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Research on the Resilience Evaluation of Urban Rail Transit Construction Organization Based on the Cloud Matter-Element Model: A Case Study of Nanchang West Station

Wei Liu and Xiuxiu Yuan *

School of Civil Engineering and Architecture, East China Jiaotong University, Nanchang 330013, China; liuwei@ecjtu.edu.cn
* Correspondence: 2022018085901054@ecjtu.edu.cn

Abstract: In the construction of urban rail transit projects, the disturbance of equipment, sudden failure, rainstorms, and other emergencies may bring serious safety risks. Resilience theory emphasizes the ability of the system to resist, adapt, absorb, and learn from risks in the whole process before, during, and after the occurrence of risks. It is introduced into the safety management of construction organization of urban rail transit projects to describe the ability of urban rail transit projects to cope with risks in the whole process of dealing with construction risks. This study defines the connotation of the resilience of the project construction organization and uses the literature frequency statistics method to determine the resilience evaluation indexes. The game theory combination weighting method is used to determine the index weights, and the cloud matter element model is used to establish the evaluation model of construction organization resilience of urban rail transit projects. Taking Nanchang West Station of Phase 1 Project of Nanchang Line 2 as an example, the validity and accuracy of the model are verified. The results show that the resilience grade of the construction organization of the project is "higher resilience," which is consistent with the actual survey situation, and the evaluation model is reasonable. In addition, in the evaluation results, the key indexes and risk indexes of the project are determined, and the safety management measures of the construction organization of the project are put forward according to the key indexes and risk indexes.

Keywords: urban rail transit projects; construction organization; safety management; resilience evaluation; game theory combinatorial weighting; cloud matter element model

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1. Introduction

Urban rail transit is an important vehicle for improving the quality of life of residents and enhancing the people's sense of accessibility and well-being. It plays an important role in providing convenient transportation, boosting economic development, improving environmental quality, and strengthening social activities, and it has a positive and important impact on building a more livable, workable, and tourist-friendly urban environment. However, with the acceleration of China's urbanization process, a large number of people have poured into cities, which has brought great pressure on urban traffic. In order to solve the problem of traffic congestion and traffic accidents caused by population density, the development and construction of urban rail transit are undoubtedly important choices.

Urban rail transit projects face the complexity and variability of the surrounding environment and the project's own investment in the large, long construction period and other uncertainties and risks. Construction accidents cause economic losses and will even affect the safety of people's lives. Therefore, it is of great significance for the project to take preventive measures to avoid risks before accidents occur, implement measures to reduce losses during accidents, and quickly recover and optimize learning after accidents occur, continuously improving the project's ability to cope with risks. According to previous practical experience, the identification and evaluation of risks within the construction

organization of a project before they occur can facilitate the proposal of countermeasures to reduce the probability of risk occurrence [1]. However, the traditional pre-risk prevention model can take certain preventive measures for specific risks in project construction, but it cannot make the project able to cope with risks in the dynamic changes of the whole process before, during, and after the occurrence of risks. This also shows that risk management from the perspective of prevention in advance cannot meet the safety management needs of the construction organization of the current urban rail transit project. Resilience theory emphasizes the ability of the system to resist, adapt, absorb, and learn from the whole process before, during, and after the occurrence of risks. Therefore, resilience theory is introduced into the construction organization safety of urban rail transit projects. The ability of projects to cope with risks in the construction organization process is also studied to achieve dynamic safety management.

The concept of resilience was originally used to measure the reaction ability and elasticity of materials or systems under external pressure or change. After Canadian ecologist Holling first introduced resilience theory into the study of ecosystem assessment, researchers at home and abroad found that using resilience theory can extend the scope of risk evaluation and enhance the self-stability of the system. Urban resilience is a hot topic in resilience research at home and abroad. Mrak et al. proposed the evaluation model 'urban resilience strategic planning-SPUR model' to help urban scenario construction, evaluation, and planning options [2]. Serbanica et al. explored the changes in the perception of urban challenges in cities participating in the "100 Resilient Cities" program and the interaction between identification and coding hazards, shocks, and pressures [3]. Fang et al. proposed that only by scientifically allocating resources to various urban systems can the overall resilience level of the city be improved [4]. At the level of disaster resilience, Navid et al. proposed a quantitative method for assessing organizational resilience in sudden disasters considering preparedness actions (PAs) and verified the feasibility of the method [5]. McConkey et al. enhance community resilience by exploring the suitability of specific variables used in the BRIC index and the suitability of the variable capturing known events and expected activities that affect resiliency [6]. Žičkienė et al. put forward that the weighted sum of the impact of payment on the resilience of the main economic functions of the sector is regarded as the overall level of the impact of direct payment on the economic resilience of the sector [7]. Egidi et al. studied desertification risk, land degradation, and socio-demographic dynamics from a" resilience" perspective to examine their close relationship with economic resilience [8]. Based on the investigation of the actual recovery process after an urban disaster, Miu et al. constructed the RECOVER system of resilience evaluation to provide guidance and support for future urban disaster prevention and mitigation work [9]. Xu et al. applied the cloud matter-element method to construct a comprehensive evaluation model of urban disaster resilience to promote the construction of urban disaster resilience [10]. From the perspective of the infrastructure coupling relationships, Zhou et al. constructed an urban resilience evaluation model of urban three-layer network coupling and obtained the cascading failure phenomenon between infrastructure systems with an adjustable coupling relationship [11]. Gu et al. studied the disaster response and control of a single structure, focusing on "disaster/environmental action-structural response-disaster control-resilience improvement" [12]. Some scholars have integrated resilience into the field of urban rail transit construction. By introducing the concept of resilience, Chen et al. constructed a Bayesian network resilience model to enhance system resilience and ensure the safe and orderly development of normal construction [13]. Huang et al. constructed a fuzzy comprehensive evaluation model of fire safety resilience of subway stations based on the concept of resilience and demonstrated it with a case. It is summarized that the automatic fire alarm system has the greatest impact on overall resilience [14]. Chen et al. used the concept of resilience and subway construction safety management to analyze the factors affecting the resilience of the subway construction safety system [15]. Wang et al. proposed the concept of deep foundation pit resilience

theory of subway stations and used the Euclidean distance method to evaluate the safety engineering properties of the deep foundation pit structure of subway stations [16].

Through the analysis and summary of the research on resilience, it is found that resilience, as a new research direction, has certain differences in application across different fields. However, in general, it can be found that resilience is used to improve the safety and risk response ability in a certain field. At the same time, the study found that resilience is the most widely studied field in cities and disasters, but the research content relating to urban rail transit construction organization is less involved and relatively lacking. There is a large space for exploration on how to define construction organization resilience in urban rail transit projects and explore the resilience performance of urban rail transit projects in construction organization. Therefore, this study combines the concept of resilience theory and the safety management concept of urban rail transit project construction organization, defines the connotation of resilience in urban rail transit project construction organization, and then clarifies the safety management elements and resilience characteristic elements of the construction organization. Based on this, the resilience evaluation index is established using the literature frequency statistics method. On this basis, a resilience evaluation model based on game combination weighting and the cloud matter-element model is constructed to explore the resilience performance of urban rail transit projects in the process of construction organization to put forward targeted promotion strategies for the resilience of urban rail transit project construction organization and help the development of the urban rail transit industry.

2. Literature Review

2.1. Construction Organization of Urban Rail Transit Project

The construction and development of urban rail transit has been highly valued by domestic and western developed countries. In the construction of urban rail transit projects, the construction organization stage is the key to project success. Construction organization refers to the organization and planning of manpower, capital, materials, machinery, technology, and other factors in space, time, and resources during the construction process so that the projects can be carried out in a reasonable and orderly manner and the projects quality, low cost, and fast progress can be guaranteed [17]. By using the AHP-EW model to construct the adaptability system of the TBM tunnel, Tan et al. proposed that the program using modern information technology can deal with the tunnel engineering problems under uncertain conditions in the construction process and further strengthen the adaptability of TBM tunneling in the formation [18]. Fouladgar et al. used the TOPSIS method to address multi-standard decision-making to identify risk parameters of uncertainty to assess the degree of risk the tunnel project encounters in the construction organization. Finally, collapse is the most dangerous parameter of tunnel engineering [19]. Based on the contribution of construction site research, Mikaeil et al. used a meta-heuristic algorithm to determine the risk clustering optimization technology to implement risk organization and management in the life cycle of tunnel projects. Finally, it is found that the performance of the intelligent model has a significant ability to evaluate the geotechnical engineering risk of the tunnel [20]. Wu et al. used video recognition and dynamic monitoring technology to improve the efficiency of discovering and disposing of hidden dangers on the construction site [21]. Meng et al. proposed a complete set of risk management information system development programs. It aims to solve the concealment, complexity, and difficulty of predicting urban rail transit construction projects [22]. Based on the perspective of the whole process management of the construction stage, Zhang et al. analyzed the cost application of BIM in the construction stage of urban rail transit and realized the fine and dynamic cost control [23].

In terms of construction organization safety factors, Einstein et al. proposed tunnel decision support (DAT) to predict various uncertain risk factors in the process of underground construction organization and found that the tunnel construction process can be continuously updated through exploration [24]. Based on the game theory G2-EW-TOPSIS

model, Yang et al. found that construction quality is the core index in the process of tunnel construction [25]. Guha used factor analysis, multiple regression, and other methods to analyze the safety management problems of existing construction organizations in Kolkata, India. The study found that strengthening the safety training of managers has an important impact on improving the safety awareness of managers and workers [26]. Liu et al., based on the K-means mean value of the urban rail transit construction safety accident clustering analysis of the main process, found that the bad complex geological conditions of the construction organization are the dominant safety factors [27]. Xu et al. introduced the concept of information entropy through the text mining method, improved the traditional TF-IDF value, and concluded that the instability of the support system, the confusion of on-site management, and illegal construction operation were the accident-causing factors with high importance [28]. Pan used the importance-performance analysis method to quantitatively evaluate a subway project in Foshan City, China and proposed carrying out safe construction management in strict accordance with the specifications and construction environment [29]. Liu used game theory and the G1-AEW method to analyze the safety of subway tunnel construction organization and concluded that rainfall intensity was the most important factor affecting the safety of subway tunnel construction organization [30].

Previous studies have made the construction organization and management of rail transit projects in China more scientific and standardized in terms of technology and safety, promoting the sustainable development of rail transit construction in China to a certain extent. However, for the organizational safety control of urban rail transit projects in construction, it is more likely to stay at the pre-risk static level, ignoring the dynamic and uncertain risks of the project in the construction organization.

2.2. Project Construction Organization Resilience Evaluation

Project construction organization resilience refers to the implementation of a series of resilience-strengthening measures in the process of project construction organization to improve the project's anti-interference ability, adaptability, and recovery ability to cope with emergencies so that projects can reach a new safety state and have stronger sustainable development ability. Based on the concept of resilience in project construction organization, Alexander et al. studied the extent to which the new railway tunnel design phase in Sweden took into account the resiliency of the rail system [31]. Makana et al. described the development of a new Sustainability Evaluation of Underground Use Resilience (SUURE) framework for assessing the utilization of utility tunnels in the East End of Birmingham, England. The research shows that the evaluation effect is good [32]. Paula et al. optimized the placement of sensors in the tunnel to obtain the temperature evolution during the fire to improve the tunnel's disaster prevention resilience [33]. Peñaloza et al. applied the Resilience Assessment Grid (RAG) in construction and applied the Technology, Organization and Environment (TOE) framework to construction resilience safety management, thereby determining the key resilience factors of construction organization projects [34]. He et al. conducted an empirical evaluation and analysis of the construction organization resilience of the subway projects under the rainstorm waterlogging disaster from the aspects of robustness, redundancy, resilience, and adaptability. They obtained the advantage resilience index, balance resilience index, and weakness resilience index of the subway project [35]. Based on the resilience theory, Wei proposed the resilience management model based on risk prevention and control and the framework of resilience construction management mode of major railway engineering construction organization to improve the resilience of construction organization facing risk challenges as a whole [36]. Ji adopted multiple protections, absorption protection, deformation protection, and ecological protection, to improve the resilience of engineering construction organization [37]. Lu established a resilience evaluation method based on the performance time history curve and put forward suggestions for the development of decision optimization of resilience design schemes [38]. Based on the resilience theory, Mo et al. took defense ability and recovery ability as the basic variables of each evaluation index. They established the entropy weight-two-dimensional cloud

model of resilience evaluation of engineering systems in the process of high-speed railway construction organization [39]. Zhu established a waterlogging resilience evaluation model of subway stations based on game theory combined with a weighted matter-element extension model from three aspects of personnel management, material equipment, and environment and applied the model to verify its effectiveness [40].

Reviewing the above literature, more and more experts and scholars in the field of construction safety management combine the conceptual framework of resilience theory with the traditional safety risk management of construction organization to improve the safety management level of actual construction organization. However, the exploration of the evaluation of construction organization resilience of urban rail transit projects is still in its infancy. There are still some problems in the relevant research, such as the construction of the evaluation index system not being perfect enough and the effectiveness of relevant evaluation models needing to be verified.

2.3. Evaluation Method

There are many evaluation methods, but there are relatively few comprehensive evaluation methods for the construction organization resilience of urban rail transit projects. The following are several common evaluation methods.

The BP neural network method is less subjectively disturbed by the evaluation subject. It can not only accurately evaluate the resilience level of urban rail transit but also track the impact path that causes the final price result to a certain extent, which is conducive to the analysis of the causes of the results. However, in the process of application, a large amount of effective data support is needed, and a series of data processing is needed to obtain effective results. This is difficult to implement in the field of construction organization resilience of current urban rail transit projects, and further research by scholars is needed.

The traditional mathematical method has great defects in overcoming the uncertainty problem. Academic Li Deyi proposed using the digital characteristics of the cloud model to represent the randomness and fuzziness of things and complete the mutual transformation of qualitative and quantitative [41]. The trust evaluation method based on the cloud model, such as Zhang, realizes the qualitative and quantitative transformation of trust and objectively reflects the randomness, fuzziness, and unpredictability of trust [42]. Zhang used the cloud model to calculate the degree of correlation of the risk in the reservoir-induced earthquake risk assessment system to the overall goal, which greatly avoided the error caused by personal subjective influence [43]. Wu et al. used the cloud model to realize the transformation of experts classification of risk probability from qualitative to quantitative, which made the risk of surface subsidence in the subway shield construction stage clearer and more impressive [44].

There are contradictions in some things in real life. In order to solve such problems, Professor Cai Wen puts forward the matter-element theory, which expresses the characteristics of things and the quantitative value of things about the characteristics and things together and successfully transforms the contradiction of things into compatibility to achieve better decision-making effects [45]. Huang used the extension analysis theory, quantitative analysis, and qualitative analysis methods to establish a matter-element analysis model to study the composition selection and conversion of mechanical products to achieve a product design that is more suitable for market demand [46]. Mei quantifies the risk of waterways through the matter-element extension model, improves the emphasis on bad indicators, and makes the evaluation results closer to reality [47]. Zheng et al. introduced the matter-element extension theory, determined the rockburst grade according to the maximum correlation criterion, and applied this method to the rockburst prediction of the diversion tunnel in Jinping II Hydropower Station, with the results obtained being consistent with the on-site outcomes [48].

At present, resilience, as a new concept or theoretical thought, is still in the immature stage. Due to the differences in the definition and quantitative methods of resilience in different fields, the research content is diversified, which leads to the lack of a unified quantitative

method system in the research, and it is impossible to deeply explore the essence of resilience and realize its various forms of application. Research on the resilience of construction organization of urban rail transit projects is low-level resilience research compared with resilience research in urban, ecological, and other fields, and more emphasis is placed on quantitative research. Based on this defect and considering the advantages of the cloud model and matter-element theory and their mature applications, this paper selects a combination of the cloud model and matter-element theory as a quantitative research method. In this paper, by combining the two methods, a cloud matter-element model is established to evaluate the construction organization resilience of urban rail transit projects to achieve a mathematical characterization of stochasticity and ambiguity in the evaluation process.

3. Urban Rail Transit Projects Construction Organization Resilience

3.1. Connotation of Resilience

3.1.1. Definition of Resilience Concept

In the relevant literature research on resilience theory, the concept of resilience is usually defined as the ability of the system to cope with, reorganize, adjust, improve, and develop its own system using internal and external resources when the system is impacted or disturbed by emergencies. The infinite cycle of optimization learning improves the ability to resist, adapt, absorb, and learn risks so that the system can reach a new security state. The concept of urban rail transit project construction organization is to organize and plan the factors such as manpower, capital, materials, machinery, and technology in space, time, and resources during the construction process so that the projects can be carried out in a reasonable and orderly manner, and project quality is guaranteed, i.e., good, low cost, fast progress. Based on the above concept of resilience and the definition of the construction organization concept of urban rail transit projects, the paper defines the concept of construction organization resilience in urban rail transit projects as the process of construction organization and management of urban rail transit projects when facing the disturbance and impact of emergencies. It can continuously deal with, reorganize, adjust, improve, and develop itself using human, capital, materials, machinery, technology, and other elements. Through the infinite cycle of optimization learning, it can improve the ability of project construction organization to resist, respond, recover, and optimize risks so that the projects can reach a new safety state to ensure the reasonable and orderly progress of the projects.

3.1.2. The Process of Resilience Action

The resilience change process of urban rail transit project construction organization is a dynamic evolution process. The process of its resilience function can be divided into pre-disturbance (t_0~t_1), disturbance (t_1~t_3), and post-disturbance (t_3~t_4), including the stability maintenance stage (t_0~t_1), reaction stage (t_1~t_2), recovery stage (t_2~t_3), and optimization stage (t_3~t_4). When there is an emergency disturbance, construction projects can complete the dynamic evolution of the three processes and five stages through their own resilience to achieve a better safety state through continuous optimization learning.

Figure 1 shows the process curve of construction organization resilience of urban rail transit projects. The horizontal coordinate represents the time t, and the ordinate represents the state level of construction organization resilience changing with time. In the stability maintenance stage (t_0~t_1), the project's system is not disturbed by emergencies or is less disturbed. It can rely on its security and stability performance to resist the intrusion of emergencies and keep the project's system in the initial security state. From the moment of t_1, when the project system is subjected to more than the disturbance threshold, the safe and stable performance of the system is damaged, and the system enters the reaction stage (t_1~t_2). With the continuous aggravation of the disturbance, the absorption performance of the system is gradually weakened, resulting in the anti-disturbance amount exceeding the maximum tolerance limit of the system (safe capacity). The system suffers damage, and it is necessary to take a certain amount of emergency protection measures to deal with

the disturbance impact to restore the system to a safe state. That is, from the time t_2, the disturbance level and the reaction level of the system enter the flat state and then enter the recovery stage (t_2~t_3). With the continuous strengthening of safety control measures, the system structure and performance have been restored and strengthened and gradually entered the optimization stage (t_3~t_4), that is, the initial safety state (S_2) or better safety state (S_1). However, when there are problems with project planning and design, inadequate risk management, insufficient resource support, lack of synergy and communication, and lack of coordination of emergency response mechanisms, the system can fail to re-shape resilience, causing system resiliency to collapse (S_3), which cannot be restored to the initial safety state.

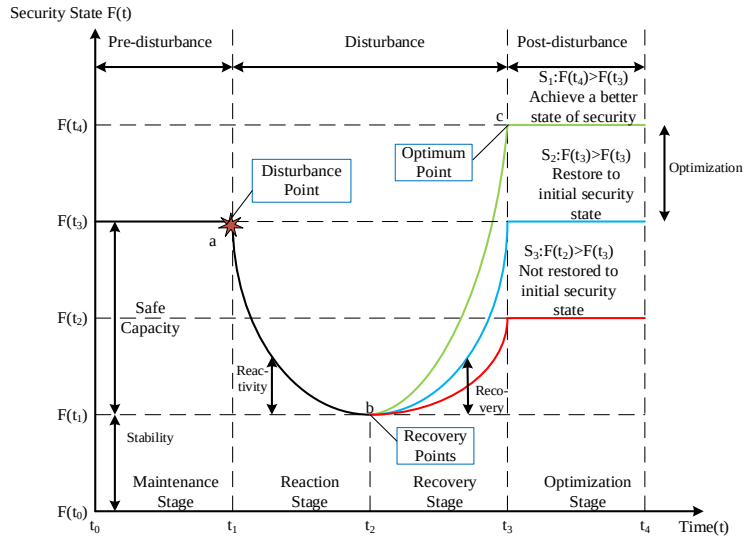


Figure 1. The resilience process of construction organization of urban rail transit projects.

3.2. Resilience Characteristic Elements

The construction organization of an urban rail transit project is a complex and comprehensive system engineering, which is affected by factors such as organization personnel and material and environmental information. In the process of resilience, the system has anti-interference, response, recovery, and optimization abilities when facing the disturbance impact of emergencies. In the process of ability exertion, the resilience characteristic elements are expressed as immunity, redundancy, efficiency, and adaptability. In the construction organization resilience, through the interaction between the organization personnel management elements, material management elements, environmental management elements, and information management elements, the resilience law of the construction organization system is presented, and the urban rail transit project construction organization resilience characteristic element performance model is formed (Figure 2). Its immunity refers to the urban rail transit projects in the process of construction organization in the face of emergency disturbance to maximize the ability to maintain the stability and normal operation of the project's construction organization system. For example, in the process of construction organization, strengthening the safety cognition ability of operators and the safety operation ability of mechanical equipment can improve the response ability to emergencies, strengthen social relations, the survey and analysis of engineering geological conditions, the ability to identify and deal with hidden dangers, and ensure the immunity of the system. Redundancy is when the project's construction organization system suffers a major sudden disturbance, resulting in damage to the original system module and the use of spare equipment, material, information, and other safety margins to ensure that the system can continue operating safely. For example, the redundancy of emergency support facilities and the establishment and improvement of emergency rescue activities and emergency organization systems can ensure that the construction organization can

minimize the overall shutdown caused by risk disturbance or accident disaster and meet the emergency rescue needs in emergency situations. Efficiency refers to the reaction time of the project's construction organization system to quickly return to a safe state in the face of sudden disturbances and the reaction efficiency of decision-making measures. For example, the division of the functions of the organization personnel, the emergency response ability of the organization personnel to deal with emergencies, and the complete emergency plan will directly strengthen the efficiency of the system to deal with risks and accidents. Adaptability refers to the project's construction organization system by drawing on the experience and continuous learning to adjust and change its structure, function, or behavior to adapt to the changing environment and needs. For example, safety education and training for members of the organization are powerful measures to improve the adaptability of personnel to risks and adverse events. The application and popularization of intelligent construction machinery and equipment, as well as the strengthening of intelligent risk monitoring and accident warning systems, will further improve the adaptability of the project in the construction organization.

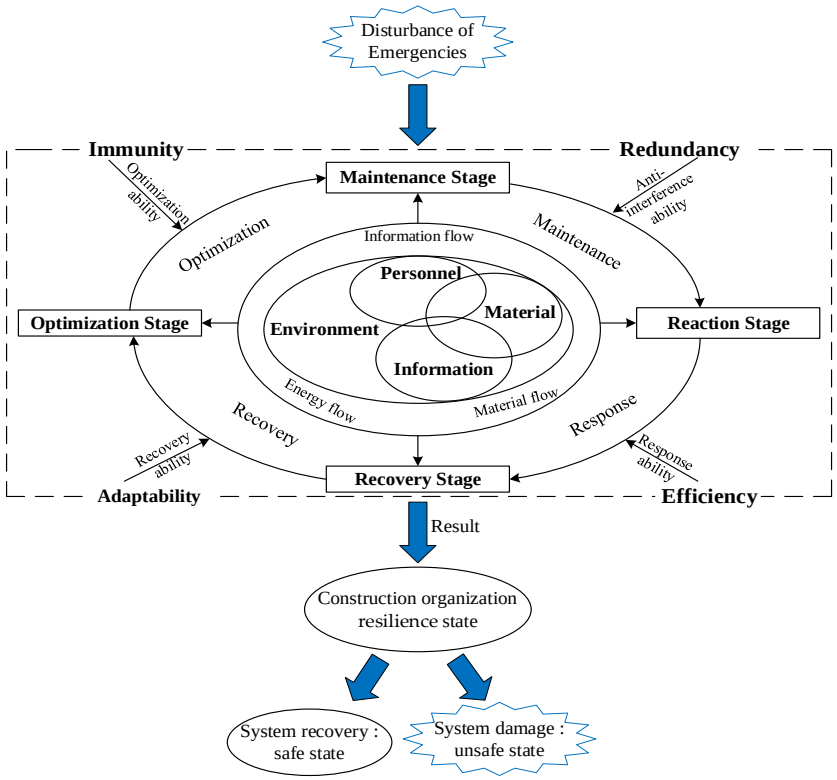


Figure 2. Performance model of resilience characteristic elements of urban rail transit projects construction organization.

3.3. Resilience Index System

Construction organization has an important impact on the safety resilience of urban rail transit projects. Establishing a systematic, comprehensive, and reasonable evaluation index system is necessary to evaluate the resilience level. The paper first uses the literature frequency statistics method to search for keywords such as "urban rail transit", "construction organization", "construction safety", and "resilience evaluation" in the full-text database of China Knowledge Network. The search scope is from 2010 to 2023, and a total of 537 related literatures are obtained, and 78 effective literatures are selected to select the resilience indexes. Then, according to the definition of the concept of construction organization resilience of urban rail transit projects, the resilience evaluation index matching the resilience characteristic elements of immunity, redundancy, efficiency, and fitness is selected from the four construction organization safety management elements of

personnel, material, environment, and information. Finally, 10 practitioners and managers in the related fields of urban rail transit were invited to reasonably evaluate the selected indicators and jointly construct the resilience evaluation index system for urban rail transit project construction organization (Figure 3).



Figure 3. Evaluation index system of construction organization resilience of urban rail transit projects.

4. Materials and Methods

4.1. Index Weight

4.1.1. DEMATEL Method

The DEMATEL method is a subjective weighting method used to analyze and evaluate the decision-making method that affects the degree of interaction between various elements in a system [49]. It can scientifically quantify and systematize the judgments made by experts based on knowledge and experience and provide relatively objective evaluation results for decision-making. The specific calculation steps are as follows:

Step 1: Determine the direct influence matrix A. According to the evaluation index of construction organization resilience of urban rail transit projects constructed in Figure 3, experts and scholars are invited to score the degree of mutual influence between resilience indexes. The scores of 0–4 indicate "no influence", "little influence", "moderate influence", "great influence", and "great influence". The initial direct influence matrix A is obtained after the arithmetic average processing of the scores of all experts.

$$A = \begin{bmatrix} 0 & A_{12} & \cdots & A_{1n} \\ A_{21} & 0 & \cdots & A_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ A_{n1} & A_{n2} & \cdots & 0 \end{bmatrix} = (A_{ij})_{n \times n} \tag{1}$$

In the formula, $A_{ij}(i, j = 1, 2, \cdots, n)$ represents the direct influence of factor A_i on factor A_j. If $i = j$, $A_{ij} = 0$.

Step 2: Normalization of direct influence matrix B. Through the standardization of the direct influence matrix A of the resilience index of the construction organization, the standardized direct influence matrix B is obtained. In this paper, the row and maximum method is used to normalize the matrix A. That is to say, the maximum value is taken after the sum of each row of the matrix A, and the factors of the matrix A are normalized to obtain the normative influence matrix B.

$$\begin{gathered} B = \frac{A}{\max\limits_{1 \le i \le n} \left(\sum_{j=1}^{n} A_{ij} \right)} \\ 1 \le i \le n, 1 \le j \le n \end{gathered} \tag{2}$$

Step 3: Finding the comprehensive influence matrix T. In order to eliminate the influence of the change in the resilience index on other indexes and also take into account the indirect effect between resilience indexes, the comprehensive influence matrix T, which is the accumulation of direct and indirect effects between systems, is calculated. The comprehensive influence matrix T is obtained by the following formula.

$$T = B + B^2 + B^3 + \cdots + B^n = \sum_{k=1}^{\infty} B^n = B\left(\frac{E - B^{n-1}}{E - B} \right) = B(E - B)^{-1} \tag{3}$$

In the formula, E is the unit matrix. Normalization directly affects the matrix B after multiplication, and the matrix value tends to 0, that is, $\lim\limits_{n \to \infty} B^n = 0$.

Step 4: The influence degree of each resilience index is calculated (D_i), including the affected degree (C_i), cause degree (R_i), and centrality (M_i) of the factors.

The influence degree D_i refers to the sum of the row values in B, which indexes the influence degree of each row resilience index on other indexes. The affected degree C_i refers to the sum of the values of each column in B, indicating the degree of influence of each column resilience index by other indexes.

$$D_i = \sum_{j=1}^{n} A_{ij}, (i = 1, 2, \cdots n) \tag{4}$$

$$C_i = \sum_{j=1}^{n} A_{ji}, (i = 1, 2, \cdots n) \tag{5}$$

Centrality M_i refers to the sum of the influence degree D_i of the resilience index and the affected degree C_i, which indicates the role of the index in the evaluation system. The cause degree R_i refers to the difference between the influence degree D_i and the affected degree C_i of the index. When the cause degree R_i is greater than 0, it indicates that the index has a greater impact on other indicators, which is the cause index. When the cause degree R_i is less than 0, it means that the index has less influence on other indicators, which is the result index.

$$M_i = D_i + C_i, (i = 1, 2, \cdots, n) \tag{6}$$

$$R_i = D_i - C_i, (i = 1, 2, \cdots, n) \tag{7}$$

Step 5: Find the weight of the resilience index ${W_j}^s$. The resilience index weight A represents the ratio of the center degree B of the index to the center degree of all the indexes.

$${W_j}^s = \frac{M_j}{\sum_{j=1}^{n} M_j} \tag{8}$$

4.1.2. Entropy Weight Method

The entropy weight method evaluates the importance of the index by calculating the information entropy of each index value and then determining the weight [50]. In this paper, the resilience evaluation information of the urban rail transit project construction organization with m resilience evaluation experts and n resilience evaluation indexes of construction organization is used. For a certain resilience evaluation index, the greater the difference between the index values judged by the evaluation experts, the greater the effect and the higher the weight given. The main calculation steps are as follows:

Step 1: Construct a judgment matrix F. The judgment matrix F is constructed by m experts and n evaluation indexes, that is, $F = (f_{ij})_{m \times n}$.

$$F = \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ f_{m1} & f_{m2} & \cdots & f_{mn} \end{bmatrix}_{m \times n} \tag{9}$$

Among them $f_{ij} (i = 1, 2, 3, \cdots, m,\ j = 1, 2, 3, \cdots n)$ represents the evaluation value of the i expert on the j index.

Step 2: Construction of a standardized matrix F'. F is standardized to obtain a standardized matrix $F' = (f_{ij}\prime)_{m \times n}$.

$$f_{ij}\prime = \frac{f_{ij} - \min\{f_{ij}\}}{\max\{f_{ij}\} - \min\{f_{ij}\}} \tag{10}$$

Step 3: Calculate the information entropy value of each index E_j.

$$E_j = -k \sum_{i=1}^{m} Y_{ij} \ln Y_{ij},\ j = 1, 2, \cdots\cdots, n \tag{11}$$

In the formula, $Y_{ij} = \frac{f_{ij}}{\sum_{i=1}^{m} f_{ij}}$, $j = 1, 2, \cdots\cdots, n$, and $Y_{ij} = 0$, then $\lim_{Y_{ij} \to \infty} Y_{ij} \ln Y_{ij} = 0$. Y_{ij} represents the proportion of each index value judged by the i judgment expert in all experts.

Step 4: Calculate the entropy weight ${W_j}^o$. Substitute the information entropy value.

$${W_j}^o = \frac{1 - E_j}{\sum_{j=1}^{n} (1 - E_j)},\ j = 1, 2, \cdots\cdots, n \tag{12}$$

4.1.3. Weight Determination of Game Combination Weighting Method

Game theory is a discipline that studies strategic interaction. It involves the problem of decision-makers making strategies under the condition of the existence of opponents. The game combination weighting method in this paper combines the index weights obtained using the DEMATEL and entropy weight methods and realizes the balance between weights by solving the minimization difference between different weights of each index to determine the comprehensive weight [51]. The specific methods are as follows:

Step 1: Calculate the comprehensive weight. The subjective and objective weight values of the construction organization resilience evaluation indexes of urban rail transit projects are obtained using the DEMATEL and entropy weight methods, respectively. The comprehensive weight W of the two weights is:

$$W = \lambda_0 W_j^{\mathrm{s}} + \lambda_1 W_j^{o} \tag{13}$$

Among them W_j^{s} is the subjective weight determined using the DEMATEL method, W_j^{o} is the objective weight determined using the entropy weight method, the weight vector set is $W = \left\{W_j^{\mathrm{s}}, W_j^{o}\right\}^T$, λ_0 and λ_1 are the linear combination coefficients of the DEMATEL method and entropy weight method, respectively.

Step 2: Determine the combination weight coefficient. Using the game theory combination principle, the above weights are linearly combined. With the goal of minimizing the deviation, the linear combination coefficients λ_0 and λ_1 of the above equation are calculated to obtain reasonable weights. Therefore, the objective function is:

$$\min \|W - w\|^2 \tag{14}$$

Step 3: The linear equations are obtained. By differentiating (14), a linear system of equations for optimizing the first derivative is obtained:

$$\begin{pmatrix} w^{\mathrm{s}} w^{\mathrm{sT}} & w^{\mathrm{s}} w^{\mathrm{oT}} \\ w^{\mathrm{o}} w^{\mathrm{oT}} & w^{\mathrm{o}} w^{\mathrm{oT}} \end{pmatrix} \begin{bmatrix} \lambda_0 \\ \lambda_1 \end{bmatrix} = \begin{bmatrix} w^{s} w^{sT} \\ w^{o} w^{oT} \end{bmatrix} \tag{15}$$

Step 4: Determine the final comprehensive weight W. After the combination weight coefficient is obtained, the normalized processing is carried out, and the comprehensive weight under the game comprehensive weighting method is finally determined:

$$W = \overline{\lambda}_0 w^{sT} + \overline{\lambda}_1 w^{oT} \tag{16}$$

In the formula, $\overline{\lambda}_0 = \frac{\lambda_0}{\lambda_0 + \lambda_1}$; $\overline{\lambda}_1 = 1 - \overline{\lambda}_0$.

4.2. Cloud Matter-Element Evaluation Model

4.2.1. Determine the Matter Element to Be Evaluated

The evaluation index of construction organization resilience of urban rail transit projects is mainly a qualitative index. The nature of the qualitative index can only be described using natural language, and the specific and accurate index value cannot be obtained. This problem can be solved using a cloud matter element. The qualitative index can be transformed into a cloud matter element with normal distribution through the cloud model, and then the cloud membership degree between the qualitative index and the standard cloud can be determined using the calculation method of the membership degree between the cloud matter elements. In this paper, R is expressed as the matter element to be evaluated, N is the construction organization resilience of the evaluation object urban rail transit project, C is the feature of things, its index set is $C = \{C_1, C_2, \ldots, C_u\}$, and u is the number of indicators.

$$R_i = \begin{bmatrix} N & C_1 & V_1 \\ & C_2 & V_2 \\ & \vdots & \vdots \\ & C_u & V_u \end{bmatrix} \tag{17}$$

Among them, $(E_{x_{uj}}, E_{n_{uj}}, H_{e_{uj}})$ is the cloud description of the resilience evaluation index C_i about grade j.

4.2.2. Build Evaluation Standard Cloud

The relevant regulations such as the "Code for Construction Management of Underground Engineering of Urban Rail Transit", "Safety Evaluation Standard for Metro Construction", "Safety Inspection Standard for Construction of Subway Construction", and other relevant regulations, combined with the characteristics of resilience of the construction organization and the opinions of experts in the industry, the resilience level of construction organization of urban rail transit projects is divided into five grades. The interpretation of the resilience grade is shown in Table 1.

Table 1. Division and Interpretation of Resilience Grade.

Resilience Grade	Interpretation of Resilience Grade
V (Highest resilience)	The system has the highest anti-interference ability and the shortest recovery time.
IV (Higher resilience)	The system has high anti-interference ability and short recovery time.
III (Medium resilience)	The system has medium anti-interference ability and normal recovery time.
II (Lower resilience)	The system has a lower anti-interference ability and a longer recovery time.
I (Lowest resilience)	The system has the lowest anti-interference ability and the shortest recovery time.

In the cloud matter-element model, the cloud model reflects the fuzziness and randomness of things, and the definition of resilience evaluation grade is blurred. Each evaluation grade interval is transformed from a numerical value to a standard cloud to support more accurate and comprehensive evaluation results [52]. The resilience grade interval can be divided and determined according to the actual engineering situation. The calculation formula for cloud parameters is as follows:

$$E_x = \frac{C_{\min} + C_{\max}}{2} \tag{18}$$

$$E_n = \frac{C_{\max} - C_{\min}}{6} \tag{19}$$

$$H_e = \eta \tag{20}$$

Among them E_x is the expected value, which represents the point value of the concept of grade boundary corresponding to the resilience of construction organization. E_n is the entropy, which can be used to describe the randomness of index data and the fuzziness and randomness of the evaluation grade boundary in the process of construction organization resilience grade evaluation. H_e is the super entropy, which reflects the correlation between the degree of dispersion of the evaluation data of the resilience level of construction organization and the randomness and fuzziness in the evaluation. $C_{\max}, C_{\min}$ are the maximum and minimum boundaries of the evaluation grade value, respectively; η is a constant, which can be adjusted according to the ambiguity of the variable. In this paper, 0.3 is used.

4.2.3. Determine the Cloud Membership Degree

Step 1: Determine the membership degree of the secondary indexes; the formula is as follows:

$$y = \exp\left[\frac{-(-x - E_x)^2}{2(E_n')^2}\right] \tag{21}$$

The evaluation value of each secondary index is regarded as a cloud droplet, and the cloud membership degree between the actual evaluation value of each index and the standard normal cloud of the construction organization resilience evaluation grade can be calculated using Formula (21). When calculating the membership degree of cloud droplets and standard clouds, the generated random number is based on the fact that the super entropy H_e is randomly determined. The calculation results are uncertain and random, and it is necessary to solve the calculation many times to eliminate and reduce the randomness. Using the MATLAB R2021b version software to repeat the above steps n times (n takes 2000 times), and the average of all results is the final membership value. Finally, the comprehensive membership matrix K is obtained.

$$K = \begin{bmatrix} k_1(c_1) & k_2(c_1) & \cdots & k_m(c_1) \\ k_1(c_2) & k_2(c_2) & \cdots & k_m(c_2) \\ \vdots & \vdots & & \vdots \\ k_1(c_u) & k_2(c_u) & \cdots & k_m(c_u) \end{bmatrix} \tag{22}$$

In the formula, $k_m(c_u)$ is the cloud membership degree of resilience evaluation index c_i and resilience grade j.

Step 2: Determine the membership degree of primary indexes $K(b_i)$. The membership degree of primary indexes can be obtained by weighting the membership degree and the weight of the secondary indexes. The formula is as follows:

$$K(b_i) = (w_{c1}, w_{c2}, \cdots w_{cn}) \cdot K \tag{23}$$

In the formula, w_{cn} is the weight vector of the secondary index and K is the membership matrix of the secondary index. $b_i = b_1, b_2, b_3, b_4$ represent four first-level indicators of immunity, redundancy, efficiency, and fitness, respectively.

Step 3: Determine the membership degree $K(a_i)$ of the target layer. The membership degree of the target layer can be obtained by weighting the membership degree of the primary indices. The formula is as follows:

$$K(a_i) = (w_{b1}, w_{b2}, \cdots w_{b\rho}) \cdot K(b_i) \tag{24}$$

w_{bp} is the primary Index weight vector and $K(b_i)$ is the primary index membership matrix.

4.3. Determination of Resilience Evaluation Grade

Step 1: According to the principle of maximum membership degree, if the condition conforms to $K_j(N) = \max_{j=\{1,2\ldots,m\}} Kj(N)$, the construction organization resilience grade of the object N to be evaluated is grade j, j ={1, 2, 3, 4, 5}, and the corresponding scores are 1, 2, 3, 4, 5 respectively.

$$\overline{K}j(N) = \frac{K_j(N) - \min_j K_j(N)}{\max_j K_j(N) - \min_j K_j(N)} \tag{25}$$

$$j^* = \frac{\sum_{j=1}^{m} j \cdot \overline{K}_j(N)}{\sum_{j=1}^{m} \overline{K}_j(N)} \tag{26}$$

In the formula, j^* is the target layer, that is, the comprehensive score value of the construction organization resilience of the urban rail transit projects, that is, a certain degree of resilience.

Step 2: In order to avoid the failure of cloud membership between the index and the grade caused by the too-divergent cloud model and ensure the accuracy and credibility of the evaluation results, the credibility factor g is introduced to calculate the credibility of the evaluation results of the model. The calculation formula is as follows:

$$E_m = \sqrt{\frac{\sum_{i=1}^{n} (j_i^*(x) - E_{rx})^2}{n}} \tag{27}$$

$$E_{rx} = \frac{\sum_{i=1}^{n} j^*(x)}{n} \tag{28}$$

$$g = \frac{E_m}{E_{rx}} \tag{29}$$

In the formula, E_m is the entropy value of the comprehensive score of the target layer, E_{rx} is the expected value of the comprehensive score of the target layer, and $j_i^*(x)$ is the comprehensive score obtained by the second operation. The larger the credibility factor g, the more dispersed the resilience evaluation results, and the smaller the credibility. On the contrary, the smaller the dispersion degree of the resilience evaluation results, the higher the credibility. The cloud matter-element model usually considers that the results are credible when $g < 0.01$.

5. Case Study

As an important representative traffic of urban rail transit, the resilience level of subway construction is a key link in the development of urban rail transit projects. This paper takes the Nanchang area as an example. The first phase of the Nanchang Line 2 starts from the south station, through the Hong Gu Tan area, the central and western parts of the East Lake area, the northeastern part of the West Lake area, and the western part of the Qingshan Lake area, and ends at Xin Jia Ao station. The length of the line is about 23.3 km, all of which are underground lines. There are 21 stations, with an average station spacing of 1.11 km. In this paper, Nanchang West Station, in the first section of the first phase of Nanchang Line 2, is selected as an example of construction organization resilience evaluation of urban rail transit projects, and the cloud matter-element model is empirically analyzed.

Xi Qu Street in Hong Gutan District has a large population flow intensity and a relatively active economy. The surrounding terrain is flat, and the natural environment is good. In response to Jiangxi's urban traffic development planning power, choosing its location as Nanchang West Station will further strengthen Nanchang's transportation hub status. The station is composed of two floors on the ground, three floors underground, and elevated ring lanes. The viaduct has interchanges in four directions, southeast, northwest, and northwest, which realizes the connection between the railway station and municipal traffic.

5.1. Determination of Index Weight

The index weight is the importance of each index. In different situations, the same set of indicators will draw different weight coefficients, and different weight coefficients will lead to completely different or even opposite conclusions. Therefore, to obtain a scientific and appropriate weight of the resilience index of the project construction organization, this paper invited 12 relevant experts from the Nanchang West Station project in the first section of the first phase of Nanchang Line 2 to participate in scoring the resilience evaluation index. The subjective and objective weights are obtained by combining Formulas (1)–(12) of the DEMATEL method and the entropy weight method to avoid the uncertainty and inconsistency of the subjective weights. Then, Formulas (13)–(16) of the game theory

combination weighting method are used to obtain the combination weight, which ensures that the optimal distribution result is found between the subjective and objective index weights so that the weight assignment of the resilience index is more scientific, where $\overline{\lambda}_0 = 0.647$ and $\overline{\lambda}_1 = 0.353$ are calculated according to Formulas (15) and (16). The weight of its resilience evaluation indexes is shown in Table 2. Its secondary evaluation weight distribution is shown in Figure 4.

Table 2. Weight of resilience evaluation indexes.

Primary Indexes	Combination Weight	Secondary Indexes	Subjective Weights	Objective Weights	Combination Weight
B_1	0.4227	C_1	0.0170	0.0195	0.0179
		C_2	0.0230	0.0242	0.0234
		C_3	0.0610	0.1122	0.0791
		C_4	0.0410	0.0431	0.0417
		C_5	0.0230	0.0199	0.0219
		C_6	0.0230	0.0298	0.0254
		C_7	0.0380	0.0357	0.0372
		C_8	0.0220	0.0452	0.0302
		C_9	0.0450	0.0431	0.0443
		C_{10}	0.0310	0.0472	0.0367
		C_{11}	0.0290	0.0472	0.0354
		C_{12}	0.0350	0.0194	0.0295
B_2	0..2236	C_{13}	0.0290	0.0149	0.0240
		C_{14}	0.0380	0.0334	0.0364
		C_{15}	0.0580	0.0853	0.0676
		C_{16}	0.0410	0.0202	0.0337
		C_{17}	0.0380	0.0214	0.0321
		C_{18}	0.0370	0.0167	0.0298
B_3	0.2091	C_{19}	0.0290	0.0157	0.0243
		C_{20}	0.0340	0.0197	0.0290
		C_{21}	0.040	0.0223	0.0338
		C_{22}	0.0440	0.0147	0.0337
		C_{23}	0.0290	0.0298	0.0293
		C_{24}	0.0640	0.0498	0.0590
B_4	0.1441	C_{25}	0.0160	0.0429	0.0255
		C_{26}	0.0340	0.0326	0.0335
		C_{27}	0.0330	0.0298	0.0319
		C_{28}	0.0470	0.0645	0.0532

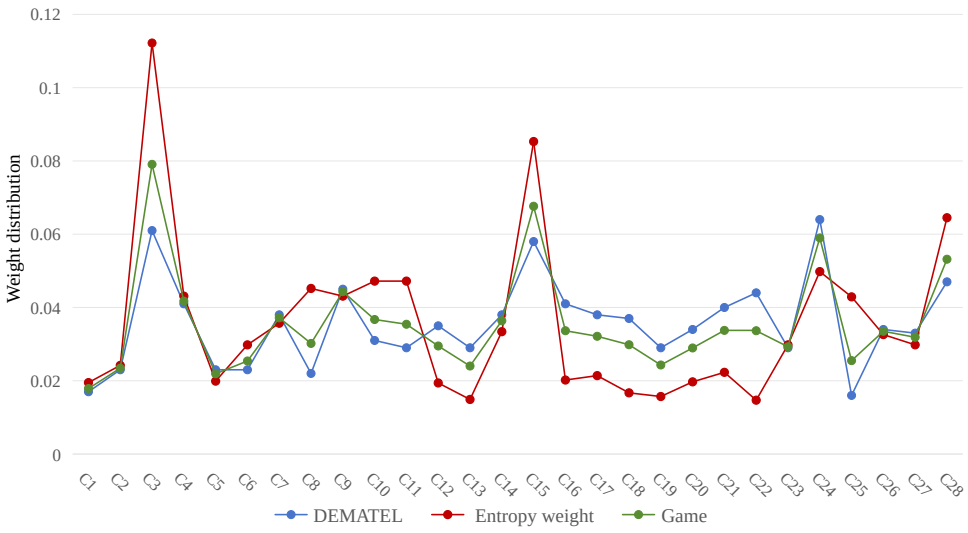


Figure 4. Weight distribution of the resilience indexes.

5.2. Resilience Grade Threshold Determination

By summarizing the existing relevant literature research and consulting authoritative experts, the paper divides the resilience level threshold of the construction organization resilience evaluation indexes of urban rail transit projects and forms the constraint boundary. The corresponding resilience grade threshold is shown in Table 3.

Table 3. Resilience grade threshold.

Indexes	Grade V	Grade IV	Grade III	Grade II	Grade I
C_1	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_2	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_3	(100,90]	(90,80]	(80,60]	(60,30]	(30,0)
C_4	(100,90]	(90,80]	(80,60]	(60,30]	(30,0)
C_5	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_6	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_7	(100,90]	(90,80]	(80,60]	(60,30]	(30,0)
C_8	(100,90]	(90,80]	(80,60]	(60,30]	(30,0)
C_9	(100,90]	(90,80]	(80,60]	(60,30]	(30,0)
C_{10}	(100,90]	(90,80]	(80,60]	(60,30]	(30,0)
C_{11}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{12}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{13}	(100,90]	(90,80]	(80,60]	(60,30]	(30,0)
C_{14}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{15}	(100,90]	(90,80]	(80,60]	(60,30]	(30,0)
C_{16}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{17}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{18}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{19}	(100,90]	(90,80]	(80,60]	(60,30]	(30,0)
C_{20}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{21}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{22}	(100,90]	(90,80]	(80,60]	(60,30]	(30,0)
C_{23}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{24}	(100,90]	(90,80]	(80,60]	(60,30]	(30,0)
C_{25}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{26}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{27}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)
C_{28}	(100,85]	(85,75]	(75,60]	(60,30]	(30,0)

5.3. Evaluation of Cloud Matter-Element Model

5.3.1. Determine the Matter Element to Be Evaluated

In order to analyze the construction organization resilience level of Nanchang station in the first section of the first phase of Nanchang Metro Line 2, a total of 12 relevant experts and staff members of the projects were invited to score the construction organization resilience evaluation indexes of the constructed urban rail transit projects, including four experts in the safety management of urban rail transit, four workers and technicians of the construction unit in this project, two senior managers of the construction unit in this project, and two academic researchers in the urban rail transit industry. The scores of the evaluation indexes of 12 experts were summarized, and the average value was taken as the score value of the construction organization resilience evaluation indexes of Nanchang West Station in the first phase of Nanchang Metro Line 2. The following is its matter element to be evaluated.

$$R_1 = \begin{bmatrix} N & C_1 & 87.17 \\ & C_2 & 81.25 \\ & C_3 & 90.92 \\ & C_4 & 91.00 \\ & C_5 & 88.50 \\ & C_6 & 80.92 \\ & C_7 & 89.42 \\ & C_8 & 87.50 \\ & C_9 & 85.33 \\ & C_{10} & 88.83 \\ & C_{11} & 74.33 \\ & C_{12} & 79.33 \end{bmatrix}; R_2 = \begin{bmatrix} N & C_{13} & 78.00 \\ & C_{14} & 81.08 \\ & C_{15} & 87.25 \\ & C_{16} & 85.92 \\ & C_{17} & 83.83 \\ & C_{18} & 79.00 \end{bmatrix}; R_3 = \begin{bmatrix} N & C_{19} & 86.42 \\ & C_{20} & 77.33 \\ & C_{21} & 79.67 \\ & C_{22} & 74.25 \\ & C_{23} & 73.92 \\ & C_{24} & 87.92 \end{bmatrix}; R_3 = \begin{bmatrix} N & C_{25} & 87.50 \\ & C_{26} & 74.75 \\ & C_{27} & 78.08 \\ & C_{28} & 83.08 \end{bmatrix}$$

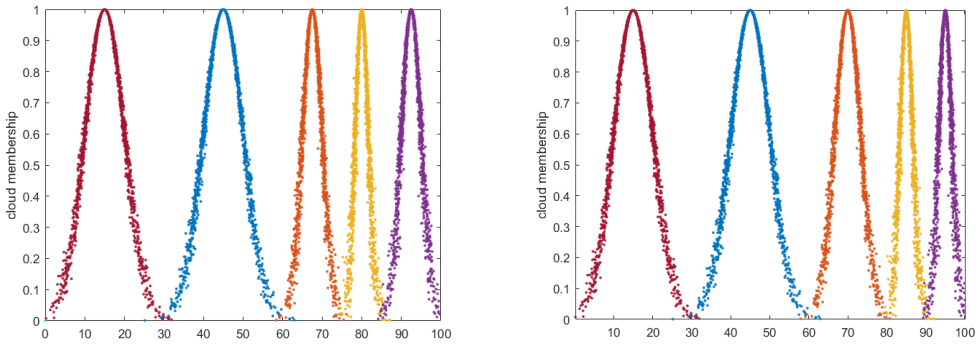
5.3.2. Building a Cloud of Evaluation Standards

According to the determination of the resilience grade threshold of urban rail transit projects in Table 3, Formulas (18)–(20) are used to cloud model the corresponding grade threshold of each resilience index, and three characteristic values (E_x, E_n, H_e) of each evaluation index under each evaluation grade can be obtained. Then, the standard cloud model of the resilience evaluation index of urban rail transit projects construction organization is obtained, that is, the grade cloud matter element in the resilience evaluation index of urban rail transit projects construction organization (as shown in Table 4).

Table 4. Cloud matter element of the resilience evaluation indexes grade.

Indexes	Grade V	Grade IV	Grade III	Grade II	Grade I
C_1	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_2	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_3	(95,1.67,0.3)	(85,1.67,0.3)	(70,3.33,0.3)	(45,5,0.3)	(15,5,0.3)
C_4	(95,1.67,0.3)	(85,1.67,0.3)	(70,3.33,0.3)	(45,5,0.3)	(15,5,0.3)
C_5	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_6	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_7	(95,1.67,0.3)	(85,1.67,0.3)	(70,3.33,0.3)	(45,5,0.3)	(15,5,0.3)
C_8	(95,1.67,0.3)	(85,1.67,0.3)	(70,3.33,0.3)	(45,5,0.3)	(15,5,0.3)
C_9	(95,1.67,0.3)	(85,1.67,0.3)	(70,3.33,0.3)	(45,5,0.3)	(15,5,0.3)
C_{10}	(95,1.67,0.3)	(85,1.67,0.3)	(70,3.33,0.3)	(45,5,0.3)	(15,5,0.3)
C_{11}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{12}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{13}	(95,1.67,0.3)	(85,1.67,0.3)	(70,3.33,0.3)	(45,5,0.3)	(15,5,0.3)
C_{14}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{15}	(95,1.67,0.3)	(85,1.67,0.3)	(70,3.33,0.3)	(45,5,0.3)	(15,5,0.3)
C_{16}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{17}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{18}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{19}	(95,1.67,0.3)	(85,1.67,0.3)	(70,3.33,0.3)	(45,5,0.3)	(15,5,0.3)
C_{20}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{21}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{22}	(95,1.67,0.3)	(85,1.67,0.3)	(70,3.33,0.3)	(45,5,0.3)	(15,5,0.3)
C_{23}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{24}	(95,1.67,0.3)	(85,1.67,0.3)	(70,3.33,0.3)	(45,5,0.3)	(15,5,0.3)
C_{25}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{26}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{27}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)
C_{28}	(92.5,2.5,0.3)	(80,1.67,0.3)	(67.5,2.5,0.3)	(45,5,0.3)	(15,5,0.3)

Using MATLAB standard cloud code, the five grade descriptions of construction organization resilience of urban rail transit projects are transformed into a grade standard cloud chart. Therefore, the standard cloud chart corresponding to each resilience index can be obtained. Taking C_2 and C_3 as examples, the standard cloud chart is shown in Figure 5.



(**a**) (**b**)

Figure 5. Grade cloud chart. (**a**) Index C1 resilience grade cloud chart; (**b**) index C2 resilience grade cloud chart.

5.3.3. Determine the Cloud Membership Degree

(1) Determination of membership degree of secondary resilience evaluation indexes

According to the calculation formula of cloud membership degree (21)–(22) and the standard cloud model of the index, the membership degree of resilience evaluation indexes are calculated using the MATLAB R2021b version software. In order to eliminate the fuzziness, randomness, and unreliability of the cloud matter-element model, the calculation number $n = 2000$ is taken. The calculation results of the membership degree of the secondary resilience evaluation indexes are shown in Table 5, where the membership degree less than 0.001 is simplified to 0. According to the principle of maximum membership degree, the secondary resilience evaluation index is determined, as shown in Figure 6.

Table 5. Calculation of membership degree of secondary resilience evaluation indexes.

Indexes	Score	Weight	Grade V	Grade IV	Grade III	Grade II	Grade I
C_1	87.17	0.0179	0.1085	0.0008	0.0000	0.0000	0.0000
C_2	81.25	0.0234	0.0002	0.7353	0.0000	0.0000	0.0000
C_3	90.92	0.0791	0.0633	0.0054	0.0000	0.0000	0.0000
C_4	91.00	0.0417	0.0703	0.0050	0.0000	0.0000	0.0000
C_5	88.50	0.0219	0.2789	0.0001	0.0000	0.0000	0.0000
C_6	80.92	0.0254	0.0001	0.8464	0.0000	0.0000	0.0000
C_7	89.42	0.0372	0.0090	0.0408	0.0000	0.0000	0.0000
C_8	87.50	0.0302	0.0005	0.3265	0.0000	0.0000	0.0000
C_9	85.33	0.0443	0.0000	0.9783	0.0001	0.0000	0.0000
C_{10}	88.83	0.0367	0.0037	0.0883	0.0000	0.0000	0.0000
C_{11}	74.33	0.0354	0.0000	0.0081	0.0298	0.0000	0.0000
C_{12}	79.33	0.0295	0.0000	0.9160	0.0001	0.0000	0.0000
C_{13}	78.00	0.0240	0.0000	0.0011	0.0592	0.0000	0.0000
C_{14}	81.08	0.0364	0.0002	0.7967	0.0000	0.0000	0.0000
C_{15}	87.25	0.0676	0.0003	0.3866	0.0000	0.0000	0.0000
C_{16}	85.92	0.0337	0.0374	0.0054	0.0000	0.0000	0.0000
C_{17}	83.83	0.0321	0.0046	0.0859	0.0000	0.0000	0.0000
C_{18}	79.00	0.0298	0.0000	0.8229	0.0001	0.0000	0.0000
C_{19}	86.42	0.0243	0.0001	0.6752	0.0000	0.0000	0.0000
C_{20}	77.33	0.0290	0.0000	0.2796	0.0011	0.0000	0.0000
C_{21}	79.67	0.0338	0.0000	0.9783	0.0001	0.0000	0.0000
C_{22}	74.25	0.0337	0.0000	0.0000	0.4410	0.0000	0.0000
C_{23}	73.92	0.0293	0.0000	0.0048	0.0441	0.0000	0.0000
C_{24}	87.92	0.0590	0.0010	0.2171	0.0000	0.0000	0.0000
C_{25}	87.50	0.0255	0.0191	0.0005	0.0000	0.0000	0.0000
C_{26}	74.75	0.0335	0.0000	0.0139	0.0198	0.0000	0.0000
C_{27}	78.08	0.0319	0.0000	0.4997	0.0004	0.0000	0.0000
C_{28}	83.08	0.0532	0.0018	0.1902	0.000	0.0000	0.0000

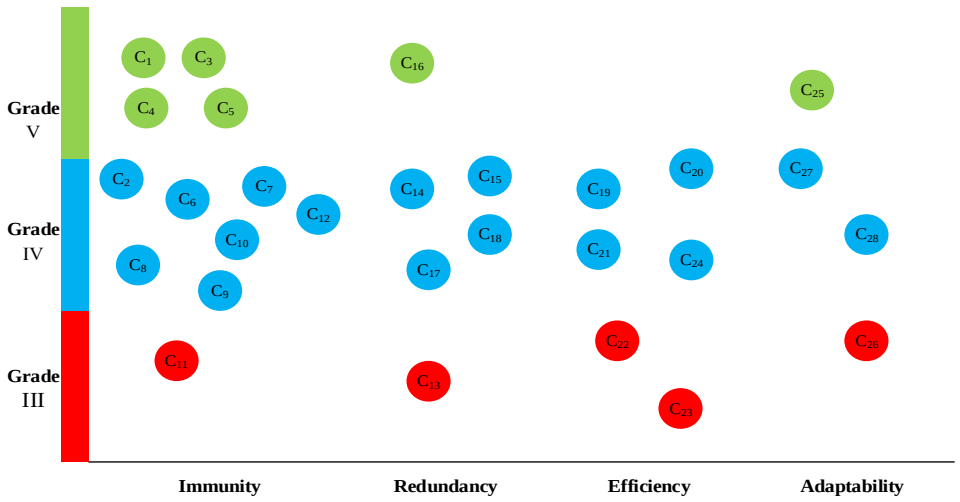


Figure 6. Secondary resilience evaluation index grade.

(2) Determination of the membership degree of the primary resilience evaluation indexes and the membership degree of the target layer

According to the calculation formula of cloud membership degree (23)–(26), the membership degree of the primary resilience evaluation indexes and the membership degree of the target layer are calculated using the MATLAB R2021b version software. The final calculation results are shown in Tables 6 and 7, respectively.

Table 6. Calculation of membership degree of the primary resilience evaluation index.

Indexes	Weight	Grade V	Grade IV	Grade III	Grade II	Grade I	Grade
B_1	0.4227	0.0165	0.1246	0.0011	0.0000	0.0000	IV
B_2	0.2236	0.0014	0.0826	0.0014	0.0000	0.0000	IV
B_3	0.2091	0.0001	0.0705	0.0162	0.0000	0.0000	IV
B_4	0.1441	0.0006	0.0265	0.0007	0.0000	0.0000	IV

Table 7. Calculation of membership degree of the target layer.

Target Layer	Grade V	Grade IV	Grade III	Grade II	Grade I	Grade	Level
A	0.0074	0.0897	0.0042	0.0000	0.0000	IV	Higher

5.3.4. Determine Evaluation Grade

According to the principle of maximum membership degree, the evaluation grade of the construction organization resilience of Nanchang West Station in the first section of the first phase of Nanchang Metro Line 2 is determined to be grade IV (higher resilience) using Formula (25). According to Formula (26), it is finally found that the comprehensive score value j^* of the construction organization resilience of Nanchang West Station is 4.0305. The forward cloud generator is used to generate a comprehensive cloud chart. As shown in Figure 7, the cloud droplets of the model are between grade IV and grade V, which is basically biased towards grade IV. This shows that the evaluation results of the construction organization resilience of the Nanchang West Railway Station project are consistent with the cloud droplet results generated by the model.

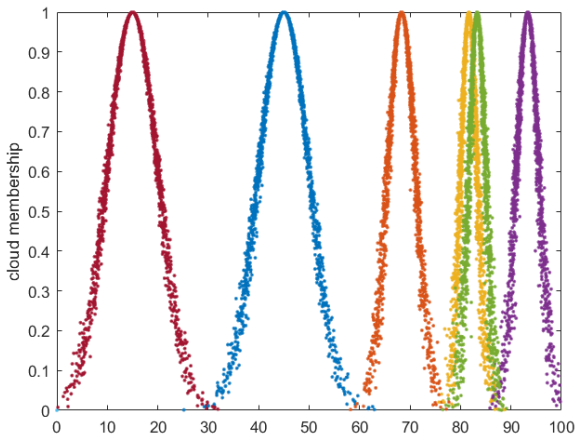


Figure 7. Comprehensive resilience grade evaluation cloud chart.

5.4. Result and Discussion

5.4.1. Evaluation Result

Through the cloud matter-element analysis of the resilience of the construction organization of the Nanchang West Station project in the first section of the first phase of

Nanchang Metro Line 2, the final evaluation results show that the resilience grade of the construction organization of the project is IV (higher resilience), See Table 8.

Table 8. Evaluation results of construction organization resilience of urban rail transit project.

Project	Membership	Grade	Credibility	Moderate Risk Index
A	0.0897	IV	0.0055	C_{11}, C_{13}, C_{22}, C_{23}, C_{26}

According to Formulas (27)–(29), $E_m = 0.0224$, $E_{rx} = 4.0305$, $g = 0.0055 < 0.01$ is calculated using the MATLAB R2021b version software, which shows that the evaluation results are highly reliable and the results are credible. In addition, through consulting the relevant personnel of the project, it is learned that there has never been a major accident in the project. It can be seen that the resilience level of the project is consistent with the actual assessment, which verifies the accuracy and effectiveness of the evaluation model.

In the urban rail transit projects construction organization resilience, the index resilience grade of grade V is a good index, the grade of grade IV is an index to be improved, the grade of grade III is a moderate risk index, the grade of grade II is a risk index, and the grade of grade I is a high-risk index. It can be seen from Table 8 that there are no risk and high-risk indexes in the Nanchang West Station project in the first section of the first phase of Nanchang Metro Line 2. The moderate risk index in the second-level index belongs to grade III being the survey of the natural environment (C_{11}), the preparation of a construction emergency plan (C_{22}), organization personnel emergency deployment ability (C_{13}), information technology system recovery performance (C_{23}), and intelligent application level of construction machinery and equipment (C_{26}). Focusing on strengthening rectification and reform is necessary, and relevant measures should be taken immediately to improve its resilience level.

5.4.2. Discussion

As an important part of China's transportation network construction, improving urban rail transit construction will play a vital role in enhancing China's transportation capacity. Due to the characteristics of many safety risks and strong risk coupling in the project construction process, the consequences of construction accidents are unimaginable. The safety construction of urban rail transit is mainly based on the static control mode of risk prevention. Although the prevention mode can take preventive measures against specific risks, it still cannot maintain the dynamic stability of the safety state of the construction organization. In order to deal with these challenges, this study integrates resilience theory into the safety management of construction organization of urban rail transit projects. It constructs a resilience evaluation model based on game theory combination weighting–cloud matter-element, aiming to understand the dynamic stability of urban rail transit projects in construction organization.

The resilience of urban rail transit project construction organization is manifested in the ability to cope with risks when disturbed by sudden risks, and the resilience characteristic elements in the process of ability are immunity, redundancy, efficiency, and adaptability. Therefore, the strengthening of resilience can be studied from the aspects of characteristic elements. In the case of the Nanchang West Railway Station project, it is found from the combined weight value that the influence of the four first-level indicators on the construction organization resilience of the urban rail transit project is in the order of immunity B_1, redundancy B_2, efficiency B_3, and adaptability B_4. For urban rail transit projects, the immunity of construction organization resilience is the key to ensuring the project's sustainable development. Personnel safety is the basis of the project construction organization. Therefore, construction of emergency evacuation measures must be considered in the construction organization stage. This includes the rational design of evacuation routes and the number and location of exits based on the number of personnel according to national safety regulations and standards. At the same time, clear emergency evacuation guidelines and an effective communication system

are established to guide the safe evacuation of personnel in emergency situations. In addition, considering the failure of long-distance trains, passengers are informed in a timely manner and guided to evacuate safely through an integrated emergency response system. By implementing these measures, we can ensure that the objectives of the construction organization stage can be achieved to lay a solid foundation for the later operation efficiency of the project. Secondly, it strengthens the redundancy and efficiency management of the resilience of the project construction organization, improves the construction emergency plan, and stores and retains the reserve resources. Taking the high precipitation in Nanchang as an example, flood control is the key. During the construction of the subway station, a two-story design was selected to ensure that the subway station was higher than the highest flood level in history. A waterproof wall is added at the entrance of the basement, and a pumping station is installed in the station for rapid drainage. Sandbags, sufficient emergency lamps, and firefighting equipment are prepared to protect the flood control of the construction organization site and deal with possible sudden flood events. This can enhance the response and recovery ability of the project construction. Finally, it focuses on strengthening the adaptability management of project construction organization resilience. Based on the management of redundancy and efficiency, through the study of previous experience, the project construction organization resilience is continuously optimized and improved to improve the risk adaptation learning ability of the project. For instance, when shutting down the power to the subway's contact network in the event of an emergency risk to ensure fire safety, drawing from experience in similar emergency situations, and assessing the safety of the surrounding area, the status of the contact network power cut, the inspection and maintenance of fire-fighting equipment, the status of reserved backup power supplies, and the communication with emergency service agencies, optimization and improvements in redundancy and efficiency can be conducted to enhance the project's ability to adapt to risks within the construction organization.

In this paper, the DEMATEL method and entropy weight method are used to calculate the subjective and objective weights, respectively, and the game theory is introduced to combine them. This can avoid the uncertainty and inconsistency of the subjective weight, eliminate the excessive objectivity of the objective weight, and give full play to the advantages of the two. Through complementary advantages, the rationality of index weight can be improved to a certain extent.

The matter-element theory is combined with the cloud model theory to establish a game theory combination weighting-cloud matter-element resilience evaluation model. Its level is evaluated by quantifying the resilience of the urban rail transit project construction organization stage. The quantitative method not only solves the boundary fuzziness and randomness of the index but also measures and controls the uncertainty, which increases the rationality of the evaluation process. The Nanchang West Station Project of Nanchang Metro Line 2 is used to verify the resilience evaluation model, and it is concluded that the overall construction organization resilience level of the project is higher resilience. The results are consistent with the field assessment results, indicating that the resilience evaluation model has a certain feasibility.

In order to strengthen the construction organization resilience level of the Nanchang West Station Project of Nanchang Metro Line 2, based on the evaluation results of the resilience index, the moderate risk indexes survey of the natural environment (C_{11}), The preparation of the construction emergency plan (C_{22}), organization personnel emergency deployment ability (C_{13}), information technology system recovery performance (C_{23}), and intelligent application level of construction machinery and equipment (C_{26}) of the project are obtained. Therefore, in this project, it is necessary to focus on the influence of the hydrogeological environment, such as underground rock, soil, and stratum structure, on the construction of underground pipelines and stations in rail transit construction. It is necessary to pay attention to the formulation of a sound emergency plan, clarify the emergency organization, rationally allocate human resources, prepare the emergency disposal process, not ignore the training of personnel emergency deployment skills, and regularly investigate the potential safety hazards. In addition, redundant servers, storage

devices, and network devices, as well as real-time data synchronization and fault-switching technology, can be used to ensure that the system can quickly switch to standby devices when a single point of failure occurs, ensuring the continuity of the system. Reasonable use of firewalls, intrusion detection systems, security audit tools, and other technical means can detect and respond to potential security threats in a timely manner and control the stability and reliability of the project as a whole. At the same time, advanced construction management software and technologies, such as BIM (Revit2019), virtual reality, artificial intelligence, etc., are used to realize real-time data collection, processing, and sharing in the process of construction organization and further refine the whole process of construction organization. Monitoring and effective risk control. Other similar projects can learn from the above measures; combined with their own actual situation, they can adopt targeted measures to improve the resilience of the construction organization stage and the anti-interference ability and defense ability of the project construction organization.

6. Conclusions

(1) In traditional project construction organization safety management, there is more to staying at the static level. In this paper, the resilience theory is introduced into the construction organization of urban rail transit projects to realize the dynamic safety management of the whole process. The application of resilience can further improve the dynamic anti-interference ability of urban rail transit projects in the process of construction organization, and enhance the redundancy and stability of its construction organization. Evaluating the construction safety of urban rail transit projects has certain innovations and references.

(2) Based on the characteristics of resilience, such as immunity, redundancy, efficiency, and adaptability, considering that the resilience of construction organization is affected by four aspects: organization personnel, material, environment, and information, this paper uses the literature frequency statistics method to determine the resilience evaluation index system of urban rail transit construction organization. In the index weight, game theory is used to optimize the subjective weight of the DEMATEL method and the objective weight of the entropy weight method to obtain the optimal allocation result, which overcomes the limitations of the single method.

(3) In order to solve the problem of fuzziness and uncertainty of evaluation indexes, this study selects matter-element theory and cloud model theory to establish a game theory combination weighting-cloud matter-element resilience evaluation model. The construction organization resilience of the Nanchang West Station Project of Nanchang Metro Line 2 is evaluated by determining the matter element to be evaluated, drawing a standard cloud map, and calculating the cloud membership degree. The final evaluation results show that the construction organization resilience grade of the Nanchang West Station Project of Nanchang Metro Line 2 is grade IV (higher resilience). After consulting and investigating, it is concluded that the resilience level of the construction organization of the project is consistent with the actual assessment situation, which further verifies the accuracy and effectiveness of the evaluation model. The application of this method has a certain reference for the construction organization resilience evaluation of other similar projects to a certain extent, and it is helpful to promote the sustainable development of urban rail transit construction.

(4) The resilience grade of each level index is obtained based on the evaluation results. As far as this empirical project is concerned, in the process of construction organization, managers should focus on strengthening the management of immunity, redundancy, efficiency, and adaptability. Specifically, in the process of project construction organization, comprehensive risk assessment can be carried out according to different disaster scenarios, and corresponding emergency plans and disaster management strategies can be formulated. At the same time, equipment and systems with high reliability and strong anti-interference ability are selected to improve the immunity and resilience of the project construction organization. The introduction of redundant equipment and systems in the project construction organization and the reserve of sufficient human resources are essential to improving the re-

silience of the project construction organization. As the response efficiency of risk response, the project can adopt advanced technologies and tools in the process of the construction organization, such as the internet of things, artificial intelligence, and big data analysis, to improve the operation and maintenance efficiency and fault early warning ability; adaptability has better resistance and post-learning ability. Managers should regularly carry out disaster drills and simulated emergency training and establish a sound monitoring mechanism. Each disaster or accident event should be evaluated and improved afterward to continuously improve disaster resistance and management levels.

(5) From the ranking of the combined weight results, the construction plan preparation, the improvement of the emergency management system, the communication and coordination of the unit department, and the intelligent level of construction risk monitoring and early warning have the most significant impact on the resilience of the construction organization of the Nanchang West Railway Station project. The determination of key indicators can help managers provide decision-making reference directions. In particular, attention should be paid to the preparation of the construction plan with the highest weight value, which is a key document for transforming the design plan into an implementable construction plan. Before the preparation of the construction plan, it is necessary to understand the characteristics of the project, constraints, risk factors, etc. At the same time, it is necessary to cooperate with a number of relevant departments and units, as well as to combine the current advanced technologies and methods to continuously innovate and optimize the construction plan.

In this study, the resilience theory is introduced into the field of construction organization safety of urban rail transit projects to realize the dynamic safety management of the whole process. At the same time, the game theory combination weighting-cloud matter-element model is used to form a unified quantitative method system to concretize resilience. The construction organization resilience evaluation system process can be applied to other similar projects. According to the actual situation of other similar projects, the application scope of the theory and method is expanded, which provides key theory and method tools for project safety managers and is of great significance to help urban design and build a more resilient urban rail transit system.

At the same time, due to the comprehensive influence of emerging fields and frontiers and their interdisciplinary nature, this study has certain limitations on the selection of evaluation indexes for construction organization resilience in urban rail transit projects. In order to solve this problem, future research can improve the accuracy of indexes through multi-domain expert consultation, in-depth research, case analysis, and regular revision of evaluation indexes. At the same time, the game comprehensive weighting method involves the weighting of the additive form to determine the comprehensive weight of the evaluation index. Usually, the additive weighting is considered that the index is independent of each other, and its importance is not affected by other factors. However, in the actual situation, the relationship between the evaluation indexes may be more complicated and dependent, but this method cannot capture this complexity and dependence. Therefore, the stability and reliability of this method need to be further explored to a certain extent. In addition, the paper evaluates the resilience of the whole construction organization of urban rail transit projects and does not evaluate a specific construction organization stage. Future research can start from the different construction organization stages of the station's foundation pit excavation construction organization stage, entrance and exit construction organization stage, channel construction organization stage, etc. The corresponding evaluation index system is constructed, and then the construction organization resilience evaluation of different construction organization stages is carried out. The resilience evaluation results of each stage are integrated to obtain the total resilience evaluation level, which further improves the accuracy and operability of the resilience evaluation.

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