

Original Article: Risk Management in EPC Projects



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ABSTRACT

In this article, while reviewing the "EPC" contracts and the different stages of risk management according to the "PMBOK" standard, a general proposed model for this type of contract is presented, in which the necessity of planning and managing risk in the stages before winning the tender and after winning and signing the contract has been examined and considered. In recent years, the construction market has moved towards contracts in which the final amount and the time of completion of the work are guaranteed. Risk management knowledge, as a subset of project management knowledge, has gradually become a source of influence with such developments. The "PMBOK" standard has divided the risk management process into 6 stages: risk planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response and risk control. The proposed model in this research is that the contractor must implement stages 1 to 4 of risk management before bidding and after signing the contract, perform the 6 mentioned stages. In this model, the results of the pre-bid risk management review can be used as input to the post-contract phase. The six risk management phases operate like a cycle and are similar to a trial and error method. Initially, the work phases begin with limited parameters. As the project progresses and more details of the work are identified, the impact of risks on more activities must be considered and more risks become apparent, so risk management needs to plan, identify, analyze, respond to, and control new risks over a specific period of time. Methods were also proposed and reviewed for the risk planning and risk identification phases, so that EPC contractors can more easily review and manage risks in these types of contracts.

Introduction

The word risk comes from the Italian word "RISCARE", which is the equivalent of the English word "To VENTURE". This concept implies taking risks in making informed decisions. On the other hand, the basis of risk concepts is also in the stochastic planning method [1]. The first formal project planning method that incorporated project risk and uncertainties

related to the timing of project activities into planning was the planning network structure (Project "PERT" Evaluation & Review Technique), which emerged in the late 1950s for the implementation of the Polaris missile construction and launch project. In the late 1960s, probabilistic models of the decision tree structure derived from Marco processes were proposed [2]. The Graphical "GERT" Evaluation & Review Technique model is the term used to

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describe this type of model. This model allows activities to be defined throughout the project life cycle and at different times, in other words, the existence of activities can also be expressed in a probabilistic manner (3).

The Project Management Institute (PMI) was founded in 1969 with the aim of gathering the experiences and records of various management environments. During a seminar in Montreal, Canada in 1976, the association proposed the idea of documenting experiences in the form of a standard, which became the beginning of explaining "project management" as a profession.

In the 1980s, a document entitled: "Project Management Body of Knowledge" (PMBOK) was published. Again in 1991, a plan to update this document was proposed. "PMBOK" has been the standard for implementing professional project management since 2001 (4). Risk management is one of the nine main branches discussed in the Project Management Body of Knowledge Guide, which has been approved by the American National Standards Institute (ANSI) [5].

It can be said that especially in our country, risk management knowledge is among the relatively new and fresh topics that there is a lot of research space on it. Many standards and criteria have been defined for risk management, which are general and general, but risk management for various types of projects can be examined in a more specialized and detailed manner. In this article, the authors, using experiences gathered in several "EPC" projects, as well as using face-to-face interviews and questionnaires, have sought the opinions of officials, managers, and experts, and by analyzing those opinions, have presented models for examining and managing risk in "EPC" contracts according to the "PMBOK" standard.

Brief Introduction to "EPC" Contracts

Over a long period, projects were executed by two actors (client and builder). In the 1900s, as design knowledge increased in complexity and sophistication, especially in the years after World War II, the three-actor method (client, consultant, and contractor) for executing such projects spread. This method became the conventional or traditional method for the generation of engineers trained in later periods. In the 1970s and 1980s, a modified form of this method called management contracting or management of construction emerged in Europe and America, and in the mid-1990s, a new two-actor method called "combined design and construction" became popular. At the dawn of the twenty-first century, this method was considered the optimal solution for some projects (8). In design and construction, the contractor, in addition to supplying the necessary goods and equipment and constructing it, is also responsible for conducting detailed design studies. In a more developed version of this method, the responsibility of the designer-builder contractor extends to the stage of preliminary supplementary studies. This type of method is called an "EPC" contract. "EPC" includes three main concepts: "Engineering", "Procurement", and "Construction". Carrying out projects in the "EPC" form has advantages over the traditional method, some of which include the following (5):

- ✓ Reduction in project completion time.
- ✓ Certainty of time and cost.
- ✓ Increase in the ability to build designs.
- ✓ Reduction in claims and lawsuits.
- ✓ Construction flexibility.
- ✓ Possibility of financing from non-governmental sources.
- ✓ Cost reduction.

Risk in EPC Contracts

FIDIC-type contracts have been widely used for the execution of civil, electrical and mechanical works over the past several decades and have been noted, among other things, for their observance of the principles of balanced risk sharing between the employer and the contractor. The principles of balanced risk sharing continue to be included in the new books or contracts for the execution of "construction works" and "equipment and design". In "EPC" projects, the contractor assumes responsibility for a wider range of risks than in traditional FIDIC-type contracts. To ensure greater certainty about the final amount, the contractor is often asked to examine all possible risks and to bring what the employer has prepared as its conditions to a conclusion in accordance with the intended objectives. If the contractor is to assume these risks, it is clear that the employer must, before asking the contractor to sign a fixed-price contract, give him sufficient time and opportunity to receive and examine all relevant information and to include the cost of the risks in his pricing (6). The General Conditions of EPC Contracts have been prepared by the National Planning and Management Organization. It divides the risks between the employer and the contractor as follows:

A) Employer's Responsibilities in Accepting Losses (RISKS): The employer's responsibilities in accepting losses are as follows:

- 1- Occurrence of force majeure such as war, riots, nuclear radiation, outbreak of infectious diseases, etc.
- 2- Exploitation and possession of all or part of the works by the employer, or third parties, and the occurrence of risks not caused by the contractor's negligence [7].
- 3- Errors in the drawings, technical documents prepared by the employer, or errors in the

basic design information submitted by him to the contractor or delays in their delivery.

- 4- Losses resulting from the execution of parts of the work by the employer.
- 5- Failure to fulfill contractual obligations by the employer, or any of the factors attributed to him.
- 6- Changes in domestic laws and regulations that significantly lead to an increase in the cost or time of execution of the work [8].

B) Contractor's responsibilities in accepting losses and damages (RISKS):

The contractor's responsibilities in accepting risks and damages include all responsibilities included in the contract and accepting all types of risks and damages, except for what is specified as the employer's responsibilities in Article 71. The following are among the risks accepted by the contractor:

- 1- The contractor is responsible for compensating for any damage caused to third parties or their claims in matters related to the subject matter of the contract, and he is obliged to respond and compensate for the damages and keep the employer safe from such claims and damages.
- 2- Despite the transfer of ownership of the materials and equipment to the employer from the time of packaging or loading, the responsibility for the care of all equipment and materials lies with the contractor in accordance with Article 1-72 [9].

Carrying out a project using the "EPC" method has many similarities with traditional methods. When the employer intends to carry out all stages of design and engineering, procurement and implementation together, he holds a tender to select a contractor. A successful "EPC" contractor is a company that has a risk management group along with other specialized groups from the very beginning. Because:

1- As mentioned, in "EPC" contracts, the employer delivers the entire work to the contractor at a fixed price and transfers the risks in the project to the contractor. The presence of a risk committee before the tender allows the risks in the project to be reviewed and the contractor, considering the acceptance of the risks, applies a coefficient called "risk coefficient" implicitly to its proposed price [10].

2- Deterministic planning is not suitable for "EPC" projects. Because it is very unlikely that the contractor will be able to accurately predict the amount and time of project completion at the beginning of the work. Therefore, the presence of the risk committee before the tendering process causes a time and financial range to be provided using the stochastic method, so that the project management can determine what percentage of probability there is that the project will be completed with a certain amount of riyals and at a certain time.

3- One of the important stages of the risk management process from the perspective of the "PMBOK" standard is risk management planning. This planning will be successful if the contractor's strategy before participating in the tender and after winning and starting the project operations is the same. This requires that, first, the risk committee be present before participating in the tender and, second, that the same risk committee is also responsible for managing the risk of project implementation. By documenting the opinions of the risk owners before the tender, the risk analyst ensures that each person accepts responsibility for their financial and time forecasts during the work, and if, for example, an activity is carried out with a delay in time or costs more than predicted, there should be a body called the risk committee to investigate whether the initial forecast was incorrect or whether other factors caused the delay in time or increased cost of that activity. Therefore, risk

management can be applied in two stages before the tender and after winning the tender. For risk management planning, the formation of a risk committee as a subset of project management is recommended. At this stage, the risk analyst should identify the risk owners based on the organizational chart and his knowledge of the company's structure. The risk analyst can be a member of the company's personnel or a natural or legal person as a consultant to the EPC contractor company. Risk owners must be members of the contracting company and be accountable for the decisions and opinions they have made before the contract is signed, during the execution stages of the work [11].

Various options have been proposed to select the characteristics of risk owners, and according to the results of statistical questionnaires completed by experts, the following results can be obtained:

The three important and major departments (engineering, procurement and implementation), which are the three main pillars of "EPC" contracts, must have representatives as risk owners in the risk committee. Because most of the risks are related to these three stages.

The project control unit must also have a representative in the risk committee. Because the project control and risk management units have many similarities and a two-way relationship must be established between them, so that the risk management input information is provided by the project control group's schedule, and also to update the schedule, the project control group needs risk management information.

Contracts affairs must also have a representative in the risk committee. Because, considering the newness of EPC contracts, the people responsible for contracting the contract must have sufficient information about the

general and private conditions of EPC contracts [12].

The experience and expertise of the price estimation group is also very decisive. Because the amount of EPC contracts is fixed and the error of the measurement and estimation group is irreparable. Therefore, the presence of a representative of this group in the risk committee is also recommended.

Financial units and departments that are responsible for providing project liquidity should also have representatives in the risk committee. Because in many large EPC projects, the contractor provides temporary financing for the project. The importance of the existence and timely circulation of money for the contractor company is very high. If there is no adequate liquidity to advance the work, there will be disruption in the implementation of project activities. In general, considering the above, the presence of the following specialists as risk owners in the risk committee can be recommended as a necessary condition:

- ❖ Engineering.
- ❖ Procurement.
- ❖ Execution.
- ❖ Project Control.
- ❖ Contractual Affairs.
- ❖ Measurement and Estimation.
- ❖ Finance and Cash Flow (5).

Providing a Suitable Model for Identifying Risks in "EPC" Contracts

Risk identification is a repeatable process. It is first carried out by selected individuals from the project group or the project risk management group and then by a larger number of project individuals, especially the main project owners. Risk identification is probably the most difficult and important part of the process, risk management. Because if a risk cannot be identified, this risk is excluded from future analysis and probably no measures will be taken for it. "PMBOK" divides the risk

identification process into the following three stages. The necessary input for risk identification, which includes the following:

- ❖ Risk management plan.
- ❖ Other planning results.
- ❖ Risk types.
- ❖ Historical records.

Techniques and tools required for risk identification, which include the following:

- ❖ Document review.
- ❖ Information collection techniques.
- ❖ Control forms.
- ❖ Assumption analysis.
- ❖ Diagram techniques.

The results of risk identification, which include the following:

- ❖ Potential hazardous events.
- ❖ Risk indicators.
- ❖ Input from other processes.

At this stage, the potential risks arising from the different stages of the implementation of an "EPC" project should be identified. Risks can be divided into threats and opportunities. Threats include negative impacts and opportunities include positive impacts on time, cost and quality of work. In classifying opportunities and threats, different approaches can be taken depending on the type of expectation from calculations or the nature of the project:

- ❖ Classification based on organizational units including commercial, financial, technical, contracts, warehouse, etc.
- ❖ Classification based on the nature of risks including technical, managerial, organizational, external, etc.
- ❖ Classification based on the nature of operations including contractual, design, preparation, etc [13].

The degree of breaking uncertainties into opportunities and threats continues to the extent that:

- ❖ It is possible to distinguish opportunities from threats.
- ❖ It is possible to analyze opportunities and threats.

In "PMBOK", the types of risks are classified as follows:

- ❖ Technical, quality and performance risk.
- ❖ Project management risk.
- ❖ Intra-organizational risk.
- ❖ External risk.

In "EPC" contracts, such risks mainly exist in the three main parts of this type of contract, namely engineering, procurement and construction. In addition to these three main parts, the stage of participating in the tender and providing the correct and achievable price and execution time are very important in this type of contract.

In this regard, the groups of meters and estimates and contract affairs are very involved. Therefore, the risks of this part should also be considered. In many "EPC" projects, the contractor is responsible for financing the project temporarily and in short periods between the completion of the work and the receipt of the performance fees. This issue also has risks that can have very important effects on the project implementation process. If risks are identified in "EPC" contracts that are not within the framework of the above categories, such risks can be defined in a set called miscellaneous risks.

Case Study of a Mini Refinery Project in Iran

With a case study of a mini refinery project, which is an example of an "EPC" contract, and using interviews with relevant managers and officials, the risks identified in this project are as follows. To avoid making the article too long, the most important risks identified have been considered and risks with low financial and time effects that are also unlikely to occur have been avoided.

A) Important risks in contract estimation:

- ❖ Error in the initial contract estimate by the employer.
- ❖ Error in the contractor's estimate for participating in the tender and providing incorrect amount and duration.
- ❖ Error in the main contractor's estimate for the contract with subcontractors.

B) Risks from the time of tendering to the start date:

- ❖ Delay between the contractor's proposed price and the start date.
- ❖ Delay in the contract signing date.
- ❖ Delay in handing over the land to the contractor [14].

C) Important risks of the engineering (design) sector:

- 1- Receiving incomplete or in some cases incorrect information from an external partner.
- 2- Design errors in units within the company.
- 3- Design errors of sub-consultants.
- 4- Structural calculation error.
- 5- Facility calculation error.
- 6- Inconsistency of structural and architectural drawings.
- 7- Inconsistency of civil and facility drawings.

D) Important risks of the procurement sector:

- 1- Delay in the arrival of materials and equipment for implementation.
- 2- Delay due to technical inspection.
- 3- Equipment manufacturing error.
- 4- Sudden change in the price of some materials and equipment.
- 5- Scarcity of some materials and equipment in the market.
- 6- Instability in the management system of equipment manufacturing plants.
- 7- Lack of proper feasibility study for selecting manufacturing companies [15].

E) Important risks of the implementation sector:

- ❖ Delay in handling the temporary and final status report, adjustment of the main contractor and subcontractors.
- ❖ Delay in subcontractor contracts.
- ❖ Inability of subcontractors.
- ❖ Lack of safety in the workshop and loss of life and property.
- ❖ Errors in the implementation of foundations.
- ❖ Errors in the implementation of metal or concrete structures.
- ❖ Errors in the hardening stage.
- ❖ Errors in the finishing stage.
- ❖ Errors in electrical, mechanical and piping sections [16].
- ❖ Errors in equipment installation.
- ❖ Errors in concrete, soil and asphalt tests.

F) Important risks in the financial sector:

- ❖ The existence of numerous problems in financing the project.
- ❖ Delays in paying the statements of the main contractor and, consequently, the subcontractors.
- ❖ The ambiguity of some contract provisions.
- ❖ Inflation and price increases.
- ❖ Delays in extending the "LC" due to political reasons.
- ❖ The ambiguity of the insurance issue of some subcontractors.

G) Other risks

- 1- Errors in project planning and control.
- 2- The existence of administrative bureaucracy and lack of coordination between the parts involved in the project.
- 3- Changes in key personnel and skilled workers of the company.
- 4- Unexpected events (earthquake, flood, war, etc.).
- 5- Delay due to weather factors.

6- Delay due to political developments and issues in the country.

After identifying the risks, the qualitative risk analysis stage comes. In the Tabas Coal Project case study, the probability and impact ranking matrix method was used. In the next stage, a quantitative analysis of the identified and prioritized risks was carried out, and finally the degrees of probability of achieving the project's time and cost objectives were determined [17].

Risk Allocation Using Contingent Contracts by SPV

In the risk management process, the identified risks are transferred to the designated partners as much as possible. Lenders have a comprehensive approach to the allocation of risks between different actors. This is clear from the set of lenders' contracts with SPVs. Lenders are looking for clients and SPVs are ready to allocate their risks using a set of preliminary contracts and cover the remaining risks with insurance. This method depends on risk coverage, so the lender may want some changes and therefore negotiate the contracts. In this case, renegotiation can lead to the lender entering into a direct contract with some of the partners involved. In any case, complex situations may arise in the project for which a solution is not foreseen by the lenders in the contract. If these risks pose a crisis to the success of the project, the following solutions are considered for them:

- ✓ Stop financing until the issue is resolved.
- ✓ The resolution of the issue is postponed until financing is terminated, provided that the credit agreement includes a performance bond.

Supply Chain Risk Allocation: Put-or-Pay Contracts

To cover and eliminate supply chain risk, unconditional contracts are concluded with

suppliers, these contracts are called Put-or-Pay contracts. According to this contract, the supplier sells a certain volume of input to the SPV at a predetermined price in the regulatory contract. If the supplier breaches the contract and demands a higher price from the SPV due to increased costs and the SPV does not accept, the supplier must introduce a replacement supplier to the SPV [18].

Operational Risk Allocation: Operation and Maintenance (O&M) Contracts

Operational risks can be reduced by reputable and experienced executors, as O&M contracts tend to use two solutions for operational risk management:

1- Fixed Price Contract: In this contract, the executor assumes the risks associated with fluctuations in execution costs and profitability. Profitability occurs when the actual costs of loss are less than the actual price.

2- Transfer contract: In this contract, the executor receives a fixed amount plus a performance bonus, and in this case, the SPV pays the executor's costs. In these contracts, the level of return is fixed and if the return does not reach a certain level, the executor is penalized. As a supplementary guarantee, the lender requests the right to intervene in the project, so that if it wants, it can remove the main executor or replace it with another company. This is a type of direct contract that is concluded between the bank and the different partners of the SPV [19].

Market Risk Allocation

Hedging market risk in projects is a crucial issue in project financing. This is because it reduces or eliminates market risk. This is because market risk can cause the SPV to be unable to repay its cash flows or cause volatility in the SPV's cash flows. It should be noted that this hedging is not always possible. This is only

possible when there is only one unique buyer for the goods or services, but when dealing with the retail market. It is completely impossible to hedge market risk. For example, in the power industry, it is easy to conclude long-term contracts with buyers or energy users, but in the transport and tourism sectors, the situation is very complex and it is not easy to completely eliminate fluctuations in traffic and tourist flows, so the solution is to use sponsors:

- ✓ Sponsors can measure reactions to specific conditions by performing sensitivity analysis.
- ✓ Sponsors try to limit fluctuations in demand and do this through contracts they enter into with specific partners.
- ✓ Sponsors can use the power of public opinion to ensure a minimum level of return in these markets.

Allocation of exchange rate, interest rate and inflation risk

To manage exchange rate and interest rate risk, modern financial instruments such as options, futures, forward contracts and swaps are used, but in Iranian conditions it is not possible to use these instruments fully, so we will briefly review them. Because they can be used for foreign projects:

1- Option: An option is an agreement between the assignor and the acquirer, giving them the right to buy or sell a pledged asset. In this way, the acquirer (the holder of the option) will have the right to buy or sell a specific asset, whether financial or non-financial, at a specified price and on a specified date in the future. In project financing, options are used to hedge exchange rate risk and protect SPV cash flows against interest rates.

2- Futures contract: A futures contract is an agreement between the parties to a contract to carry out a transaction at a specific time in the future, with the quantity of the commodity and

its price also specified in the contract. In this contract, the parties adjust the contract based on their personal knowledge and their needs and desires, and since the futures contract is not standardized, the contract is concluded based on the opinions of the parties for all assets [20].

3- Forward rate contract (FRA) or interest rate futures contract: It is a type of futures contract that was created in 1983 by the banking system. This contract was created in London banks and British bankers are still among the major traders in this market.

4- Interest rate futures contract: It is derived from the futures contract in the future. This contract is common between large banks and based on which one bank agrees to invest in another bank.

5- Futures contract on exchange rate: The foreign exchange market, like the commodity market and other markets, is also subject to price changes. These changes create exchange rate risk for market participants, which can be covered by futures contracts.

6- Futures contract: A futures contract is a standardized type of futures contract. In this contract, the delivery of goods and payment for their price are made at a future time, and everything is defined regarding the nature and price of the goods at the time of the contract.

7- Cross-border contract: In a cross-border contract, a set of cash flows at a fixed rate and a set of cash flows at a floating rate are crossed with each other. In this way, people who seek to avoid price fluctuations choose the fixed cash flow, and other market participants who use these opportunities by accepting risk due to their profession choose the floating cash flow. Among the strike contracts are the interest rate strike contract and the exchange rate strike contract:

A) Interest rate strike contract: A strike contract can exchange a set of fixed interest rate payments for a set of floating interest rate

payments based on the LIBOR rate or another reference rate [21].

B) Exchange rate strike contract: An exchange rate strike contract is a bilateral contract for the exchange of two different currencies. Exchange rate strike is also defined as a currency strike.

C) Inflation rate strike contract: Inflation rate strike contracts concluded with a hedging bank are used to hedge inflation risk.

Using insurance to hedge risk

Insurance instruments can be used to cover other risks such as environmental risk, regulatory risk, legal risk, and credit risk [21].

Conclusion

The successful implementation of a project depends on a careful analysis of possible risks in adverse conditions throughout the economic life of the project, and until the project is operational, risks can erupt during each phase of the project. In addition to the ability to pay debts, each project must also have appropriate profitability. The existence of various risks can affect the cash flows of the project, which, if not controlled, leads to a shortage of liquidity, and if this shortage of liquidity is so great that creditors' claims cannot be paid, the project will fail. Therefore, risk analysis is a very important factor in the success and outcome of the project.

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