

Analysis on Engineering Risk Management of International EPC Project

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Abstract. At present, China attaches great importance to international engineering, among which EPC general contracting mode is one of the most commonly used modes in international engineering projects. Improve the risk management ability of international EPC project is the key factor to evaluate the performance of international EPC project. In order to improve the research level of international EPC project risk management and the collaboration between different countries, this paper analyzes and collates the literatures on CNKI database, Web of Science database and SCI database. Based on the development of EPC in China, this paper finds out the characteristics of EPC international engineering risk management, and divides the risks of international EPC construction projects into four aspects: engineering risk, procurement risk, construction risk and other risks. Finally, solutions are provided for these four risks. Furthermore, this paper provides a theoretical basis for the future development of international EPC projects in China.

Keywords: Project Management; International EPC Projects; Risk Identification; Risk Management.

1. Introduction

Driven by the 'Belt and Road Initiative' strategy in China, more and more contractors began to undertake international engineering projects. EPC (Engineering Procurement Construction) model has gradually become one of the main modes of international engineering projects. According to statistics, in 2016, China signed contracts with countries along 'The Belt and Road Initiative' worth 1260.3 billion USD, of which more than 40% were undertaken by EPC mode [1]. As one of the evaluation factors of project success, project risk management has always been an important concern factor. A success in risk management can not only realize economic value but also maximize profits. In international projects, the risk is much higher than that of domestic projects because of more preparatory work, high procurement costs and communication problems. In the project planning stage, the key points of the project are still in the exploration stage, and the risk classification cannot be clearly defined. Therefore, the risks in international project management are highly unrecognizable [2].

The research on EPC international engineering project in China was in the exploratory stage from 1982 to 2003, and now it has entered a high-speed development stage [3]. Although there were some studies on international engineering, there are still some problems. There is no specific risk management department in the enterprise, there are still loopholes in professional risk avoidance, and there is no perfect risk management mechanism for international projects. China is in the transition period of industrialization, many risk management work is still mechanically based on previous work experience. Therefore, it causes a lack of relevant management methods and means for risk management of EPC international projects. Therefore, it is necessary to conduct the suitable risk management methods for international EPC projects in China, by analyzing various possible factors, and finding out the risk management methods of various stakeholders for international projects.

Based on the previous research in the field of risk management of EPC general contracting projects domestically and internationally, this paper will analyze the connotation of EPC contracting mode, carry out risk identification and risk assessment and finally find the risk management measures suitable for China. The aim is to improve the level of risk management of EPC contracting projects for international projects and provide a reference for the research of risk management of EPC contracting projects for international projects.

2. Method

In this research, the Chinese literature was collected by analyzing published conference papers in the China National Knowledge Infrastructure and the foreign literature was obtained from the conference papers in the Index to Scientific & Technical Proceedings and Web of Science. To improve the accuracy of the study, this research used advanced research. The keywords of "EPC project", "risk" and "international" were searched in the two databases from 2013 to 2022, and 1409 conference papers were retrieved. Among them, 1400 papers were retrieved from ISTP, and 9 papers were retrieved from CNKI. By analyzing those papers, I found that the risk control of international engineering EPC projects has gradually been in great demand. The annual data changes by year are shown in Figure 1.

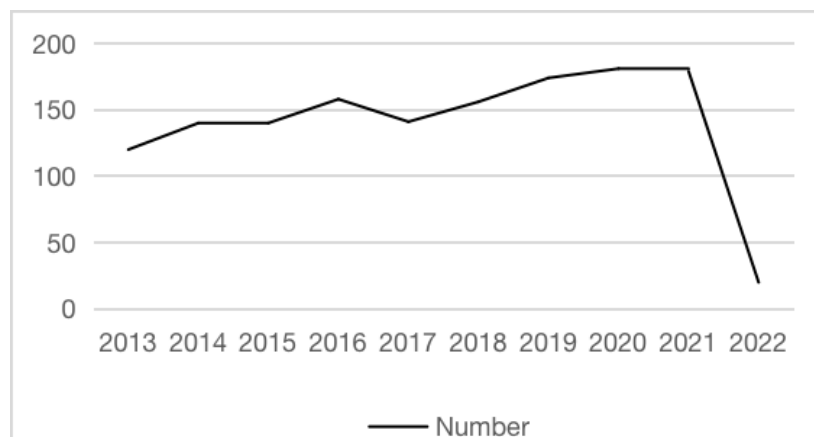


Figure 1. The annual data changes by year

Through cluster analysis and word frequency statistics of the screened papers, the main body of research is divided into three parts: the EPC model, international engineering project risk identification, and countermeasures. In this paper, the literature review will be discussed and studied from these three aspects.

3. ‘Engineering Procurement Construction’ Mode

3.1 Definition

Engineering Procurement and Construction project, also called EPC project, is one of the general contracting modes for construction projects. It is the mode of “Turnkey”, which means that a general contractor undertakes the design, procurement, and construction of the entire process of the project according to the contract. Also, the EPC project always uses a lump sum contract. EPC contract requires the general contracting enterprise to take the responsibility for the risk of quality, cost, schedule, etc. A typical EPC project workflow is shown in Figure 2.

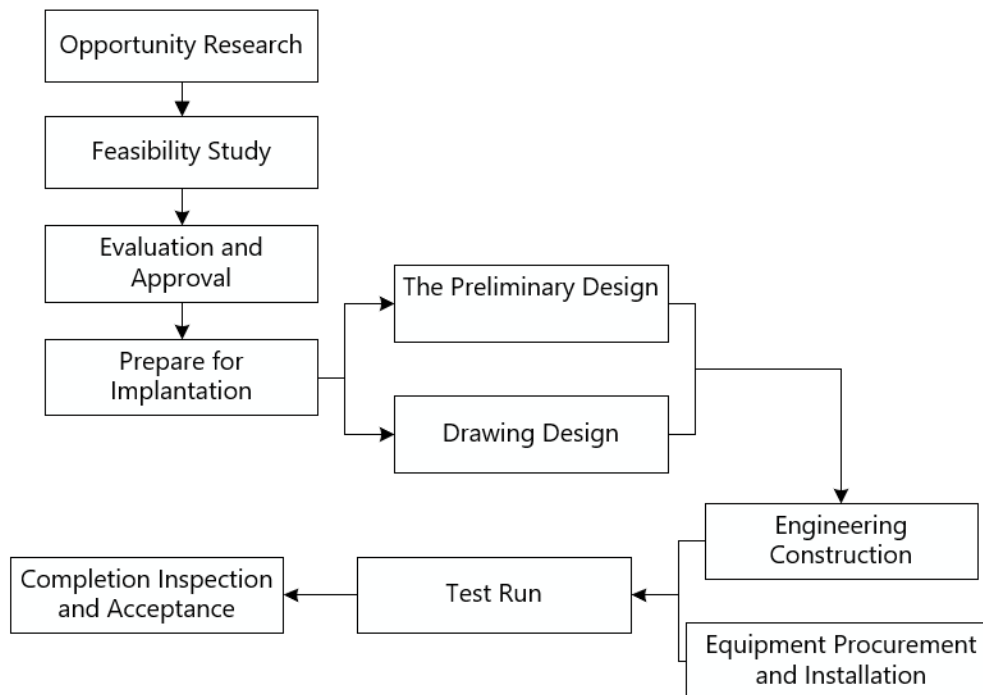


Figure 2. A typical EPC project workflow

The EPC contracting model has many advantages. The first is that it is more conducive to integrated planning and collaboration since the general contracting company is solely responsible for the construction process and management of the project. This approach can largely reduce the conflict between the design department and construction departments. It can also improve the efficiency of the project construction. Secondly, the use of the EPC management mode can reduce the risk of the investor for it transfers the risk to the general contractor. The risk will be shared with each candidate rather than only the owner undertaking. At the same time, it makes who is responsible for the quality of the project clearer, and it is easier to clarify who is responsible for possible engineering accidents. In addition, the EPC contract can maximize the advantages of each participant and further achieve the project goals through the control of various aspects of the project. Along with the benefits, the EPC general contracting mode also requires careful examination of the general contractor's qualifications because of the excessive transfer of liability risks to the general contractor, which imposes more requirements and responsibilities on the contractor. If there is a greater risk to the general contractor's finances during the project, it has a greater impact on the project. In addition, the contractor's control of the project relies only on the control of the general contractor and has low actual involvement in the project. Such factors also require a critical examination of the project's contractors.

3.2 Origin and development

The EPC model originated in the model engineering contract published by the Fédération Internationale Des Ingénieurs Conseils (FIDIC) in 1999 [4]. In engineering projects, EPC is used in many industries, such as petrochemical, engineering industry, manufacturing industry, etc... It has high requirements on investment capital, contracting units, and management difficulty. The EPC mode is more widely used in Europe and the United States and has been applied to private investment projects [5]. The beginning of the EPC contracting mode in construction in China was later than in other countries, starting in the 1980s. Chinese national government administration gradually introduced corresponding policies and terms to support the use of EPC's general contracting mode in engineering projects. From 1984 to 2002, it was the experimental stage of the EPC general contracting mode. Many construction enterprises tried to be in line with international standards under the influence of government support, like relevant laws and regulations. In 1999, the Ministry of

Construction issued 'Guidance on Promoting Large Design Units to Create International Engineering Companies' to spend the next few years cultivating large international companies capable of undertaking all design, procurement, and construction. By the end of 1999, EPC in China had completed a total of \$54 billion and signed contracts worth \$75 billion. The number of companies with the right to operate foreign contracting projects and labor cooperation increased to more than 1,000. From then to 2003 was a period of further exploration for China to speed up the pace of convergence with international standards. With the progress of society and the background of gradually fierce competition in the international market, China's construction industry continues to make improvements. The government also promoted the development of EPC projects through policies and regulations. At this stage, EPC has gradually become one of the main contracting methods in China, and after 2014, China has further promoted the EPC project model to restrict the specific specification system and improve the problems encountered in actual cases [6]. In February 2017, the General Office of the State Council requested to accelerate the implementation of EPC, and in December, the Ministry of Housing and Construction further elaborated on the management method of EPC and found the development direction. The bidding of engineering projects, the setting of project economy, and the optimization of the process are proposed approaches.

Overall, China's current EPC projects have entered a stage of steady development and comprehensive promotion. However, through the literature research and the combination with related projects, there are still certain problems in the development of EPC in China. First is the lack of management experience. Due to the relatively limited number of general contractor companies proficient in project design, engineering and construction, they often lack experience in managing EPC projects. This leads to confusion in the process of the project, and it is also difficult to control the cost. In addition, in the actual project, the investor has their own needs for the project and they are always involved in the project process out of their responsibility, rather than leaving the project completely to the general contractor. This can eventually lead to disruptions in the schedule of multiple departments.

4. Risk identification of international engineering projects

EPC projects are usually very large with many risks; therefore, a proactive approach is needed to address threats and identify opportunities. Especially on international projects, there will be more opportunities for risks to arise due to information mismatch [7]. Risk management in engineering projects includes the identification of risks, which can find potential types of risks, risk assessment, which evaluates the controllability of risks, and finally finding corresponding solutions for the existing risks. Therefore, it is necessary to study the risk management of EPC projects.

4.1 Characteristics of risk management in EPC projects

4.1.1 Systematic

EPC projects are different from the traditional model which means there is no third-party role of 'consulting engineer' and it is no longer a three-party relationship of mutual constraints. The employer assigns the general contractor to take full responsibility for managing the project instead of them. The general contractor systematically manages the risk of the whole project instead of only focusing on part of the subcontract works.

4.1.2 Diversity

The general contracting of EPC projects includes design, procurement, construction, and other aspects. The responsibility of the general contractor needs to contract with different subcontractors, and all risks need to be borne by the general contractor. The layers and perspectives of risk management are more diversified, and the requirements for the general contractor are higher, requiring intervention in multiple subcontracting projects for risk management.

4.1.3 Challenging

EPC projects are more challenging for general contractors. The scale of the project is usually large and only suitable for companies with all-around capability in design, procurement, and construction at the same time. Meanwhile, the EPC model is also challenging for the company's personnel requirements, requiring people who have mastered the project construction and procurement and other multi-dimensional to accept the challenge. If the team is simply reconstituted at the time of bidding or external personnel, a lot of time and cost will be wasted on bonding, which will affect the progress of project management. In addition, EPC projects involve a large number of works and require contracts with a large number of subcontractors. If there is a problem with one of the subcontractors, it is easy to generate problems of delay and cost overrun. There are more coordination and communication with each subcontractor, which is a great challenge to the information-sharing ability and project management level of the general contracting company.

4.2 Risk classification

Hui An et al. analyze the sources of risk from both owner and contractor perspectives [8]. The owner's risk mainly comes from the selection of contractors and the influence of policy factors; the increase of bid price from the contractor, the selection of subcontractors, the risk of design and procurement, etc. Jing-nan Yang et al. divided the risk of the EPC projects into operational risk, professional risk, and external risk [9]. Operational risk includes contracting risk, bidding risk, and commercial operation risk; professional risk refers to the risk of specialization in design, procurement, and construction; external risk refers to factors unrelated to the project itself, including policy factors, economic factors, social factors, natural factors, etc. Qing Wang et al. mainly focus on procurement in EPC projects [10]. They identified 25 possible risks in the procurement process through case studies, literature analysis, and expert interviews, and used Integrated Interpretative Structural Modelling (ISM) and Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) to identify the risks in the procurement process. Jingshi He et al. conducted a detailed analysis of the risks in the transportation of material procurement in international projects based on the characteristics of international projects and used the entropy-DEA (Data Envelopment Analysis) method to analyze the risks in each logistics [11]. Patricia Galloway presents the risks that EPC projects may encounter contractually in today's fast-changing society, including pricing issues in turnkey contracts, prudential requirements, and risks to ensure sustainability [12]. In the study of project performance evaluation, the risks of EPC projects are divided by Kamyar Kabirifar into three levels: risks in engineering, risks in procurement, and risks in construction. Indicators are classified according to the risk factors that may occur for each type of risk [13]. By using the TOPSIS method as a multi-attribute group decision-making technique, the key activities of EPC for large residential construction projects in Iran were analyzed and ranked. Chunguang Lin classified the risks of EPC international projects into political factors, religious factors, economic factors, policy factors, and other aspects using hierarchical analysis to assign weight to each risk factor [14]. Hongdong Zhang et al. classified EPC project risks into 5 major categories and 22 subcategories. These five categories are contract risk, design risk, procurement risk, construction risk, and external environment risk [15]. He developed a structural equation model to analyze the risks of EPC international projects qualitatively and quantitatively.

According to literature research, this paper classifies the risks of EPC projects in international engineering into engineering risk, procurement risk, construction risk, and other risks.

4.2.1 Engineering risk

(1) Project planning. The preliminary planning of the project includes the positioning of the building, the style or the scale of land, etc. The owner needs to be responsible for the overall planning of the project in advance. The project objectives, standards, and planning requirements need to be accurately explained to the general contractor. Errors in the base information of the project will lead to delays in the growth in the supply chain and consequently increase costs.

(2) Design Changes. The design of the project is the most fundamental part of the project, and whether the project is good directly affects the final result. According to the characteristics of EPC projects, the turnkey is responsible for the whole process of the project to achieve the project objectives. If the design plan changes, it has a great impact on the project as a whole and also harms the contractor's selection of subcontractors.

4.2.2 Procurement risk

(1) Selection of subcontractors. As the general contractor of the project, it needs to find the subcontractors of different sub-projects as soon as possible after receiving the task from the owner. Subcontractors undertake direct contact with the project, and the quality of subcontractors has a great impact on the project results. Subcontractors with poor reputations have problems with the selection of raw materials, storage of equipment, etc. The general contractor needs to choose the right subcontractor.

(2) Contract risk. EPC projects usually use standard general contracting terms, but in the contract, the owner or the general contractor as a project participant will always think of ways to increase their interests, which is a risk to the completion and schedule of the project. If a dispute arises from the contract, it will have a greater impact on the project schedule and completion. At present, the contract management of EPC projects in China is still in an extensive era, and there may be some loss of relevant evidence. In the future, China should refine the contract management of EPC projects as soon as possible.

(3) Procurement of construction materials. The selection of construction materials depends largely on the selection of subcontractors. Choosing subcontractors who have cooperated can reduce the risk caused by a lack of understanding. In addition to the quality of construction materials, the transportation of construction materials will also have great risks, such as damage and loss during transportation, delayed delivery of suppliers, etc.

4.2.3 Construction risk

(1) Construction safety risk. Construction quality during the construction process is one of the important objectives of EPC international projects. Only by ensuring the quality of the project can the safety of the project be guaranteed. The general contractor has to supervise the quality of the project. At the same time, the project should follow the principle of safe and civilized construction to prevent and control the occurrence of construction safety accidents so as not to affect the construction progress.

(2) Construction duration risk. The completion of the project should be carried out according to the duration. Accidents usually cause a delay in the EPC project. EPC projects are usually larger projects, each delay will affect the completion of the next progress.

(3) Construction cost risk. The cost of EPC projects is large and usually in the form of lump-sum contracts, which require high requirements for contractors' bid quotations and bid management. Unlike FIDIC's single-price contracts, EPC projects require negotiations between the two parties and the determination of the lump sum price. Delays or other contingencies in any of the general contractor's subprojects can affect the cost of the project. And because the EPC contractor assumes full responsibility for design, procurement, and construction, it is difficult to claim the lump sum once it is fixed.

4.2.4 another risk

In addition to the risks of the project itself, for international EPC projects, some other risks like political factors, cultural factors, and other reasons may produce a different stage from the normal construction state. For example, the change of rulers, the emergence of reactionaries, etc will affect the implementation. It is also possible that the supplier's supply chain receives impact because of economic problems; the impact of force majeure environmental factors such as tsunamis, earthquakes, epidemics, etc. These factors, although not related to the construction process, can also create risks to the schedule, quality, and cost of the project.

4.3 Countermeasures

4.3.1 Countermeasures for engineering risk

For engineering risks, the owner needs to strengthen risk management in the design phase. The owner and the general contractor can set up a corresponding risk management department to check the design plan for the project organization and technology to reduce the probability of design risk. When encountering design errors, they should set up corresponding program previews, clarify the responsibilities of all parties, and contact work hot-warming to solve the corresponding problems. At the same time, the EPC general contractor needs to review the design plan to ensure that the project is carried out properly. In the bidding stage, the general contractor also needs to check the project information to avoid the final cost overrun due to the wrong information.

4.3.2 Countermeasures for procurement risk

Owners and suppliers are the participants of EPC project procurement, and they should be more cautious about the selection of suppliers. Especially for international EPC projects, suppliers may come from abroad and need to be delivered through overseas logistics. General contractors and subcontractors should carefully select overseas logistics carriers to ensure a strict delivery time. The contractor reviews and files the qualification of suppliers summarizes the past transaction experience of each supplier, and regularly examines the actual operation of suppliers. Communication should be enhanced for suppliers developed by the owner to avoid delays caused by miscommunication [16].

4.3.3 Countermeasures for construction risk

More risks of international engineering EPC projects occur in the construction phase, and the occurrence of accidents will inevitably affect the schedule and thus the cost of the project. During the construction process, the review of the project is completed on time, including schedule, cost, safety, and other aspects. Also, because of the need to comply with the local construction, the construction schedule, construction techniques, and control of incoming materials should be negotiated at the beginning of the project.

4.3.4 Countermeasures for another risk

Political factors, natural environment, legal policies, and other factors are important potential risks of the project, which may lead to deeper risks if not given attention. Risk management of international EPC projects should have a comprehensive understanding of the environment and humanities of the project site and be sensitive to political and institutional changes while the project is in progress. Also, consider purchasing commercial insurance for procured materials to reduce losses due to other risks. A more effective way is to select subcontractors with local resources to learn more about changes in local policies, etc.

5. Conclusions

International EPC projects as a general contractor are responsible for the quality and schedule of the project is very different from the ordinary delivery method, usually, the project scale is large, and the requirements of the general contractor are higher. The risk management of the project requires the owner and the general contractor to join hands to control the project to meet the project objectives. Risk management needs to start from design, procurement, construction, and other aspects to do the corresponding risk prevention to better complete the project.

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