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Effective Risk Analysis for Delivering Overseas Engineering-Procurement-Construction Projects In an Unexplored Market

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Abstract: *The management of overseas engineering-procurement-construction (EPC) projects in an unexplored market is prone to risks. Risks can occur because of the business entity's lack of adequate overseas environmental information and local execution experience. Hence, the application of a suitable methodology to deliver EPC projects and the identification and the control of the potential risk factors in a new environment is important. In this paper, the author first presents a hierarchical structure of risk classifications with the identified risk factors that might occur during project execution. Second, preventive countermeasures in view of the identified main risk factors are discussed. Third, the cause-effect relationships among the critical success factors (CSFs), project risk management, and EPC project performance are systematically investigated by establishing and testing an input, tool and technique, and output (ITTO) conceptual model to deliver EPC projects. With the support of data collected from experienced EPC contractors through survey questionnaires, the results provide empirical evidence that proves the existence of a close link and a strong influence among the CSFs, project risk management, and EPC project performance. On the basis of risk analysis, this article provides reference points for the risk management planning of overseas EPC projects in an unexplored market.*

Keywords: *Engineering-procurement-construction (EPC), Risk factor, Critical success factors (CSFs), Input, tool and technique, output (ITTO)*

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I. Introduction

The engineering-procurement-construction (EPC) approach is being increasingly adopted by public and private organizations. EPC has become a favored construction project delivery mode that combines engineering, procurement, construction, pre-commissioning, and commissioning services in one contract (Migliaccio 2009; Hu and Zhou 2011). By applying the EPC approach, clients expect an EPC contractor as a single entity to be responsible for the project execution up to its completion (Park 2009; Du et al. 2016). In the context of internationalization, EPC contractors are directly exposed to special risks due to the differences among countries and regions. These risks include exchange rates, religions, customs, cultures, resources, politics, and decrees (Ogunsanmi et al. 2011; Peckiene et al. 2013). The risk management of EPC contractors may directly affect their overall power of execution, especially when they are in an unexplored market where they have no previous operating experience. Uncertain risk factors may lead to difficulties in project execution (Mulcahy 2010). The execution could be characterized by comparatively complicated dynamic changes. Hence, transnational engineering companies should rely on their systematic risk management scheme to properly control or cope with complicated and dynamically changing risk factors.

Limited research has addressed the relationships among the inputs, the tools and techniques, and the outputs (ITTO) related to the delivery of EPC projects. Few studies focus on the newcomer's identification and control of potential risks in an unexplored market. Hence, this paper aims to fill this significant literature gap by using a systematic review methodology to investigate and test the cause-effect relationships among critical success factors, project risk management, and EPC project performance. An ITTO model of delivering EPC projects and a comprehensive risk management method are introduced. A hierarchical structure for classifying the various sources of risk in unexplored markets is presented. Following this, the identification of potential risk factors is investigated. Then, an effective risk assessment technique, which combines a risk probability analysis with a risk impact assessment, is introduced. The risk response techniques for EPC projects are also examined, and countermeasures for risk allocation among projects are suggested.

II. Conceptual Model of Delivering EPC Projects

2.1 Literature Review

EPC projects are prone to risks that are influenced by a number of external and internal factors. Risks are prevalent in all aspects of overseas EPC projects, particularly in an unexplored market (Zhi 1995; Yeo and

Ning 2002). EPC contractors should examine the risk factors in the environment and in their organizations from a broad perspective to include all possible risks in the future (Yang et al. 2010; Zou et al. 2010). Risks must be avoided, reduced, transferred, or accepted, but not ignored (Peckiene et al. 2013). Choudhry et al. (2014) stated that projects should have backup plans for the possible occurrence of risks. These plans should include the anticipation, reduction, and the provision of a response for negative events that may or may not occur. Risk management is one of the ten knowledge areas in project management per the project management body of knowledge (PMBOK).Risk management is important because it provides a chance for project team members to review and control the potential risks of the entire project (PMI 2011). The review of risk factors can be made by means of a workshop where the stakeholders can communicate and better understand and assess the risks that can cause potential problems. Thereafter, they should identify a reasonable response to monitor and control risks (Chapman 2001). As Oztas and Okmen (2004) stated, risk management is a continuous and iterative activity that should be performed throughout the tender preparation and project execution stages. In addition, critical success factors (CSFs) are used as guidelines or philosophies that govern the management behaviors and drive the risk management process to deliver EPC projects (Alias 2014; Akram and Pilbeam 2015). CSFs can improve the effectiveness of risk management by drawing the attention of the management to key activities and tasks. Oehmen et al. (2014) prepared a list of specific risk management practices related to CSFs through literature reviews and interviews with experts. The International Standardization Organization (ISO 2015) states that CSFs link a risk management framework and practice to its strategic goals of delivering EPC performance and properly aligning project activities. Table 1 lists the key papers that describe project risk management and CSFs, which compares the knowledge gap and insufficiency required for previous studies. The analysis methods of these previous studies are also described. Hence, a comprehensive study such as this present research might be required for reference.

Table 1 Key Papers for Project Risk Management and CSF

Author(s)	Research Objective	Problem Solving					Analysis Method
		External and Internal Risks	Model	Risk Classifications	Countermeasures	CSFs	
Du et al. (2016)	Cause-effect relationships among partnering, risk management, and organizational capacity	V	V	-	-	V	Questionnaires
Zhi He (1995)	Identify and control vital risk factors in an overseas project	V	-	V	V	-	Qualitative risk analysis
Ling and Hoi (2006)	Identify risks and risk response	V	-	V	V	-	Interview questions
Tang et al. (2007)	Risk management from the perspectives of various project participants	Internal risk	-	V	-	-	Questionnaires and interview
Ogunsanmi et al. (2011)	Risk classification	V	-	V	-	-	Questionnaires
Hu and Zhou (2011)	Identify and reduce risks	V	-	V	V	-	Qualitative and Quantitative risk analysis
An and Shuai (2011)	Risk analysis and countermeasures in EPC projects	Internal risk	-	V	V	-	Qualitative risk analysis
Peckiene et al. (2013)	Risk allocation	V	-	V	V	-	Qualitative risk analysis
Akram and Pilbeam (2015)	CSF for effective risk management	V	V	-	-	V	Literature review
Alias et al. (2014)	Identify the extent of the relationship between CSF and project performance	Internal risk	V	-	-	V	Framework
This Study	*ITTO model to deliver EPC projects *Cause-effect relationships among CSF, project risk management, and project performance *Identify risk factors and suggest countermeasures	V	V	V	V	V	Questionnaires and Qualitative risk analysis

The above viewpoints see EPC contractors as open systems that can take input from the CSFs, use project risk management as an effective tool and technique, and convey the fulfilled projects as the output to meet the EPC project performance. A conceptual model (Figure 1) has been proposed by the author to aid in understanding the ITTO relationships among critical success factors, project risk management, and EPC project performance, which achieve the EPC project objectives, including quality, schedule, cost, and scope.

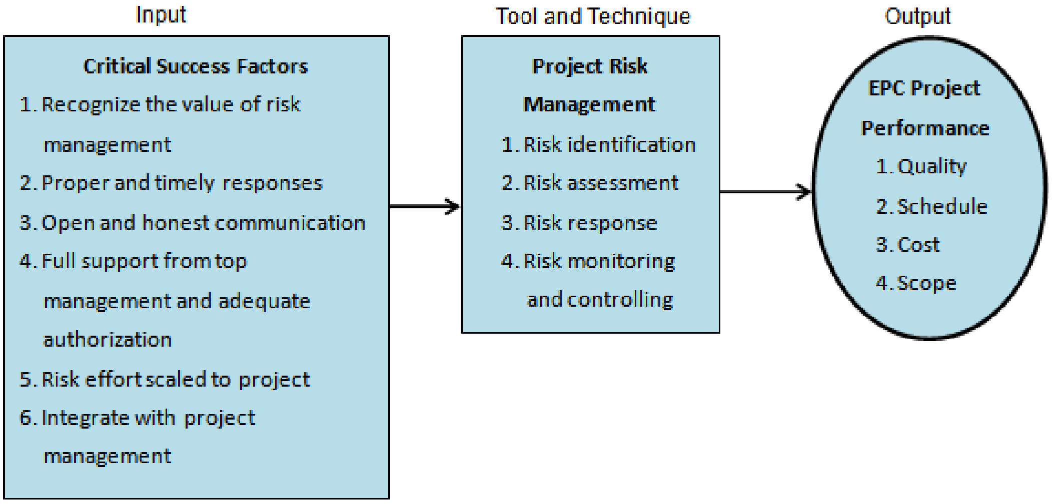

Figure 1 Conceptual model for delivering EPC projects

2.2 CSFs

Many studies employed the CSFs concept for construction projects. To ensure that risk management will continue to provide the strategic and operational values that will improve EPC project performance, the risk management process has to be supported by certain CSFs that will ensure project success (Osei-Kyei and Chan 2015).

The main CSFs identified by Project Management Institute (PMI 2009) include the recognition of the value of risk management, individual commitment and responsibility, open and honest communication, organizational commitment, scaling of risk effort to project, and integration with project management. These identified factors are also supported by other researches. CSF1: Recognition of the value of risk management (Akram and Pilbeam 2015) - Project risk management is deemed valuable and beneficial to the organizational management, the internal and external stakeholders, the project management, and the project team. CSF2: Proper and timely responses (Fang et al. 2015)- Risk management is the duty of everyone. Thus, all project participants and stakeholders cannot avoid responsibility and they must do their best to take proper and timely responses to prevent potential risks. CSF3: Open and honest communication (Tang et al. 2006) - Everyone must participate in risk management directly or by providing effective decisions to prevent any action or behavior that may cause communication barriers. CSF4: Full support from top management and adequate authorization (Alias et al. 2014) - Risk management must be consistent with organizational goals and values. Senior executives should take charge of project risk management because various risk countermeasures or response policies must be reviewed and approved by the project manager or the upper management. Risk owners shall act on the countermeasures upon receiving adequate authorization of top management. CSF5: Scaling of risk effort to project(Osei-Kyei and Chan 2015) - Project risk management activities should be consistent with the value of the project to the organization. The level of project risk, its scale, and other organizational constraints should also be considered. For example, the cost of project risk management should be directly proportional to the contribution value of the project management to the organization. CSF6: Integration with project management (Alias et al. 2014) - Project risk management should interact with other project management processes and must be correctly performed. This approach is the way to ensure the success of projects.

CSFs are inputs to project management practice which can lead directly or indirectly to project success. CSFs are always considered as one of the vital ways to improve the effectiveness of project risk management and project performance.

2.3 Project Risk Management

Project risk management aims to reveal uncertain risk factors and allows the management to incorporate the possible risk consequences into their plan before and during the project execution. Mulcahy (2010) believed that the purpose of risk management is to make promises before losses and to ensure a satisfactory recovery after losses. ISO (2015) stated that risk management is a method of response that minimizes the adverse outcomes that arise from risks. KarimiAzari et al. (2011) believed that risk management aims to manage negative risks, control uncertainties, and exploit positive risks (opportunities). The objectives of project risk management are to increase the probability and impact of positive events, and to decrease the probability and impact of negative events in the project.

Du et al. (2016) stated that EPC activities in overseas markets, especially in an unexplored area, are much riskier than in a domestic or overseas location where the contractor had previous experiences because of the many variables that are affected by the unknown environment. EPC contractors must address a variety of risks that could arise from many uncertainties in their bidding, contracting, design, procurement of equipment and bulk materials, and construction. EPC contractors must also consider the location's economic, political, and social environment, and industry technology issues, and they must use their management techniques to monitor and control the potential risks that might occur (Park et al. 2009; Migliaccio et al. 2009; Ou-Yang and Chen 2019).

2.4 Risk Classification

A systematic framework for classifying risks in overseas EPC projects is necessary, because the risk factors cover significant areas and are accompanied by complicated associations (Ogunsanmi et al. 2011). Risks are generally classified in terms of initial sources: the external and internal aspects of an overseas EPC project. The external risks are those factors that relate to the project background or the industry technology that might have significant impacts on the project. The internal risks are those uncertainties that might arise from the project stakeholders involved or in any event during the project operation (Zhi 1995).

At the project background level, the risk factors can be classified into six categories (Hu and Zhou 2011; CTCI 2018): country and region, economic and financial situation, political situation, social environment, culture, and project characteristics. The risk factors at the industry technology level can be divided into four sub-levels (Ogunsanmi et al. 2011): technical application, differences in codes and standards, applied local law and regulation, and differences in the contract system. The risk factors at the project stakeholders' level can be grouped into six categories (Tang et al. 2007; Yang et al. 2010): clientsincluding project management consultant (PMC), partners, vendors (including suppliers and sub-contractors), government offices, community and public, and project team members. The risks at the project operation level are those directly associated with the project execution and can be grouped into five categories (CTCI 2018): project management, engineering design, procurement services, construction works, and pre-commissioning and commissioning works. The detailed structure of the classification integrated by the author is illustrated in Figure 2.

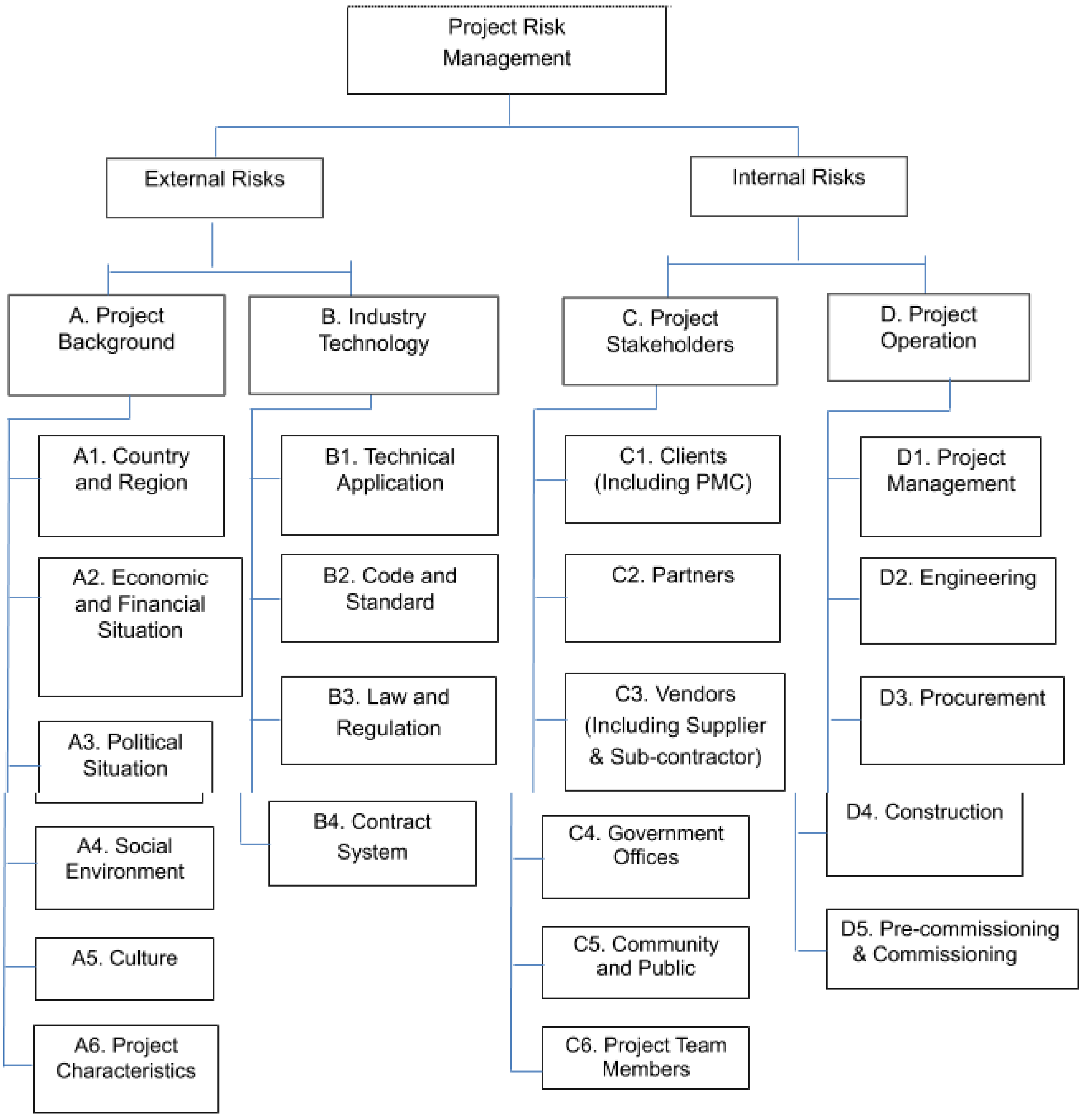

Figure 2 Risk identification hierarchy for overseas EPC projects

2.5 Risk Identification

Identifying the risks in an unexplored market is important. Figure 2 lists the general factors in line with the four risk classification groups above, and Table 2 lists the detailed identified project risk factors that may occur in an unexplored market for an overseas EPC project. These factors were researched in many previous studies (Tang et al. 2007; Tsai and Yang 2010; Hu and Zhou 2011; An and Shuai 2011; Ou-Yang and Chen 2017) and have been discussed in workshops with experienced EPC team members.

Table 2 Identified project risk factors in an overseas EPC project

A1. Country and Region A1.1 Unfamiliar or new country / region A1.2 Unfamiliar local market conditions A1.3 Area Turbulence **A2. Economic and Financial Situation** A2.1 State of overall economy A2.2 Taxation effects	B1.2 Inexperience technology B1.3 New quality requirement **B2. Code and Standard** B2.1 Specification incomplete or misleading B2.2 Unclear spec. or regulations **B3. Laws and Regulations**	**C2. Partners** C2.1 Ability to meet commitment C2.2 Unstable financial problems C2.3 Disharmony of relationship **C3. Vendors** C3.1 Availability C3.2 Poor cooperation of nominated vendor C3.3 Schedule slippage C3.4 Bankruptcy, financial problems C3.5 Claims, variation	**D1. Project Management** D1.1 Schedule delays problems D1.2 Cost overrun problems D1.3 Product defect problems **D2. Engineering** D2.1 Incomplete basic design data D2.2 Difficult

A2.3 Actions by competition A2.4 Inflation A2.5 Currency stability and rate variation A2.6 Fluctuation A2.7 Working capital requirements **A3. Political Situation** A3.1 War, revolution, civil disorders **A4. Social Environment** A4.1 Government/policy inconsistency A4.2 Government/policy intervention A4.3 Stability **A5. Culture** A5.1 Language barrier A5.2 Religion inconsistency A5.3 bribe and corruption **A6. Project Characteristics** A6.1 Revamping of the existing plant **B1. Technical Application** B1.1 New unproven technology	B3.1 Incompatible arbitration system and unclear regulation **B4. Contract System** B4.1 Intellectual property rights B4.2 Ambiguous contract problems B4.3 Mandated local participations B4.4 Differences among the contract provisions and the company standard B4.5 Unfamiliar conditions for acceptance and the practical completion date **C1. Clients (incl. PMC)** C1.1 Unfamiliar or new Clients C1.2 Ability to meet contract comm. C1.3 misunderstanding of scope of work C1.4 Client response speed C1.5 Credit, ability and willing to pay C1.6 Attitude for change orders C1.7 Corporate culture and attitude	C3.6 Ability of delivery, skills, quality of equipment, reliability C3.7 Quality and safety attitude **C4. Government Offices** C4.1 Delay processes of permissions approval C4.2 Health, Safety and the Environment (HSE) **C5. Community and Public** C5.1 Public protest and pressure groups **C6. Project Team Members** C6.1 Management/planning/execution inexperience or inability C6.2 Key personnel change or turnover C6.3 Inadequate skills and knowledge C6.4 Spec. not fully reflect contract needs C6.5 Insufficient experienced staffing	design or costly build D2.3 Incomplete site survey information D2.4 Dangers to operate and maintain **D3. Procurement** D3.1 Early purchase problems D3.2 Poor performance of supplier D3.3 Failure of critical vendors D3.4 Heavy and oversize equip. trans. **D4. Construction** D4.1 Unforeseen site conditions D4.2 Unforeseen U/G situations D4.3 Available of special equipment D4.4 Site security D4.5 Poor performance of subcontractors **D5. Pre-comm. & Comm.** D5.1 Unable handover on schedule D5.2 Provisional acceptance certificate not provided by client

2.6 Risk Assessment

Risk assessment is performed to evaluate the effects of risks. The risk items should be assessed with their probabilities and impacts. Probability is defined as the likelihood that a risk will occur. Impact is defined as the risk effect on the project if risk occurs (PMI 2009). All who evaluate risk should use a standard interpretation for their assessment of probability and impact. With the use of a mathematical description, the risk can be described as follows (Zhi 1995; Mulcahy 2010; Gangolells et al., 2010; Ou-Yang and Chen 2017):

$$R = I \times P \qquad (1)$$

Where R is the risk score within［0, 1］, P is the probability of risk occurring within ［0, 1］, and I is the degree of impact of the risk within［0, 1］. From the above risk equation, the score of risk is close to 0 if a risk factor has either a minimal impact or a minimal probability of occurrence. By contrast, if a risk factor has a high impact and a high probability of occurrence, then its score of risk is close to 1. Thescore of risk will fall within［0, 1］, and a large value indicates a high risk of the factor. This process results in a ranking of the risk scores for all the risk factors. No standard risk rating value can be used across all projects, and the rating value varies from one project to another depending on factors such as product, contract value, project duration, project location, complexity of project design, and construction (Oztas and Okmen 2004; Ling and Hoi 2006;

KarimiAzari and Mousavi 2011).

2.7 Risk Response

Project risk management allows the concerned parties to determine an effective and appropriate risk response action in accordance with the priority of a single risk or the overall risk of a project. The most appropriate action subject to the risk attitude of stakeholders should be chosen to prevent risks from occurring and to limit the risk impact within acceptable levels (Ou-Yang and Chen 2019).

2.8 Risk Monitoring and Controlling

Constant or regular risk control is needed when executing the actions in the response plan. Objects that need to be monitored include identified risks, contingency plan, residual risks, new risks, and the response plan that is being executed and its effectiveness in the project life cycle. The outcomes effectively contribute to or benefit the project and other relevant plans, the organization, and its procedures.

III. Research Method

3.1 Data Collection

The questionnaire was chosen as the principal survey method for this study. Forty-one questionnaires were distributed, and thirty-three were collected. Thirty questionnaires were selected as samples for analysis (three questionnaires were not completed). To collect high-quality and unbiased data, questionnaires were filled out by practitioners who are experienced in executing international EPC projects and leading risk management activities. They all had training courses of PMBOK and were aware of the composition of the PMBOK-based project management framework. Approximately 90% of the respondents have more than 10 years of relevant engineering experience, are part of the management team, and hold the post of manager or above. Around 20% of respondents had project execution experience in Saudi Arabia, and others had experience in Southeast Asia areas, such as Thailand, Philippines, Indonesia, and Singapore. The EPC project experience of the respondents who participated in this study is described as follows: 10% of respondents have less than 10 years of experience, 10% of respondents have 10–15 years of experience, 17% of respondents have 16–20 years of experience, 23% of respondents have 21–25 years of experience, 17% of respondents have 26–30 years of experience, and 23% of respondents have more than 30 years of experience.

3.2 Data Analysis Techniques

Statistical Product and Service Solutions (SPSS 22.0) was used to analyze the data collected from the questionnaires. The selected techniques used in this study include the estimation of the sample population mean, the ranking of cases, the internal consistency (reliability) test, linear regression, and path analysis. Cronbach's α is calculated to measure the internal consistency, where an acceptable level of coefficient α in exploratory analysis is 0.7 (Nunnally 1978; Jaccard & Becker 1997; Du et al. 2016). Path analysis has been adopted for inferential analysis of the proposed conceptual model (see Figure 1), with the results tested by using a significance of 0.05 (Du et al. 2016).

IV. Survey Results

4.1 CSFs

The respondents were asked to rate the degree of the six CSFs that were applied to EPC projects by using a five-point scale, where 1 indicates the lowest degree to be applied and 5 indicates the highest degree to be applied. The results are shown in Table 3.

Table 3Application of CSFs in the EPC projects

Critical Success Factors	Mean	Ranking	Cronbach's α
Open and honest communication	4.73	1	0.739
Full support from top management and adequate authorization	4.70	2	
Proper and timely responses	4.27	3	
Integrate with project management	4.20	4	
Recognize the value of risk management	4.17	5	
Scale risk effect to project	3.90	6	
Overall	4.33	-	

The average rating for the six CSFs was 4.33, thereby suggesting that CSFs have been applied to EPC projects by the EPC contractors to some extent. The results in Table 3 show that the scores for "Open and honest communication" and "Full support from top management and adequate authorization" are higher than those for the others. The "Scale risk effect to project" must have a larger room for improvement. EPC contractors should consider how to leverage the risk scales to their project values.

4.2 Project Risk Management

To investigate the project risk management levels of the EPC contractors, respondents were asked to assess the extent to which the risk management tool and techniques were used in the EPC projects. The extent was assessed by using a grading scale of 1 to 5, where 1 indicates a low level of application and 5 indicates a high level of application. The results are provided in Table 4.

Table 4 Application level of risk management techniques

Techniques of Risk Management	Mean	Ranking	Cronbach's α
Risk Identification			
Checklists	4.53	1	0.804
Nominal group technique	3.47	12	
Brainstorming	4.24	5	
Expert interview	3.59	10	
Risk Assessment			
Qualitative analysis	4.28	4	
Quantitative analysis	4.0	8	
Risk Response			
Avoid	3.59	11	
Transfer	3.82	9	
Reduce	4.29	3	
Accept	2.94	13	
Risk Monitoring and Controlling			
Periodic risk status report	4.47	2	
Periodic document	4.18	6	
Risk audit	4.0	7	
Overall	3.96	-	

As shown in Table 4, the “checklists” for risk identification, the “qualitative analysis” for risk assessment, the “reduce” for risk response, and the “periodic risk status report” for risk monitoring and controlling are the most frequently used tools and techniques in risk management. Apparently, risk reduction (reduce the likelihood of risk occurrence/consequences), as the first priority in response strategies, demonstrates the contractors’ emphasis of mitigating EPC project risks.

4.3 Potential Risks in Overseas EPC Projects

The respondents were asked to identify the important risks among the identified 70 potential EPC project risks in an unexplored market (see Table 2). After determining the probability and impact weight of each risk factor from the questionnaires, the combined risk score of each factor was calculated. As shown in Figure 3, a gap existed for the first 15 items among the 70 items. Therefore, this study will focus on the first 15 risk factors as the main analysis items and explore their risk responses and countermeasures in the subsequent sections.The ranking results of the important risk factors are provided in Table 5.

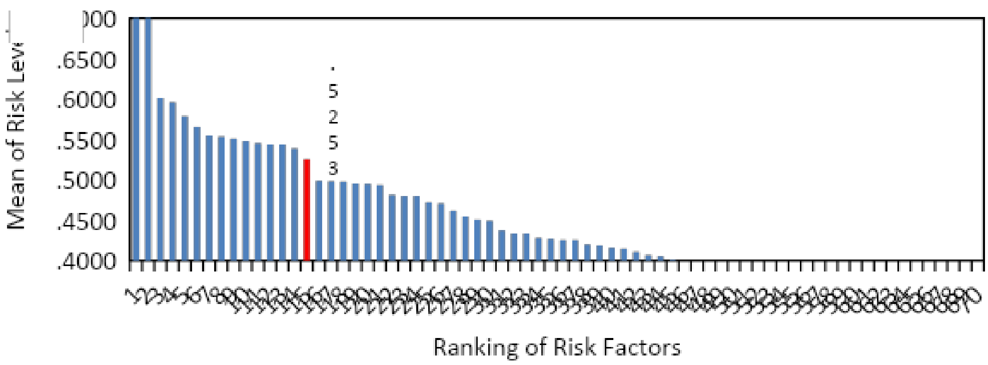

Figure 3Ranking of Risk Factors

Table 5 Perceptions of the respondents on the importance of risks

Risks	Mean of Risk Level	Ranking	Cronbach's α
Unfamiliar or new country / region	.7473	1	0.771
Unfamiliar local market conditions	.7147	2	
Project schedule delays problems	.6013	3	

Delay of review and approval processes of permissions	.5960	4	
Unclear technical specification or regulation	.5787	5	
Ambiguous contract problems	.5653	6	
Vendors' schedule slippage	.5547	7	
Health, Safety and the Environment (HSE) compliance	.5533	8	
Clients' attitude for change orders	.5507	9	
Differences among the contract provisions and the company standard	.5480	10	
Unfamiliar conditions for acceptance and the practical completion date	.5453	11	
Project cost overrun problems	.5440	12	
Revamping of the existing plant	.5440	13	
Currency stability and exchange rate variation	.5387	14	
Inaccuracies or incomplete site survey information	.5253	15	

The results in Table 5 show that project background-related risks were the most important to the EPC contractors, including "unfamiliar or new country / region" (1st), "unfamiliar local market conditions" (2nd), "revamping of the existing plant" (13th), and "currency stability and exchange rate variation" (14th), which are related to country and region, project characteristics, and economic and financial situation. Project operation-related risks were the second most important, as seen in such categories as "project schedule delays problems" (3rd), "project cost overrun problems" (12th), and "inaccuracies or incomplete site survey information" (15th), which are related to project management and engineering. Project stakeholder-related risks were also critical to EPC contractors, including "delay of review and approval processes of permissions" (4th), "vendors' schedule slippage" (7th), "Health, Safety and the Environment (HSE) compliance" (8th), and "clients' attitude for change orders" (9th), which are related to government offices, vendors, and clients. Industry technology-related risks were important to EPC contractors, including "unclear specification or regulation" (5th), "ambiguous contract problem" (6th), "differences among the contract provisions and the company standard" (10th), and "unfamiliar conditions for acceptance and the practical completion date" (11th), which are related to code and standard, and contract system.

4.4 Risk Responses and Countermeasures

The success of the risk management of EPC projects depends on the project planning beforehand. On the basis of risk analysis, a series of expert symposiums (workshops) was held to discuss the preventive countermeasures considering the top 15 risks identified above.

(1) Unfamiliar or new country/region

This factor, which has a high probability and impact, was ranked first. EPC contractors should organize the site survey first before pursuing a project, and they should meet with experienced consultants to adjust the estimation or budget basis. Besides, they can cooperate with local qualified sub-contractors.

(2) Unfamiliar Local market conditions

EPC contractors should consider the availability and the cost of raw material, commodity, labor productivity and availability, and the construction equipment. The influence of local trade unions and local market surveys should also be considered to the project. EPC contractors should consult with experienced consultants.

(3) Project schedule delay problems

The problems may be caused by the following factors: 1) management problems, 2) uncoordinated schedules among the design, procurement, construction, and commissioning teams, 3) late deliverables, 4) material shortage, 5) project changes such as scope, design, field, and execution, 6) seasonal weather influences, 7) unforeseen site conditions, 8) the effect of the interface with other projects, and 9) the design and field rework. To prevent these risks, the project team should develop a practical project baseline schedule approved by the clients. Periodic schedule review meetings should be held to track and discuss the possible impacts, and the countermeasures for any delayed and to be delayed items should be applied.Additional manpower or working hour extension may be considered to catch up on the planned schedule.

(4) Delay of review and approval processes of permissions

During the construction stage, some permits (environmental impact assessment, plant establishment, wastewater disposal, stationary pollution source, construction and miscellaneous activities, demolition, waste soil and construction disposal, and traffic impact assessment, etc.) shall be applied and approved by the government before the site work is started.To ensure that relevant permissions are obtained on time, the EPC contractors should check the local agency or the website of the local authority to collect, understand, and confirm the process, estimate the required time, and determine the documents and fees to accomplish. This application process should be incorporated into the relevant project plan considerations. Outsourcing to a professional agency can also be considered.

(5) Unclear technical specification or regulation

EPC contractors should carefully review the Invitation to Bidder (ITB) and contract to have a clear understanding with the clients. Group study meetings are required from the start of the bidding stage, and senior facilitators are required to chair the meetings.

(6) Ambiguous contract problems

Contract issues can be caused by misinterpretation, misunderstanding, and the improper power of interpretation. To avoid these situations, a group study discussion is required, and it should include a consultation with legal affairs.

(7) Vendors' schedule slippage

The problems may be caused by the following factors: 1) late deliverables, 2) material shortage, 3) poor performance of subcontractors, and 4) labor shortage. To strictly control the vendors' engineering and manufacturing progress, monthly progress review meetings should be held with the vendors via video conference. Shop visits should be considered. Periodic scheduled review meetings should be conducted to track and discuss the possible impacts and countermeasures for any delayed items. Incentives are highly effective in motivating participants to perform excellently (Tang et al. 2006). In addition, supply chain management should be applied to achieve improvement (Yeo and Ning 2002).

(8) HSE compliance

Contractors should fully understand and follow the required regulations of the local government by checking with experienced consultants and incorporate the gathered information into relevant project plan considerations.

(9) Clients' attitude for change orders

Contractors should closely communicate with clients and perform the change management. Any change should be enacted within the contract.

(10) Differences among the contract provisions and the company standard

The understanding of the contract terms between the ITB request and the company standard could be different, but these points are critical and require further clarification among all parties. These points could be the following: 1) payment terms, 2) insurance special provision, 3) guarantee, 4) warranties, 5) liability, 6) force majeure, 7) breach, 8) termination and suspension, and 9) contract change provisions. To avoid future disputes, the contractor needs to review the ITB carefully and to make clarifications to propose deviations and exceptions during the bidding stage. The risk allowance for the rejected deviation and exception items should be considered.

(11) Unfamiliar conditions for acceptance and the practical completion date

The contractor should make clarifications to propose deviations and exceptions if he or she has some concerns that should be addressed with regard to the stipulated completion date and acceptance conditions.

(12) Project cost overrun problems

Project cost overrun problems could be caused by 1) management problems, 2) schedule delays, 3) project changes, such as scope, design and field, 4) inappropriate procurement or contracting strategy, 5) vendors and subcontractors' claims, 6) inexperienced workforce, 7) errors in cost estimate, and 8) unrealistic budget. To avoid this risk, the company can perform value engineering by engineering the design units, conducting a periodic review, and preparing a balance report between the actual and estimated budget. EPC contractors should strengthen their purchasing and subcontracting control and monitoring. Risk allowance should also be prepared.

(13) Revamping of the existing plant

If this project involves a revamp of an existing plant, then the company should strictly pay attention to the following risks: 1) unclear reference data, documents, and drawings, 2) item definition and usability criteria of equipment/materials that will be reused, 3) the accuracy of the documents in the ITB, whether they are deemed reliable or need to be confirmed by the contractor, 4) field construction stipulation and restrictions, such as the requirement for work permit application processing and time, and HSE measure, 5) site survey and work permit for the cross-site, and 6) handling, ownership, and removal of the unused equipment/material. The company should organize a site survey during the bidding stage, acquire as much past maintenance history information as possible to ensure the ITB request, and make clarifications. The EPC contractors should consider the risk allowance for the rejected deviation and exception items after the clarification and adjust the estimation basis accordingly.

(14) Currency stability and exchange rate variation

The company can adopt the following points: 1) use own currency as much as possible, 2) use a consistent income and expenditure currency as much as possible, 3) use a foreign exchange hedge, and 4) use cash flow management.

(15) Inaccuracies or incomplete site survey information

The tie-in points between the existing plant and a new plant should be carefully investigated. Besides, underground obstacles should also be investigated by using specific instrumentation. The senior engineers should be involved in the survey work to verify that the survey data are accurate and complete. Additional surveys during biddings or during the early stage of the project execution should be performed as needed.

4.5 Project Performance

To understand the objectives of EPC projects, the project performance on schedule, cost, quality, and scope was measured on a scale of 1 to 5, where 1 indicates poor performance and 5 indicates the best performance. The results are shown in Table 6, and they show that cost and schedule performances are the first two most important project objectives that should be achieved.

Table 6 Performance of EPC projects

Project Objectives	Mean	Ranking	Cronbach's α
Cost	4.40	1	0.700
Schedule	4.37	2	
Quality	4.13	3	
Scope	4.10	4	

V. Testing the Model

5.1 Model Analysis

Freeman (1987), Edwards et al. (2007), and Du et al. (2016) reported that path analysis could be carried out by using the multiple regression analysis method. Regression analysis was adopted to assess path coefficients and check their significance level. In this study, linear regression is employed to carry out path analysis to test the relationships among the critical success factors, project risk management, and EPC project performance as proposed in the conceptual model of delivering EPC projects (Figure 1). The path coefficients are the standardized regression coefficients in the regression equations (β, beta coefficients) and the significance level is checked by p-value.

Jaccard and Becker (1997) stated that the mean is the best estimate of the value of the population and is the most frequently used method of central tendency in behavioral studies. Thus, this study takes the mean of sample data as the testing basis. The mean of the six CSFs, the mean of the thirteen project risk management techniques, and the mean of the four aspects of the EPC project performance are used as the indicators to calculate the relationships among them. The results are shown in Table 7.

Table 7 Test of mediated relationship among conceptual model factors

	CSFs PRM	PRM EPC PP	CSFs EPC PP
β=	0.665	0.718	0.748
p-value	< 0.01	< 0.01	< 0.001

Note: β = standardized regression coefficient.
Abbreviations: PRM = project risk management; EPC PP = EPC project performance.

The above results indicate three significant paths. The first path is the critical success factors -> project risk management, the second path is the project risk management -> EPC project performance, and the third path is the CSFs -> EPC project performance. The direct cause-effect relationships proposed in the conceptual model for delivering overseas EPC projects have been tested (Figure 4).

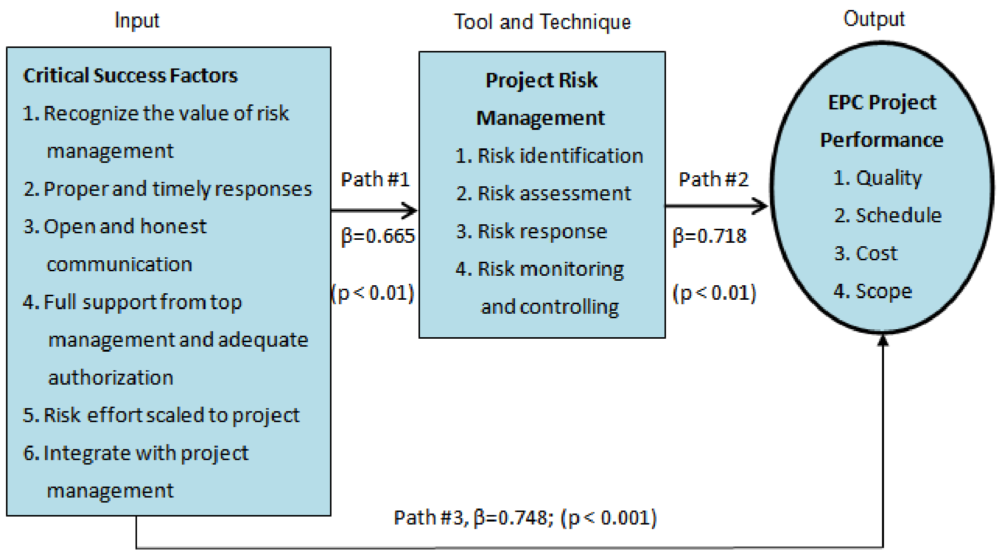

Figure 4 Relationships among the CSFs, project risk management, and EPC project performance

5.2 Relationship between CSFs and Project Risk Management

Project risk management is significantly predicted by CSFs, with the standardized regression coefficient (β) being 0.665 ($p < 0.01$), which confirms the close linkage between CSFs and the project risk management level in delivering EPC projects. As PMI (2009) stated, project risk management is not an optional activity. Regardless of project size, risk management should be applied to all projects. In implementing risk management effectively, the support of the company is required. In addition to project managers, senior managers in the organization should examine and approve many risk activities and respond with countermeasures. During quotation and execution stages, every stakeholder must be truly involved in the process of project management. In discussions, participants, regardless of their position in the organization, should be open-minded to respond from every possible influencing perspective and reach a consensus with other organization members per the difficulty level of solutions. The concept conforms considerably well to previous survey results (see Table 3).

5.3 Effects of CSFs and Project Risk Management on EPC Project Performance

As shown in Figure 4, CSFs and project risk management significantly predict EPC project performance, with the standardized regression coefficients being 0.748 ($p < 0.001$) and 0.718 ($p < 0.01$), respectively. These values demonstrate the importance of CSFs in processing resources into project outputs and the strong influence of project risk management on EPC project performance through the handling of risks from external environment and internal processes.

As established above, CSFs, project risk management, and EPC project performance are closely linked. CSFs are closely related to project risk management and project performance. Specifically, the effective implementation of CSFs can exert an influence on project risk management by facilitating the process to achieve high project performance. Strong CSF input can facilitate the continuous improvement of risk management levels using advanced techniques, innovative technologies, and optimum management strategies. Therefore, EPC contractors should take input from CSFs using project risk management techniques to deliver the output of EPC project performance. A case study of an EPC project in the Philippines is illustrated below.

5.4 Case Study: The Refinery Plant Project

A case study that uses the aforementioned risk management methodology is described in this subsection. This case is an EPC project for a refinery plant, which consists of a hydrodesulphurization area and an isomerization area. This plant is located in the Philippines and is owned by the local government. The total contract price is USD 140 million, which is the lump-sum fixed price for a turnkey project. The project contract duration is 22 months with a liquidated damage charged at 0.1% of unfulfilled portion of the contract price per calendar day of delay based on the contract condition. This project was undertaken by a Taiwan company as the EPC contractor, and the tasks of the contract included design, procurement, construction, pre-commissioning, and commissioning works. The author was one of the project team members in this case project.

The Philippines was an unexplored market to the contractor but the contractor treated it as the high potential developing market in the future. Hence, the contractor decided to approach this new market. By considering the potential risk factors, contractorconducted risk analysis and risk management since the bidding stage. The contractor devoted many resources to this project and provided full support from top management for risk countermeasures. During the bidding stage, the contractor conducted a site survey to understand the local market conditions and identify the project development risks. The survey covered project members, local government officials, and consulting firms. In addition, group study meetings chaired by senior facilitators were conducted to carefully review the ITB and contract terms and to clarify any ITB concerns with the client. Nevertheless, during the execution stage, the contractor still suffered from not being familiar with local regulation and project specification request due to the first project conducting in the Philippines. The company top management was aware the potential risks that might be occurred, countermeasures supported fromtop management were conducted to avoid any further impact on project schedule delay and cost overruns. The contractor chose local experienced consultants as designers and asked several senior engineers to join the project to achieve the planned schedules of the deliverables. Specialists were assigned to the offices of the client and the manufacturing shops to maintain close communication with related stakeholders and to observe the equipment manufacturing progress for the timely resolution of issues.These processes increased the engineering cost to improve design quality and to reduce risks in the following procurement and construction stages.Moreover, because of the extended length of the reactor (15.6mD × 75mH),the road needed to be blocked from the port to the site during transit to avoid emergencies that could damage the body structure of the reactor. Given the excessive size and weight of the reactor, the contractor had to rent a local sole crane capable of lifting 500 tons at the site while assembling the reactor. As the contractor had identified these risks and had discussed the countermeasures early at the initial stage of the project, the contractor successfully obtained the support of the client, the government, and the local authorities in dealing with social and political risks, such as project permission approval, land use, construction site security, transportation, and customs clearance. The contractor cooperated with local subcontractors and suppliers, which was an effective method to overcome the problems of labor and material shortages, and to adapt to different cultures of the complex societies in the project area location.

During the early stage of this case project, risk identifications have been conducted and risk responses for the countermeasures have been fully supported by the contractor's top management. Potential risks were identified to prevent any unforeseen accidents that could result in project schedule delays and cost overruns. Besides, all team members were aware his/her duties in this project and explored CSFs for improving project performance. The CSFs approach and the use of project risk management as a tool and technique in this project have successfully assisted the contractor in dealing with a variety of project risks and improved capabilities to achieve superior project performance. Although the contractor spent extra man powers in the engineering design stage, the total cost saving for this project was approximately USD 15 million and the project was completed 35 days earlier than the contract request. The contractor was awarded by the client for the completion bonus and the outstanding service with HSE Golden Flag and Quality Excellence Awards for the EPC project. This case illustrates how contractors input CSFs to project management practice and conduct risk management to prevent risks in unexplored areas, technical difficulties in design, shortage of labor and materials, and complex sociopolitical conditions; thereby ensuring the successful delivery of the EPC project.

VI. Discussion and Conclusions

Although existing risks are obvious when conducting overseas EPC projects in an unexplored market, most risks could be controlled and managed. When systematic risk management methods are applied, risk can be reduced by using established ideas, tools, and techniques. The specific contributions of this study could be described as follows: 1) it presents a tested model for delivering EPC projects, revealing the cause-effect relationships among CSFs, project risk management, and EPC project performance, 2) it introduces procedures and methods that provide reference points for risk management planning of EPC projects in an unexplored market, 3) it proposes a hierarchy of risk classifications together with the identified risk factors in EPC projects, and 4) it suggests countermeasures for the main potential risk factors.

The project success factors are cooperative relationships with the stakeholders, enhanced capabilities of the overall project team, and appropriate project risk management for the project and its environment. On the basis of these factors, a comprehensive method to manage the risks for EPC projects was described in this paper. The method supports a systematic thinking process that classifies, identifies, assesses, reduces, and transfers risks. In relation to the risk identification and classification processes for overseas EPC projects, the global viewpoints have been emphasized, not only the project itself, but also in the macro levels of the political and economic situation. The vital risk factors in overseas EPC projects should be carefully examined and discussed. The risk response methods and countermeasures used in overseas EPC projects vary from project to project and should be flexible in terms of their execution (Zhi 1995). An effective risk management method can help in understanding not only the kinds of risks, but also to figure out how these risks can be managed during each stage of pre-contracting and contracting for overseas EPC projects.

The risk management procedure of an enterprise must be a cyclic process that aims not to eliminate all residual risks but to make the residual risk levels fall within an acceptable range by optimizing cost efficiency. Unacceptable residual risks should be handled with the use of improvement initiatives or appropriate countermeasures. Risk management and control must be applied in each stage of a project, including marketing, quotation, price negotiation, contract conclusion, execution, testing, acceptance inspection, warranty, and case settlement. The risk management system does not end with the establishment of the project, but starts from the implementation and execution.

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