Study on schedule risk assessment of power transmission and transformation project based on improved risk chain

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Abstract. The development and management of power transmission and transformation project schedule is highly subjective, and the delay of construction period will bring risks and losses to all parties. With China's power construction entering the period of structural adjustment and transformation, it has become a new trend of power development to adopt scientific project management methods to improve the risk management level of power transmission and transformation projects. This paper first identifies the schedule risk of power transmission and transformation projects, analyzes the correlation between schedule risks based on the risk chain theory, establishes the schedule risk evaluation model based on the improved risk chain, and makes an empirical analysis on the schedule risk assessment of a power transmission and transformation project, which has a good effect on quantifying the schedule risk of power transmission and transformation project.

1. Introduction
Since the 13th five year plan, China's power demand has been further improved, and the field of power investment has been further developed. However, the traditional management methods and modes of power transmission and transformation projects can not fully adapt to the current production mode. In addition, there are some problems in the construction of power transmission and transformation projects, such as complex construction, difficult communication and coordination among multiple departments, and low efficiency of engineering projects. It has become an important topic for the development of power industry to use modern project management thinking and methods to improve the management level of power transmission and transformation construction.

Power transmission and transformation projects are often completed according to long-term experience when making progress plans, there are many subjective factors [1], and there will be uncertainty in the schedule management, which makes the transmission and transformation project from the design to the completion of each stage of great risk. Construction delay will not only bring risks or losses to the owner and the construction party, but also lead to the failure of the whole project [2]. Therefore, it is of great significance for the risk control and management of power transmission and transformation projects to reasonably select and scientifically use the existing technical methods to establish the schedule risk evaluation index system and carry out the progress risk assessment.

In order to ensure the smooth implementation of the power transmission and transformation project, it is necessary to carry out efficient schedule control. It is necessary to comprehensively evaluate and
analyze various risk factors affecting the progress in the early stage and process of the project implementation, put forward preventive measures pertinently, and actively control and properly remedy in the implementation process, so as to effectively control the schedule risk Objective [3]. In the process of actual project schedule control, there will always be various risks affecting the progress, such as natural, policy, capital, technology, social and other risks. The impact of these risks on the power transmission and transformation project at different stages is not the same, but will directly or indirectly affect the project progress [4]. These risk factors are related to each other, and the risk factors and the construction period are also related to each other, so that the impact of these risk factors on the progress is not only related to the nature of the risk itself, but also to the logical relationship between various processes.

According to the concept of risk chain, this paper finds out the relationship between schedule risks, considers the impact of schedule risk on the logical relationship of construction process, improves the schedule risk assessment model with risk chain as the evaluation object, and combines with simulation technology to achieve the purpose of minimizing the schedule risk in the implementation process of power transmission and transformation project.

2. Progress risk evaluation index system of power transmission and transformation project

2.1. Identification of schedule risk factors of power transmission and transformation project

According to many progress risk factors summarized in the analysis of historical documents, the brainstorming method is adopted to further screen and sort out the actual situation of power transmission and transformation projects. In this paper, the five dimensions of planning and construction, personnel factors, organization and management, market finance and environmental factors are subdivided. Each category is divided into several specific schedule risk influencing factors. Finally, a list of influencing factors for schedule risk of power transmission and transformation projects is listed, as shown in Table 1.

| Name | Risk type | Risk factor |
|------|-----------|-------------|
|      | Planning and construction | Demolition delay | Delay in approval |
|      |            | Quality defects and rework | Equipment procurement delay |
|      |            | Construction design change | Poor Inter Organizational Communication |
|      | Personnel factors | The level of labor force is limited | Labor shortage |
|      | Schedule risk of power transmission and transformation project | Lack of management experience | Delay of commissioning personnel in place |
|      | Organization and management | Inadequate security | Equipment commissioning delay |
|      |            | Immature key technologies | Improper construction method |
|      | Market finance | Initial funds not in place | Delay in payment by contractor |
|      | Environmental factors | Material price fluctuation | Collapse accident |
|      |            | Bad weather |
Based on the questionnaire provided to the expert group, the influencing factors and risk probability of power transmission and transformation project progress are evaluated according to the preset evaluation standards. The evaluation score standard is divided into five levels, namely 0, 1, 2, 3, and 4, respectively. Table 2 shows the risk assessment standard.

Table 2. Schedule risk assessment criteria

| Evaluation value | Evaluation type | Probability of risk occurrence |
|------------------|-----------------|--------------------------------|
| 0                | No delay.       | It doesn’t happen              |
| 1                | The impact is small. (<10%) | Rarely                        |
| 2                | The impact is relatively small. (10%-20%) | Less                          |
| 3                | The impact is relatively great. (20%-50%) | It is easy to happen          |
| 4                | The impact is great. (>50%) | Very easy to happen            |

In order to further verify the relative effectiveness of each schedule risk factor, this study used CITC value and Cronbach coefficient $\alpha$ method to analyze the reliability of the questionnaire data.

$$\alpha = \frac{x}{x-1} \left(1 - \frac{1}{\frac{\sum_{i=1}^{2} s_i^2}{s_x^2}}\right)$$

Among them, $\alpha$ is the reliability coefficient; $x$ is the item number of test items; $s_i^2$ is the variance of each subject's score; $s_x^2$ is the variance of the total score of all subjects.

Through the use of statistical software SPSS 18.0, statistical analysis and reliability measurement of the questionnaire results received. According to the questionnaire evaluation standard table 2, the risk progress factors are divided into five levels, the score is 0, 1, 2, 3, 4, 5. The reliability analysis results can be obtained by SPSS 18.0, as shown in Table 3.

Table 3. Reliability statistical table

| N   | %   | Cronbach’s alpha | Standardization term coefficient | Number of items |
|-----|-----|-------------------|----------------------------------|-----------------|
| 213 | 100 | 0.921             | 0.911                            | 20              |

In this paper, the average value and reliability analysis results of each risk factor of SPSS 18.0 are used to further subdivide the four factors of material price fluctuation, improper construction method and design change, and the reliability analysis after index correction is obtained.

In order to further analyze the influencing factors, this paper mainly uses the principal component analysis method to extract the factors, and uses the software SPSS 18.0 to realize. Before using the principal component analysis method, Bartlett's test of sphericity and KMO statistics should be calculated to test whether the indicators can adopt principal component analysis [5]. KMO statistics is usually used to compare the observed correlation coefficient value and the partial phase relationship value. Generally speaking, when the KMO value is small, it indicates that the variable index studied may not be suitable for calculation and evaluation by principal component analysis. The empirical values of KMO are listed in Table 4 for reference to the test results of indicators.

Table 4. Empirical value of KMO value

| KMO value | Meaning of results | KMO value | Meaning of results |
|-----------|--------------------|-----------|--------------------|
| 0.9 ≤ k < 1 | Excellent          | 0.6 ≤ k < 0.7 | secondary         |
| 0.8 ≤ k < 0.9 | Better            | 0.5 ≤ k < 0.6 | too bad           |
| 0.7 ≤ k < 0.8 | not so bad        | k < 0.5   | unacceptable       |
Then the principal component analysis method is used to further factor analysis on the test results, and the results of principal component analysis are shown in Table 5.

Table 5. Principal component analysis

| Component | Initial Component Characteristic Value | Explain Variance (%) | Cumulative Variance (%) | Characteristic Value | Explain Variance (%) | Cumulative Variance (%) |
|-----------|----------------------------------------|-----------------------|-------------------------|----------------------|-----------------------|-------------------------|
| 1         | 9.313                                  | 43.231                | 43.231                  | 9.313                | 43.231                | 43.231                  |
| 2         | 1.912                                  | 11.213                | 54.444                  | 1.912                | 11.213                | 54.444                  |
| 3         | 1.724                                  | 5.012                 | 59.456                  | 1.724                | 5.012                 | 59.456                  |
| 4         | 1.345                                  | 3.162                 | 62.618                  | 1.345                | 3.162                 | 62.618                  |
| 5         | 1.077                                  | 3.012                 | 65.631                  | 1.077                | 3.012                 | 65.631                  |

2.2. Construction of schedule risk evaluation index system for power transmission and transformation projects

The related technology involved in the construction of power transmission and transformation project is very complex, so the power transmission and transformation project from project approval, planning, construction, and management are faced with great risks. This paper identifies the influencing factors of schedule risk of transmission and transformation projects, and obtains the general influencing factors indexes of transmission and transformation projects. These indicators are expressed as $u_n (n=1,2,\ldots,16)$, as shown in Table 6.

Table 6. Influencing factors of schedule risk

| Name | Risk type | risk factor |
|------|-----------|-------------|
| Planning and construction | Schedule risk of power transmission and transformation project | Demolition delay $u_1$ |
| | | Delay in approval $u_2$ |
| | | Quality defects and rework $u_3$ |
| | | Equipment procurement delay $u_4$ |
| | Personnel factors | Poor Inter Organizational Communication $u_5$ |
| | | Labor shortage $u_6$ |
| | | Lack of management experience $u_7$ |
| | | Delay of commissioning personnel in place $u_8$ |
| | Organization and management | Inadequate security $u_9$ |
| | | Equipment commissioning delay $u_{10}$ |
| | | Immature key technologies $u_{11}$ |
| | Market finance | Initial funds not in place $u_{12}$ |
| | | Delay in payment by contractor $u_{13}$ |
| | | Collapse accident $u_{14}$ |
3. Progress risk evaluation model of power transmission and transformation project based on improved risk chain

This paper uses the method of Nasir D (2003) to determine the relationship between risks. Firstly, the risk association is graded according to the knowledge and experience of the expert group, and then some de subjectification methods[6] are adopted to eliminate the subjectivity of the group decision-making process of the expert group. This de subjectification method is as follows:

1. The Expert Group assesses the pairwise correlation between risks, and expresses the expert's evaluation results through four numbers (0 - no correlation, 1 - less correlation, 2 - more correlation, and 3 - inevitable correlation).

2. Determine whether there is correlation between two risk factors. Among them, $X$ is the mean value of all the scores of the expert group, $M$ is the total number of 0 and 1, and $N$ is the total number of 2 and 3. The risk correlation is evaluated according to the statistical results.

3. Finally, the risk relationship network diagram is drawn.

4. Empirical analysis

In this paper, a 110kV power transmission and transformation project is taken as an example for empirical analysis. According to the schedule of the project, according to the method of de subjectification mentioned above, the expert meeting group evaluates the risk association relationship based on knowledge and experience, and obtains the risk association network of the power transmission and transformation project. Through theorem 1 and theorem 2, each risk element is summarized and determined Independent risk chain.

The ranking coefficients of risk chain obtained in this paper are re listed and sorted, as shown in Table 7.

| Risk chain | $P_{U_i}$, % | sort |
|------------|--------------|------|
| $U_1$      | 44.47        | 4    |
| $U_2$      | 55.19        | 2    |
| $U_3$      | 46.91        | 3    |
| $U_4$      | 76.92        | 1    |
| $U_5$      | 39.53        | 5    |

Through comparative analysis, it can be concluded that different risk chains have different impacts on the 110kV power transmission and transformation project.

1. There are five risk chains in the power transmission and transformation project. The influence degree of risk chain on the construction period of the project is different. $U_4$ is the most influential, followed by $U_2$, $U_3$, $U_1$, $U_5$. The impact of risk chain $U_5$ on the total construction period is the least, only 39.53%, which is in line with the organizational form of risk management in the actual project implementation process. For the most influential risk chain $U_4$, the closely related risk factors in the same risk chain are regarded as the main task objects of the management functions of each risk management group, which brings great convenience to the scientific organization of project management.
(2) Taking the risk chain $U_3$ as an example, the risk chain has a certain impact on the processes of D, E, F, I, C, L, K and Q. Compared with the processes affected by other risk chains, it has a greater impact on the project schedule. However, in the results of Table 7, it is concluded that the risk chain $U_4$ has a total impact on the project schedule N, C, G and J have the greatest impact on the whole project, ranking first. It shows that the process of risk chain has larger free time difference and total time difference, and its time fluctuation has little correlation with the total construction period. Therefore, even if there are many processes affected, the process delay has little impact on the total project duration, and the effect of the latter on N, C, G, J The time fluctuation of these four processes is closely related to the total construction period, and the process delay has a great impact on the total construction period. Therefore, in the implementation process of the 110kV power transmission and transformation project, the managers should pay more attention to the impact of the risk chain $U_4$, and take effective preventive measures in advance.

(3) The simulation results show that the probability of project delay caused by risk chain $U_4$ is 76.92%. Project managers can understand that the main factors affecting the construction period of the project are: immature key technology, lack of management experience, quality defects and rework. Therefore, in the construction process of the project, combined with the actual situation of the project, the risk response plan should be prepared in advance for the process (N, C, G, J) of the risk chain, and the corresponding risk response measures should be taken To achieve the purpose of risk aversion, in order to achieve the project quality and quantity on time to complete the task.

5. Conclusion

Especially with the continuous development of global economy, the research of risk management theory and method based on risk chain will become an important part of enterprise management, and may become the frontier of risk management theory research. Therefore, according to the basic attributes and characteristics of the risk chain, this paper evaluates the schedule risk of power transmission and transformation projects, and analyzes the potential influencing factors that may appear in the construction process of power transmission and transformation projects, which has practical significance for managers to further work out work plans and put forward countermeasures in combination with the actual situation. In this paper, on the basis of related research on risk chain, consulting a large number of data, an improved model of risk chain evaluation is put forward, and verified in the actual case, and a better analysis result is obtained.

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