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Risk Assessment of International Electric Power Engineering Project Based on Improved Interpretation Structure Model

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Abstract

Under the background of the "Belt and Road" policy, more and more power companies are trying to improve their competitiveness through cooperation with overseas companies. Due to the complexity of the operating environment of international projects, power companies often face greater risks in external cooperation. Therefore, it's of great significance for the cooperation of International power companies to analyze the risk factors of international power engineering projects and their degree of impact. On the basis of identifying the risk factors of international power engineering projects, this paper uses the expert scoring method to determine the degree of influence on risk factors. It constructs the interpretation of structural model of project risk factors and divides the levels of hierarchical risk factors, and then it assigns weights to risk factors at the same level. This paper combines qualitative and quantitative analysis methods to determine the degree of impact of different risk factors on the project, so that enterprises can strengthen the risk perception in international development, and provide a theoretical basis for enterprises to effectively avoid risk factors.

Keywords

International power engineering project, power engineering, interpretation structural model, risk assessment, weight assignment.

1. Introduction

With the proposal of "Belt and Road Initiative" initiative and the continuous upgrading of the industrial structure of our economy, many domestic electric power enterprises, adhering to the principle of "going out", began to participate in the construction of international engineering projects. However, due to the political, economic, social and cultural differences among countries, the operating environment of international power engineering projects is more complex and uncontrollable than that of domestic projects [1], so the risk of the project is also greater. Loss of control over risk may cause the waste of resources and even the economic cost of the project. In order to ensure the scientific nature of the project decision and the maximization of the final benefit, it is necessary to carry out the risk assessment of the power engineering process.

At present, there are many studies on the identification and classification of international project risk. Such as Chen Yun, who analyzes the exchange rate risk of international hydropower project, and then strengthens the economic risk management[2]. Chang Tengyuan analyzes the political risk level of the project from the view of macro and micro, and evaluates the degree of risk faced by project contractors under different conditions[3]. Compared with the risk analysis of engineering project from a single domain, the multi-dimensional risk analysis can show the different characteristics of the project better. Kong Liang and others divided the risk of overseas power project into internal risk and

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external risk according to the source of risk, and carried out classified research[4]. Guo Wohua and others combs the common risks in power engineering project from the aspects of economy, technology, management and so on, and gave specific corresponding control measures[5].

However, based on the reference and case analysis, risk evaluation is lack of persuasion. Li Wanqing makes a comprehensive analysis of the project risks from a plurality of fields by combining the improved AHP model and the fuzzy comprehensive evaluation, so that the evaluation result is more objective, reasonable and accurate[6]. Sun Wenjian constructs the evaluation index system of the international engineering project from the aspects of law, engineering, and the owner. He optimizes the neural network model by adjusting the initial weight formula to solve the problem that the convergence time of the traditional neural network is too long, which is more suitable for the project risk evaluation[7]. Shi Zeyun applies system dynamics logic to decompose project risks into multiple modules to get the single risk of disposal mode[8]. Few scholars pay close attention to the internal link between the elements of project risk factors. The paper introduces the interpretive structural model into the risk evaluation of the international electric power engineering to analyze the relationship between risk factors. On the basis of identifying all risk factors of the international electric power engineering, it uses the interpretive structural model to divide the risk structure level .It weights the risk factors according to the degree of influence between the two factors in the same level, further identify key risk factors and underlying risk factors in international power engineering projects. The purpose is to provide scientific theoretical basis for avoiding risks in international power engineering project cooperation.

2. Project Risk and Identification of International Electric Power Engineering

The investment scale of The international power engineering project has large investment scale, high technical difficulty, complex operation environment and the like. Enterprises face the risks of different types and different properties in the operation of the electric power engineering project. Risk identification is a description of that transforming project uncertainty into understandable risks. which is the source and key part of risk management. Only the risk factors in the construction process can be correctly identified in order to manage and prevent the unknown and potential risks of the project. Combing the characteristics and implementation of the international power engineering project, with reference to the research results of many scholars, the author has identified the risk from the point of risk source of the project.

(1)Political risk

Political risks have far-reaching implications for international projects, which cannot be easily reversed or changed. Especially when the regional political conflicts will lead to social unrest and disorder, this will directly affect the transportation and basic communication of the location of international projects. In addition, if the political pattern of the project location is redistributed, it will lead to changes in the entire political environment. This situation will inevitably lead to major changes in the company's external environment, making it difficult for enterprises involved in cross-border cooperation to adapt to sudden business twists and turns, thus bringing huge losses to both partners.[9].

(2) Management risk

The management risk mainly aims at the manager, the project personnel arrangement, the construction progress and the external cooperation negotiation need to be strictly controlled by the manager. The management risk is largely due to the decision-making error of the manager. The risk of the safety management is composed of the safety risk of the power network, the risk of equipment accident and the risk of casualties. The power grid company shall also regard the safety management as the premise and foundation for business development.

(3) Technical risk

The operation of the power engineering project requires the technical personnel and the management to have extremely high professional quality. The capabilities of the technicians need to match the

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technical level required for the project ,and managers need to rationally select and screen the introduction of new technologies. For international projects, there are also differences in the technical standards of different countries[10]. The occurrence of the technical risk will not only affect the operation of the whole power engineering project in the period, but also take a large amount of manpower and material resources to correct, affecting the income of the electric power engineering project.

(4) Economic risk

Economic risk is one of the main risks to the international project, which directly affects the benefits of the enterprise, including exchange rate change, local inflation and foreign exchange control. Since the project is located overseas, when it encounters extreme situations such as political unrest, it is most likely to face difficulties in the transfer of funds and even the freezing of the funds. The proper management and control of the economic risk will affect the profitability and benefits of the project.

(5) Implementation risk

The implementation risk refers to the risk factors during the development of the power project. First, clarifying the contract terms has a decisive role in the implementation of the project. The power enterprise needs determine the specific content of the contract with partner. Otherwise, the implementation progress of the project will be affected, raising the project crisis. Secondly, for the international project, the project cooperation may be faced with the problem of language translation. Inappropriate, non-professional translation can cause ambiguity or communication obstacle, causing the project can not be carried out smoothly. Material procurement is an essential project implementation step. It is necessary to make reasonable purchase according to the requirements of the project, avoiding situations of that material quality, material quantity and material specifications does not meet the construction requirements, which results in additional losses.

(6) Social risk

The social factors that affect the power engineering project are called social risk. Especially in the international project, the social risk has a great impact on the operation and development of the project. The difference of cultural background, religious belief and trade environment between countries can cause project construction period stagnation or additional loss.

3. Construction of the Interpretation Structure Model for the Evaluation of Structural Models

3.1 Model Selection

In the process of building international power engineering projects, there are many complicated and uncertain factors, and these factors are difficult to use the traditional mathematical model for accurate quantitative analysis. Therefore it is necessary to choose the appropriate model to solve the practical problems of uncertain factors.

The interpretation structure model was proposed by American professor Warfield in 1973. It is a kind of structural modeling technology, using widely in modern systems engineering[11]. It can decompose a complex system into several subsystems and arrange them according to the degree of influence of each indicator on the overall target, which is an intuitive and well-structured relationship model.

This paper determine the factors that may cause the risk of power engineering projects to build a risk assessment model referring to a large number of literatures. This model takes the evaluation target, namely the international power engineering project risk assessment as the first-level indicator, and takes the political risk, economic risk, social risk, environmental risk, technical risk and management risk as the secondary indicators, and the specific risk content under each secondary indicator, such as political situation risk, policy and regulatory risks, terrorist activities risk, etc. as a three-level indicator. It bases on the fact that these indicators can describe the risks faced in the process of

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international power engineering projects from multiple dimensions. The specific indicators are set as shown in Table 1.

Table 1. International power engineering project risk assessment indicator setting

Primary indicator layer	Secondary indicator layer	Third indicator layer
International power engineering project risk A	Political risk B1	Political risk C1
		Policy and regulatory risk C2
		Terrorist activity risk C3
		Rights section regulatory risk C4
	Management risk B2	External coordination risk C5
		Security management risk C6
		Progress management risk C7
		Personnel management risk C8
	Economic risk B3	Inflation risk C9
		Trading control Risk C10
		Exchange rate risk C11
		Capital turnover risk C12
	Technical risk B4	Introducing new technology risks C13
		Construction technology risk C14
		Technical standard risk C15
		Product design risk C16
	Implementation risk B5	Contract terms risk C17
		Language translation risk C18
		Project change risk C19
		Material procurement risk C20
	Social risk B6	Religious custom risk C21
		Social awareness risk C22
		Cultural difference risk C23
		International trade risk C24

3.2 Construction Steps

(1) Construct the adjacency matrix of risk factors for international power engineering project

In order to get a more reasonable adjacency matrix, this paper uses the expert scoring method that invite fifteen expert teams to score. In the scoring result, if more than two-thirds of the experts believe that there is a direct influence between the two factors, then it is determined that there is a direct influence relationship between the two factors. Otherwise, it is determined that there is no direct influence between the two factors. Finally, the most direct impact relationship between the risk factors of international power engineering projects are result from the comprehensive evaluation. According to the following rules, it constructs the direct correlation between the various influencing factors, and generates the neighboring matrix P of the first step.

1) If P_i has a direct effect on P_j, the value of p_{ij} is 1;

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2) If P_i has no direct effect on P_j, the value of p_{ij} is 0.

(2) Solving the reachable matrix and its reduction matrix

Based on the given adjacency matrix, the reachable matrix can be further calculated. The solution formula of the reachable matrix R is as follows.

$$R=(A+I)^{n+1}=(P+I)^{n}\neq(P+I)^{n-1}\neq\ldots\neq(P+I)^{2}\neq(P+I) \tag{1}$$

The MATLAB tool can be used to solve the Equation (1) to obtain the reachable matrix R.

If there are some elements in the same row and column, the reduction matrix R is reduced, only retaining the repeated elements, and then obtaining the reduced reachable matrix R_1.

(3) Hierarchical division

According to the reduced reachable matrix R_1, each factor is sorted and summarized. Finally, all factors are divided into several levels. The antecedent set is defined as the set of factors affecting factor P_j, which is presented by $D(P_j)$. The reachable set is defined as the set of factors affected factor P_i, which is presented by $L(P_i)$. The intersection of antecedent set and reachable set is defined as common set, which is presented by $O\left(P_{ij}\right)=L\left(P_i\right)\cap D\left(P_j\right)$. If the common set of a certain factor is the same as its antecedent set, which is $O\left(P_{ij}\right)=D\left(P_j\right)$.

(4) Drawing the interpretation structure diagram

According to the result of the hierarchical division, the interpretation structure model containing all the factors is output.

3.3 Model Solving

(1) Using the expert scoring method and the factors affecting rules to determine the relationship between the factors, and then establishing a project risk factor relationship table, that is the initial reachable matrix. As in formula (2).

(2) Calculating the reachable matrix according to the computational properties of the Boolean matrix, as in equation (3). After removing the repeated ranks to get the formula (4).

(3) Making a hierarchical processing to the risk factors of the reachable matrix. The relationship between the risk factors after sorting is shown in formula (5).

$$\begin{bmatrix}
0&0&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&1\\
0&0&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&1\\
0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0&0\\
0&0&0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0\\
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0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1\\
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0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0&0\\
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0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1\\
0&0&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&1&0&0&0&0&0&0\\
0&0&0&0&0&0&0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0&0&0
\end{bmatrix} \tag{2}$$

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$$\begin{bmatrix}
1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
1&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&1&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
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1&0&0&0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
1&0&0&0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
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0&0&0&0&0&0&0&0&1&1&1&1&0&0&0&0&1&0&0&0&1&1&0&0\\
1&0&0&0&0&0&1&1&1&1&1&1&0&0&0&0&1&0&0&0&0&0&1&0\\
1&0&0&0&0&0&1&1&1&1&1&1&0&1&0&0&1&0&0&0&0&0&0&1
\end{bmatrix} \tag{3}$$

$$\begin{bmatrix}
1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
1&0&0&1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0\\
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1&0&1&0&0&0&1&0&0&1&0&0&0&0&0&0&0&0&1&0\\
1&0&1&0&0&0&1&0&0&1&0&0&0&0&1&0&0&0&0&1
\end{bmatrix} \tag{4}$$

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	7	16	10	4	13	20	17	1	2	5	9	21	22	14	18	6	15	8	3	23
7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
5	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
9	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
21	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
22	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
14	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
18	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
6	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
15	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0
8	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0
3	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0
23	1	0	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1

(5)

Through the above steps, the hierarchical processing of project risk factors is realize. Twenty four risk factors are divided into five levels. The risk factor interpretation structure model is shown in Figure 1. The risk factor of the first level indicates that the risk factor has the most influence on other risk factors among all risk factors, but is least affected by other risk factors; the risk factor of the fifth level indicates that this risk factor has the least impact on other risk factors among all risk factors, but is most affected by other risk factors.

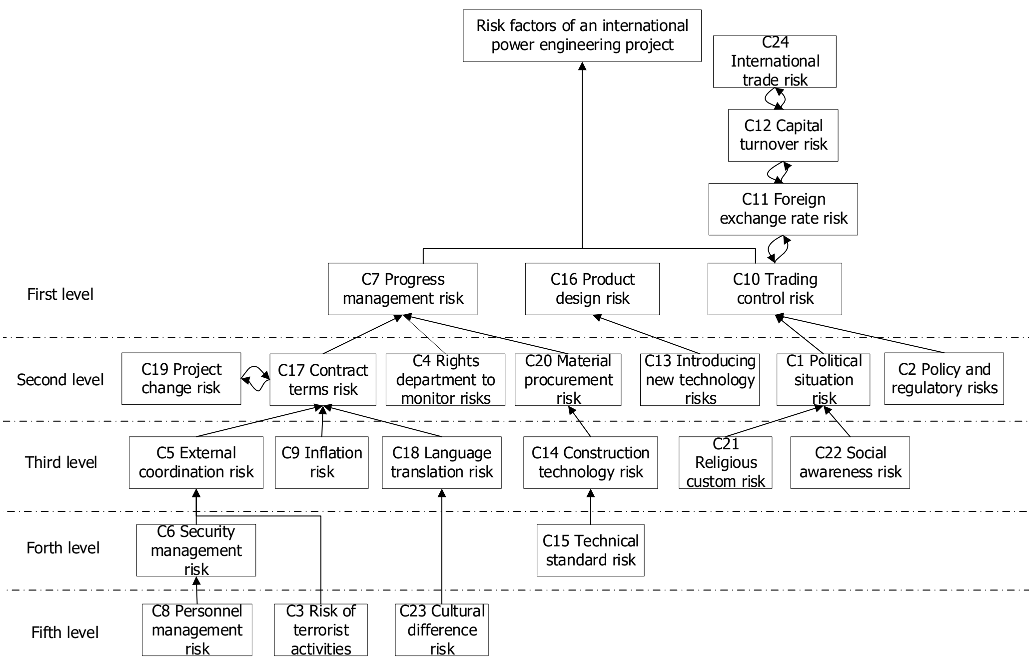

Figure 1. International power engineering project risk factor interpretation structure hierarchical model

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3.4 Weight Assignment Improved Interpretation Structure Model

Since the first, second and third levels of the interpretation structure model are located at the top half of the hierarchical model and contain many risk factors, it use the entropy weight method to assign weights to three levels of risk factors, in order to better measure the importance of multiple risks in the same level. The method performs a weight comparison of two factors, assigning the weight value of 1-9 according to the importance degree of the risk factor. According to this rule, the index weights are assigned. The risk factor moments of the three levels after the weighting are given by formulas (6), (7), and (8):

$$\begin{bmatrix} 1 & 1/2 & 1/5 & 1/5 & 1/5 & 1/5 \\ 2 & 1 & 1/3 & 1/3 & 1/3 & 1/3 \\ 5 & 3 & 1 & 1 & 1 & 1 \\ 5 & 3 & 1 & 1 & 1 & 1 \\ 5 & 3 & 1 & 1 & 1 & 1 \\ 5 & 3 & 1 & 1 & 1 & 1 \end{bmatrix} \tag{6}$$

$$\begin{bmatrix} 1 & 1 & 4 & 2 & 5 & 6 & 3 \\ 1 & 1 & 4 & 2 & 5 & 6 & 3 \\ 1/4 & 1/4 & 1 & 1/3 & 2 & 4 & 1/2 \\ 1/2 & 1/2 & 3 & 1 & 3 & 5 & 2 \\ 1/5 & 1/5 & 1/2 & 1/3 & 1 & 2 & 1/2 \\ 1/6 & 1/6 & 1/4 & 1/5 & 1/2 & 1 & 1/4 \\ 1/3 & 1/3 & 2 & 1/2 & 2 & 4 & 1 \end{bmatrix} \tag{7}$$

$$\begin{bmatrix} 1 & 1/5 & 1/3 & 2 & 3 & 4 \\ 5 & 1 & 2 & 4 & 4 & 6 \\ 3 & 1/2 & 1 & 3 & 3 & 4 \\ 1/2 & 1/4 & 1/3 & 1 & 2 & 4 \\ 1/3 & 1/4 & 1/3 & 1/2 & 1 & 2 \\ 1/4 & 1/6 & 1/4 & 1/4 & 1/2 & 1 \end{bmatrix} \tag{8}$$

By calculating the weights of the various risk factors at the three levels, the results are shown in Table 2.

Table 2. International power engineering project risk factor weight

Primary indicator layer	Secondary indicator layer	Third indicator layer	Weights
International power engineering project risk factors	First level	Progress management risk	0.0428
		Product design risk	0.0758
		Trading control Risk	0.2204
		Exchange rate risk	0.2204
		Capital turnover risk	0.2204

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		International trade risk	0.2204
	Second level	Project change risk	0.2771
		Contract terms risk	0.2771
		Rights section regulatory risk	0.0805
		Material procurement risk	0.1706
		Introducing new technology risks	0.0537
		Political situation risk	0.0331
		Policy and regulatory risk	0.1078
	Third level	External coordination risk	0.1410
		Inflation risk	0.3837
		Language translation risk	0.2351
		Construction technology risk	0.1089
		Religious custom risk	0.0709

3.5 Improved Interpretation Structural Model Results Analysis

Combining the hierarchical structure of the interpretation structural model with the weighting result, the risk factors affecting the international power engineering project are analyzed in depth. The following conclusions are obtained:

(1)The most direct factors for the risk of international power engineering projects include schedule management risk, product design risk, transaction control risk, foreign exchange rate risk, capital turnover risk and international trade risk. Both foreign exchange rate risk and capital turnover risk are economic risks, of which the weight at the first level is about 45%. Therefore, it’s clearly that the economic risk has the greatest impact on the total risk of the project. For international power engineering projects, the project is costly, which requires constant investment of large amounts of funds during the development period. The project has a long construction time and a large amount of engineering. It usually requires external financing to obtain operating capital. Once the funds for the power engineering project are not available in a timely manner, or the transaction amount changed, it will have a great impact on the project schedule.

(2) Possible factors that may cause risks to the project schedule include project change risk, contract clause risk, material procurement risk, and rights department supervision risk. In general, contract terms risk, material procurement risk and project change risk are implementation risks, accounting for more than 70% of the total weight of the second level, which means that the implementation risk has a great impact on the progress of the project. In the early stage of the project, the power company should try to negotiate with the cooperative enterprise all the details of the cooperation content, so as to avoid problems in the future implementation process, affecting the construction period or wasting resources.

(3)Trading control risk is also an important factor in the risk of power projects. It is mainly affected by political situation risk and policy and regulatory risks. The policies related to engineering projects and the current political situation in different countries are largely different. The trading control standards of their projects will also change with the situation. Therefore, before the power engineering project is launched, the project team must understand the local laws and the latest situation, strictly following the rules and regulations.

(4)External coordination risk, inflation risk and language translation risk are the main factors leading to the risk of contract clauses. It has the largest weight at the third level, exceeding 75%, of which

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inflation risk factors account for the largest proportion. In the international project cooperation, inflation is one of the risks that international cooperation often encounters. When it comes to inflation caused by the economic crisis, the content of funds in the contract terms is bound to change. This change will inevitably lead to the loss of one or more interests. Due to different language, there may be statement ambiguity or communication obstacles in the external communication. If these problems are reflected in the written contract, it will result in unclear responsibilities and mattter unclear issues, which will bring losses to the project partners.

(5) Personnel management risk, terrorist activity risk and cultural difference risk are the most basic factors that cause the risk of international power engineering projects, which are the deepest impact. Hence, in the early stage of project construction field research, it is necessary to understand the local cultural background and political environment to ensure the characteristics of the project according to local conditions. Reasonable personnel management can also reduce the possibility of project risks, including compensation, benefits, rewards and punishments play a certain role in stimulating employees.

4. Conclusion

This paper explores a series of factors that may lead to risks in international power engineering projects, analyzing the relationship between various influencing factors. It constructs an explanatory structure model for risk assessment of international power engineering projects, clarifies the hierarchical structure relationship between different factors, and uses the quantitative method of weight assignment to determine the degree of influence of the same level elements. According to the model result, economic risks have the greatest impact on international power project cooperation. Thus, power companies need to strengthen power project cost management and reasonably estimate the funds needed to carry out the project to minimize economic risks. At the same time, cultural differences and personnel management are the most basic risk factors in the construction of international power projects. They can be circumvented through preliminary research and refined personnel management to ensure the smooth progress of international power engineering projects. The research in this paper combines qualitative and quantitative methods to provide a theoretical reference for avoiding risks in international cooperation projects of power companies.

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