Analysis of Factors Influencing the Comprehensive Benefits of International Electric Power Project under EPC Mode Based on Interpretative Structure Model

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Abstract—With the further expansion of China's "Belt and Road" initiative, the Chinese enterprises are being more and more active in the overseas market in recent years. Take the power industry for example, large number of Chinese engineering companies have developed their own systematic construction framework for different type of projects in domestic market. But challenges and problems may occur once the present domestic mode is directly applied to the international projects. And it also is the main uncertainty or risk faced by the Chinese enterprises when carrying out the international projects at present stage. Under this background, this paper takes the international electric power project under EPC mode (Engineering, Procurement and Construction) as the research object and the Interpretation Structure Model (ISM) is applied to analyze the potential risk factors which may affect the economic benefit and the social benefit during the implementation of these projects by Chinese enterprise. Through carrying out the comprehensive identification of those potential risk factors, this paper aims at providing a more visualized structure to show all kinds of potential risks and their corresponding impact mechanism for the Chinese contractors, which can reduce the risk level or the potential damages effectively when carrying out the related projects in overseas markets.

Keywords- International Electric Power Project; EPC; Risk Factors; ISM.

1 INTRODUCTION

During the past eight years since the Belt and Road initiative raised by China, the economy and trade contacts among the countries along the "Silk Road Economic Belt" and the "21st century Maritime Silk Road" have been promoted significantly. According to the data established by the government, the investment amount from Chinese enterprises has reached 100 billion US dollars by the end of September 2019, which provides a good opportunity for the Chinese

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enterprises to participate in the international competition and expand the corresponding strengthes in related area [1]. Meanwhile, due to the huge differences between different countries, such as the culture, local standard and so on, more complicated risk factors will be faced by the enterprises during the implementation of such international projects compared than in the domestic market, which may increase the overall cost of the whole project if the potential risk factors can not be identified and analyzed effectively.

Referring to the relevant literatures at home and abroad, it is not difficult to find that the current researches on international project benefit analysis mainly focus on the economic benefits, including contract risk, financial risk, construction risk and so on. For example, Wang [2] divided the contract risks into two categories: subjective risk and objective risk. And the Analytic Hierarchy Process (AHP), Gray Correlation Analysis and Fuzzy Evaluation method were employed to evaluate the contract risk level of the international project. Liu [3] carried out the external risk analysis of the international electric project under the EPC mode from six aspects: politics, economy and finance, law, labor tax and natural factors, and a series of strategies and recommendations were also proposed by the author. An index system containing 9 indexes (including politics, economics, contract management and technology) was constructed by Wang et al. [4] to evaluate the risk level of the international power project, where both the internal risks and the external risks were taken into consideration during the select of indicator. Yang [5] focused on the management of partnership to reduce the risks of the international project under EPC mode, indicating that a good relationship among partners helps to reduce risks effectively.

This paper takes the international electric power project as the research object to study the complicated potential risk factors faced by the enterprises in international businesses, and the main purpose of this article is to analyze the corresponding influencing mechanism of each potential risk factor by using the Interpretative Structural Modelling (ISM) method.

2 METHOD

ISM method is an effective method to analyze the complex systems in engineering area, which was firstly raised by Professor J. Warfield from the United States, and now this method is also widely applied in social economic area [6]. It combines both the qualitative analysis and the quantitative calculation to simplify the complex system effectively by making full use of experts' experience and the computer technology, which facilitates the further study of the complicated system. And the fuzzy object is expected to be converted into a hierarchical system with clear structure by applying the ISM method, which makes it widely employed in the research on power industry, financial area, international relationships and so on [7]. As the main research object of this paper, the international electric power project plays a special role in the national economy, owing to its significance on the local energy security and the participant of foreign contractors. Thus, the ISM method is employed in this paper to analyze the risk factors which may influence the economic and social benefits of the international electric power project, and then, the corresponding influencing mechanism of those factors can be identified furtherly. The implementation of ISM method contains the following 4 steps:

- Firstly, create the Relationship Matrix of the element based on the experts' experience according to the interaction relationship among different elements.
- Secondly, construct the Adjacency Matrix by applying the following formula:

$$a_{ij} = \begin{cases} 1, & when\ element\ F_i\ has\ a\ direct\ effect\ on\ element\ F_j; \\ 0, & else; \end{cases} \quad (1)$$

where F is the element under the system and a_{ij} stands for the value in the Adjacency Matrix.

- Thirdly, calculate the Reachable Matrix according to the Adjacency Matrix obtained in Step 2.
- Finally, the hierarchical decomposition of the Reachable Matrix can be launched to analyze the structure of all elements under this system and the further analysis can also be implemented.

3 INFLUENCING FACTORS ANALYSIS

As an important part of the infrastructure industry, electric power project plays a critical role in ensuring the stable operation of the whole social economy system. And the local authority usually will hold a rather cautious attitude towards the implementation such projects in both foreign and domestic, which brings great risks and challenges to the Chinese enterprises when carrying out related activities in the overseas market, especially in those unstable countries and regions [8]. Therefore, this paper carries out the analysis of risk factors which may influence the economic and social benefits of the international electric power project from the perspective of Chinese enterprises, who undertakes the role of EPC contractor in such project. Furthermore, the impact path and the corresponding mechanism of these risk factors are also identified by using the ISM method.

3.1 Comprehensive benefit analysis of international electric project

EPC mode is widely employed during the implementation of international electric project at present stage, which helps to optimize the allocation of resources and promote the coordination of different parties during the implementation of the project, however, it also improves the risk level faced by the contractor through transferring the Employer's risk to the contractor [9].First of all, it is essential to identify what kind of economic benefits and social benefits can be created through the implementation of the international electric project. As the EPC contractor of the project, the implementation of the international electric project can create profits and obtain foreign exchanges for the Chinese enterprises through the export of labor and equipment. Meanwhile, it also can bring social benefits for different parties. For example, it contributes to enhance the mutual trust and cooperation between different countries and creates lots of jobs for the local society. In addition, it also provides a good chance for the enterprise's international strength on the related area. And it shall also be noted that the international electric power project helps to guarantee the quality and stability of local electric power system effectively.

3.2 Influencing factors of comprehensive benefits

From the perspective of the EPC contractor, the influencing factors, which may have an impact on the comprehensive benefits of the project, shall be analyzed furtherly to study the influencing mechanism of these complicated factors. From a macro point of view, factors can be divided into the internal factors and the external factors. And from the micro perspective, these factors can be divided into political factors, macro e-economic factors, localization factors, micro market and natural factors [10]. Twelve factors are finally chosen to carry out the further analysis by excluding the factors with weak relevance or strong independence and the details can be found in the following picture.

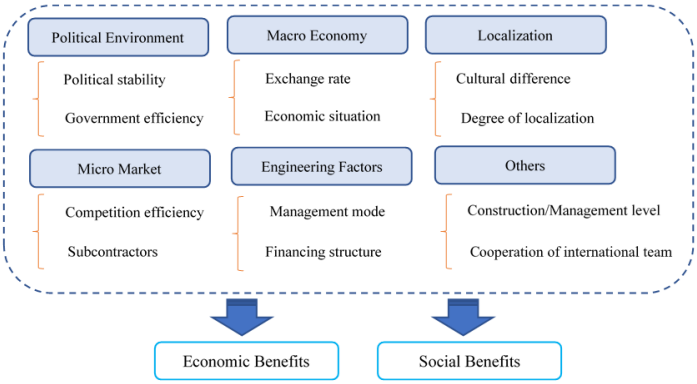

Figure1. Influencing factor of international electric project's comprehensive benefits

3.3 Factors analysis based on ISM

Based on the preliminary analysis of the factors which affects the benefits of international electric power project, the further research on the complex system can be delivered by using the ISM method to study the contribution path and mechanism of these factors, details are as following:

Firstly, establish the relationship judgment table of the factor. According to the factors obtained above, the following 12 factors can be finally determined to carry out the further research: a_1 (Political stability), a_2 (Government efficiency), a_3 (Exchange rate), a_4 (Economic situation), a_5 (Cultural difference), a_6 (Degree of localization), a_7 (Competition efficiency), a_8 (Subcontractors), a_9 (Management mode), a_{10} (Financing structure), a_{11} (Construction/Management level), a_{12} (Cooperation of international team). The judgment table of these factors can be determined accordingly based on whether there is a direct impact among any two of these factors. The result is shown in Table 1.

Table 1. The judgement table of influencing factors regarding the international electric project under EPC mode

	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}	a_{12}
a_1		▲		▲								▲

a_2						▲		▲	▲			▲
a_3					▲	▲				▲		
a_4				▲		▲		▲		▲		
a_5			▲			▲		▲	▲			▲
a_6					▲		▲	▲	▲			▲
a_7						▲		▲	▲			
a_8									▲		▲	▲
a_9						▲		▲			▲	▲
a_{10}									▲		▲	
a_{11}								▲	▲			▲
a_{12}						▲		▲	▲		▲	

Secondly, obtain the adjacency matrix of these factors A_1.

Thirdly, the reachability matrix P_1 can be calculated by using the Matlab and the result is as follows:

$$A1 = \begin{vmatrix} 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 0 \end{vmatrix}$$

$$P_1 = \begin{vmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 \end{vmatrix}$$

Fourthly, based on the reachability matrix obtained above, the Reachability Set (R_i), Antecedent Set (Q_i)and Intersection Set (C_i)can be calculated furtherly, details can be referred in Table 2.

Table 2. The reachability Set, Antecedent Set and intersection Set

i	R_i	Q_i	C_i
1	1,2,4,12	1	1
2	2,6,8,9,12	1,2,5	2
3	3,4,6,10	3,4	3,4
4	3,4,6,8,10	1,3,4	3,4

5	2,5,6,8,9,12	5,6	5,6
6	5,6,7,8,9,12	2,3,4,5,6,7,9,12	5,6,7,9,12
7	6,7,8,9	6,7	6,7
8	8,9,11,12	2,4,5,6,7,8,9,11,12	8,9,11,12
9	6,8,9,11,12	2,5,6,7,8,9,10,11,12	6,8,9,11,12
10	9,10,11	3,4,10	10
11	8,9,11,12	8,9,10,11,12	8,9,11,12
12	6,8,9,11,12	1,2,5,6,8,9,11,12	6,8,9,11,12

Fifthly, carry out the decomposition of the factors. The relationship among different factors shall be identified before studying their impact mechanism: the top level is the main goal of the project, and the factors in the lower level represents the reason of factors in the adjacent upper level. Following decomposition principle shall be applied:

$$C_i（R_i \cap Q_i） = R_i \tag{2}$$

Based on the results obtained in Table 2, factor a_8, a_9, a_{11}, a_{12} are aligned with the above formula and then, another result can be obtained by removing these four factors, the new output is shown in Table 3.

Table 3. The result after removing a_8, a_9, a_{11}, a_{12}

i	R_i	Q_i	C_i
1	1,2,4	1	1
2	2,6	1,2,5	2
3	3,4,6,10	3,4	3,4
4	3,4,6,10	1,3,4	3，4
5	2,5,6	5,6	5,6
6	5,6,7	2,3,4,5,6,7	5,6,7
7	6,7	6,7	6,7
10	10	3,4,10	10

Similarly, the rest factors can also be divided into different sets by applying the same principle.

Table 4. The result after removing a_7, a_{10}

i	R_i	Q_i	C_i
1	1,2,4	1	1
2	2,6	1,2,5	2
3	3,4,6	3,4	3,4
4	3,4,6	1,3,4	3,4
5	2,5,6	5,6	5,6
6	5,6	2,3,4,5,6	5,6

Table 5. The result after removing a_5, a_6

i	R_i	Q_i	C_i
1	1,2,4	1	1
2	2	1,2	2
3	3,4	3,4	3,4
4	3,4	1,3,4	3,4

4 CONCLUSION

According to the analysis listed above, the 12 potential risk factors can be divided into five different levels: L1={a_8, a_9, a_{11}, a_{12}}, L2={a_7, a_{10}}, L3={a_5, a_6}, L4={a_2, a_3、a_4}, L5={a_1}, and the higher number means the closer to the bottom level. Based on the decomposition result obtained in Section 3, the ISM of these 12 factors can be determined and the result is shown in Figure 2.

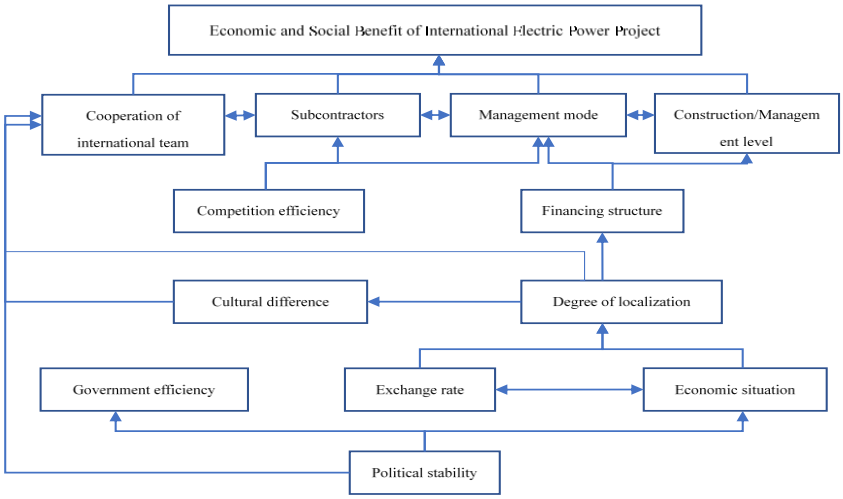

Figure2. The ISM of the factors influencing the international electric power project

From the structure model above, it is obvious that the influencing factors of the international electric power project can be divided into five levels, and the factors in the lower level usually have a direct impact on the factors in the adjacent upper level. In order to simplify the structure of the whole system, the relationships between cross-level factors are not indicated in this model. In detail, the four factors on the first level (including the Cooperation of International Team, Subcontractors, Management Mode and Construction/ Management Level) usually will have a direct impact on the economic and social benefit of the international electric power project. The second level (Competition Efficiency, Financing Structure) will produce a direct influence to the risk factors on the first level. For example, the local competition efficiency determines the number of potential subcontractors and will influence the corresponding management strategy applied during the implementation of such projects. Factors on the third level, which contains Cultural Difference and Degree of Localization, usually will affect the cooperation of the

international project team. The Government Efficiency, Exchange Rate and Economic Situation are the factors at the fourth level, and as is shown in the structure, the Exchange Rate and Economic Situation have a mutual influence and produce an effect on the localization degree as well. The Political Stability, located at the bottom level, will make a significant impact on the Government Efficiency and the Economic Situation. In addition, its impact on the Cooperation of International Team can not be ignored as well and that is why the influencing path between the two factors is shown in this structure.

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