 4.667 & 6.667 \\ 5.667 & 3.333 & 6.333 \\ 3 & 2.167 & 2 \\ 5.333 & 4.667 & 2 \\ 5.333 & 4.667 & 3.667 \\ 6.667 & 8.333 & 8 \\ 9 & 8 & 4.667 \end{bmatrix}. \tag{5}$$

The data are then normalized according to formula (1).

$$x_{11}' = \frac{x_{11} - \min\{x_{i1} | 1 \le i \le n\}}{\max\{x_{i1} | 1 \le i \le n\} - \min\{x_{i1} | 1 \le i \le n\}}. \tag{6}$$

According to this method, the standardized data matrix can be obtained as

$$\mathbf{A} = \begin{bmatrix} 0.667 & 0.405 & 0.778 \\ 0.445 & 0.189 & 0.722 \\ 0 & 0 & 0 \\ 0.389 & 0.405 & 0.278 \\ 0.611 & 1 & 1 \\ 1 & 0.946 & 0.445 \end{bmatrix}. \tag{7}$$

According to the Hamming distance method, the distance matrix can be obtained from the Hamming distance formula (2) as

$$D = \begin{bmatrix} 0 & 0.494 & 1.850 & 0.788 & 0.873 & 1.207 \\ 0.494 & 0 & 1.356 & 0.716 & 1.255 & 1.589 \\ 1.850 & 1.356 & 0 & 1.072 & 2.611 & 2.391 \\ 0.788 & 0.716 & 1.072 & 0 & 1.539 & 1.319 \\ 0.873 & 1.255 & 2.611 & 1.539 & 0 & 0.998 \\ 1.207 & 1.589 & 2.391 & 1.319 & 0.998 & 0 \end{bmatrix}. \tag{8}$$

According to formula (3), selecting = 0.3, the fuzzy similarity matrix can be calculated as

$$\mathbf{R} = \begin{bmatrix} 1 & 0.852 & 0.445 & 0.764 & 0.738 & 0.638 \\ 0.852 & 1 & 0.593 & 0.785 & 0.624 & 0.523 \\ 0.445 & 0.593 & 1 & 0.678 & 0.217 & 0.283 \\ 0.764 & 0.785 & 0.678 & 1 & 0.538 & 0.604 \\ 0.738 & 0.624 & 0.217 & 0.538 & 1 & 0.701 \\ 0.638 & 0.523 & 0.283 & 0.604 & 0.701 & 1 \end{bmatrix}. \tag{9}$$

According to the idea of Step 3, we take the classified object $x_i\,(i = 1, 2, \ldots, 6)$ as the vertex, draw the branches in descending order according to the value of the element r_{ij} in the fuzzy similarity matrix R, and mark the threshold value, and it is required that no loop is generated until all the vertices are connected, and a maximum tree is obtained, as shown in Figure 4.

The next step is to perform pruning classification. When $\lambda = 0.852$, the branch with threshold $\lambda < 0.852$ is cut off, and the obtained tree is shown in Figure 5, from which the classification result can be obtained. When = 0.852, the six categories of risk factors that are classified can be divided into five categories, namely, $\{x_1, x_2\}, \{x_3\}, \{x_4\}, \{x_5\}, \{x_6\}$.

When $\lambda = 0.785$, the branch with threshold $\lambda < 0.785$ is cut off, and the obtained tree is shown in Figure 6, from which the classification result can be obtained. When $\lambda = 0.785$, the six categories of risk factors to be classified can be divided into four categories, namely, $\{x_1, x_2, x_4\}, \{x_3\}, \{x_5\}, \{x_6\}$.

When $\lambda = 0.738$, it can be divided into three categories, namely, $\{x_1, x_2, x_4, x_5\}$, $\{x_3\}$, $\{x_6\}$. When $\lambda = 0.701$, it can be divided into two categories $\{x_1, x_2, x_4, x_5, x_6\}, \{x_3\}$, and when λ= 0.678, it is divided into one category, namely, $\{x_1, x_2, x_3, x_4, x_5, x_6\}$,. According to the above classification results, the results of cluster analysis of risk factors at different λ value levels were drawn, as shown in Figure 7.

We identify and analyze the key factors of cost risk of power grid construction projects. The results of cluster analysis show that when the threshold λ changes from large to small, the classification results become more and more rough. In order to determine an optimal classification, the λ value should be selected reasonably [21]. There are many methods for selecting the λ value, such as the expert experience method and the F-statistic method [22]. It is generally believed that the classification results when the λ value is larger, finer, and more reasonable. Based on expert experience and the actual situation of power grid engineering, the author believes that the classification results when the threshold value is $\lambda = 0.785$ are more realistic. At this λ level, 6 risk factors are divided into 4 categories as follows: category I $\{x_1, x_2, x_4\}$, category II $\{x_3\}$, category III $\{x_5\}$, and category IV $\{x_6\}$. This classification not only groups together risk factors of equal importance but also separates risk factors of different importance. Combined with the practical experience of power grid construction project cost management, when general project managers control the project cost, it often focuses on early control and

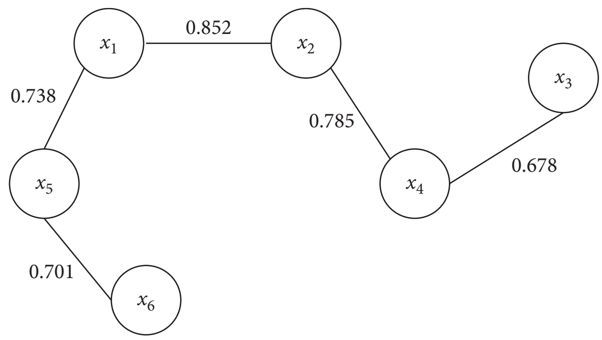

Figure 4: The maximum tree.

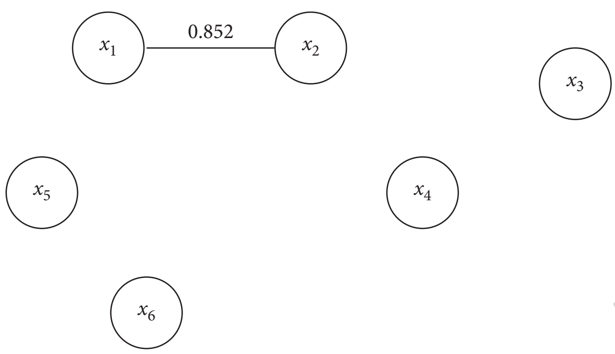

Figure 5: The tree after preliminary pruning.

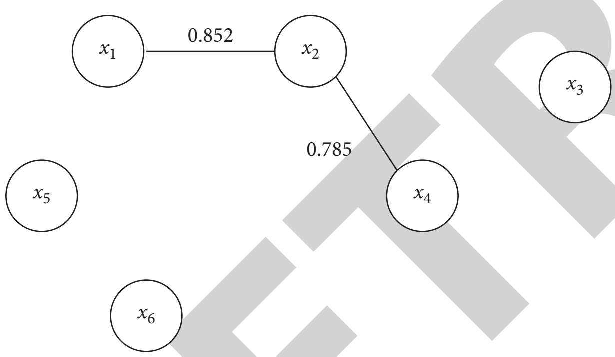

Figure 6: The tree after further pruning.

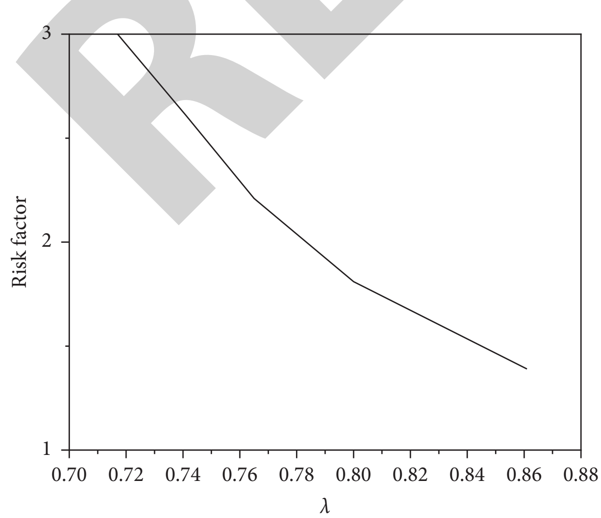

Figure 7: Clustering results of risk factors at different value levels.

process control, that is, the control is stronger in the stages of investment decision-making, feasibility study project establishment, scheme design, and construction process, that is, the attention to type I risks is greater than that of the other three types of risks. Therefore, it can be considered that the type I risk is the key risk. Therefore, through the fuzzy clustering maximum tree algorithm and the analysis of the actual situation, the planning risk of the infrastructure project, the research risk of the infrastructure project, and the change risk of the infrastructure project can be obtained; these three types of risks are the key risk factors in the cost risk of power grid construction projects.

5. Conclusion

The author analyzes the current cost risks of China's power grid construction projects and lists six major types of risks in the construction cost of power grid construction projects, and based on the fuzzy clustering maximum tree algorithm, three major types of key risks are further identified for the main existing risks. From this, the author mainly draws the following two conclusions. (1) The key risks in the cost risk of China's power grid construction projects are the planning risks of infrastructure projects, the research risks of infrastructure projects, and the cost risks of infrastructure projects. (2) Due to the complexity of the social environment of power grid construction, there are many risks in each stage of cost control; therefore, identifying the key risks can enable project managers to have pertinence in cost control of power grid construction projects; in this way, risks can be minimized and investment returns can be improved.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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