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Enhancing engineer–procure–construct project performance by partnering in international markets: Perspective from Chinese construction companies

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Abstract

The engineer–procure–construct (EPC) approach has been increasingly adopted in international markets, in which contractors need to have adequate capabilities in effectively dealing with a wide range of risks in a complex environment that consists of various stakeholders. Many researchers have embraced the strategy of partnering to integrate diverse project delivery activities by meeting the needs of all project participants. However, limited research has addressed the cause–effect relationships among partnering, risk management, and organizational capability on how performance improvements can be generated from them on a holistic view. This study systematically investigates the causal relationships among these themes by establishing and testing a conceptual model. With the support of data collected from Chinese contractors with experience in delivering EPC projects by questionnaire, interview, and a case study, the results provide empirical evidences on contractors' partnering application degree, strength, and weakness of organizational capabilities, overall picture of risk management, and project performance level, which form a sound basis for contractors' decision making during project implementation. This study further reveals that partnering can not only directly facilitate organizational capability and risk management but also exert its influence on risk management through enhanced organizational capability, thereby improving project performance. The above insights suggest research and practical emphases on combining risk management with partnering principles to assist in both intra- and inter-organizational activities, and contractors' appropriate linking with involved stakeholders to obtain necessary resources and effectively transfer them for successfully delivering international EPC projects.

Keywords: Engineer–procure–construct; Partnership; Risk management; Organizational capability; Project performance; Construction; China

1. Introduction

Increasingly adopted by both public and private organizations, the EPC approach has become a favored construction project delivery system that combines the procurement of construction services with a variable amount of engineering services in one contract (Galloway 2009; Migliaccio et al. 2009; Park et al. 2009). By using the EPC approach, clients can expect a contractor as a single-entity responsible for design/procurement/construction, to achieve superior performance in such areas as early builder involvement, innovation, cost savings, reduced schedule, and

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enhanced quality (Hale et al. 2009; Perkins 2009; Puerto et al. 2008). This approach requires the contractors in EPC projects to possess competent capabilities in effectively dealing with a wide range of risks in complex international environments that involve various stakeholders (Yang et al. 2010; Zou et al. 2010). Many researchers have suggested the partnering strategy to improve risk management and enhance the capability of project delivery by effectively managing involved stakeholders with win–win value (Bower et al. 2002; Bresnen and Marshall 2000; Chan et al. 2008; Cho et al. 2010; DeVibiss and Leonard 2000; Growley and Karim 1995; Jacobsson and Roth 2014; Rahman and Kumaraswamy 2008; Tang et al. 2006; Xu et al. 2005; Yeung et al. 2009). Partnering is a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources (CII, 1991), which is based upon trust relationship in facilitating participants' cooperatively dealing with reciprocally interdependent engineering, procurement, and construction processes (Kadefors 2004). Owing to ineffective integration of the involved participants' resources, many Chinese contactors have suffered from unsuccessful delivery of EPC projects, e.g., the Mecca Light Railway project has a cost overrun of US$ 0.676 billion accounting for 34.4% of the contractual amount (Xiang and Wan 2011), and the A2 Highway project in Poland was terminated with a potential cost overrun of US$ 0.395 billion (Xiang and Niu 2012). Impediments to successful EPC project delivery encountered by the contractors can be largely due to a lack of understanding how to integrate diverse organizational activities by meeting the needs of all EPC stakeholders, thereby facilitating the joint risk management of project participants and enhancing the contractors' capabilities to fulfill the project tasks (Cho et al. 2010; Rahman and Kumaraswamy 2008; Tang et al. 2006; Xu et al. 2005). However, limited research has addressed the cause–effect relationships among partnering, risk management, and organizational capability related to how performance improvements are generated from them on the whole value-creation process by drawing a holistic picture (Jacobssona and Rotha, 2014; Lehtiranta 2014). Understanding the above in-depth underlying causes to improve project performance will be crucial to lift multi-organizational dynamics research to a state of the art and aid contractors in the appropriate handling of multiple or conflicting objectives in EPC projects (Asmar et al. 2010; Girmscheid and Brockmann 2010; Lazar 2000; Lehtiranta 2014; Li et al. 2000; Migliaccio et al. 2009; Rosner et al. 2009; Tang et al. 2009; Wong et al. 2009). Thus, the aim of this study is to systematically investigate the causal relationships among partnering, risk management, and organizational capability, together with their impacts on EPC project performance via the development and testing of a partnering model.

2. Conceptual model of delivering EPC projects

2.1. Literature review

EPC is typically used in large and complex projects with contractors taking on additional risk compared to the traditional approach, which is attributed to that many stakeholders are involved during the implementation processes of a EPC project, especially in the complex social and economic environment of international markets (Asmar et al. 2010; Gunhan and Arditi 2005; Park et al. 2009). Stakeholders include all members of the project team as well as all interested entities that are internal or external to the organizations (PMI, 2013), and effective engagement with these stakeholders is key to a project's success (OGC, 2009). EPC contracts specify that the contractor shall design, execute, and complete the works as a single-entity, requiring the contractor, designers, suppliers, and subcontractors to form one project team in achieving EPC objectives (FIDIC, 1999; IPMA, 2009). The norms of EPC contracts (FIDIC, 1999) also regulate the relationships between the contractor and other interested entities, e.g., explicitly specifying that the contractor and the client shall make efforts to cooperate with each other, and the contractor shall take all reasonable steps to protect the environment that are closely relevant to governments' approval and local people's concerns. In general, EPC contractors should properly cooperate with their upstream business partners (e.g., clients, consulting engineers, and creditors), and downstream partners (e.g., designers, suppliers, and subcontractors) in project delivery (CII, 1991 and Tang et al., 2006; Tang et al. 2009). Besides, it is also critical for EPC contractors to cooperate with involved social–political entities (e.g., central government, local authorities, and local residents/communities), who provide resources, approval and support for enabling the project success (Cleland 1988; Gareis 1991; PMI, 2013). Partnering with the above stakeholders allows EPC contractors to examine factors in the environment and in their organizations from a broad perspective by surveying each stakeholder to ascertain if their objectives are in line with the needs of other partners (Bower et al. 2002; Bresnen and Marshall 2000; Chan et al. 2008; CII, 1991; Tang et al. 2008; Yeung et al. 2009). This win–win philosophy can enable project participants to manage the various risks collaboratively (Love et al. 2011; Rahman and Kumaraswamy 2002; Tang et al. 2007). Moreover, partnering with project stakeholders can enhance the contractors' capabilities to obtain necessary resources and successfully integrate and manage them (Anderson et al. 2001; Daft 2010; Girmscheid and Brockmann 2010; Isik et al. 2010; Nadler and Tushman 1997; Tang et al. 2009; Wethyavivorn et al. 2009).

The above views see EPC contractors as open systems that take input from the external environment consisting of various partners, add value to them in transformation process, then convey the fulfilled projects as output to meet the needs of stakeholders; by providing value added products and services, the contractors can win the markets for further gaining necessary resources to continue the process (Ancona et al. 2005; Wang et al. 2013). There is a need to shift partnering research from focusing on traditional project success factors to the whole co-creative process involving project stakeholders (Jacobssona and Rotha, 2014). From strategic management perspective, traditional success factors include project team building, optimizing the capabilities of the overall project team, appropriately managing risks from the project and its relevant environment, emphasizing the cooperative relationships with stakeholders (Cleland 1988; Gareis 1991). However, how these

factors are interrelated to improve project performance has not been addressed within an overall framework. Thus, by viewing EPC contractors as open systems, a conceptual model has been established by the authors to aid in the understanding the cause–effect relationships among partnering, risk management, and organizational capability with their influences on project performance, as shown in Fig. 1.

2.2. Partnering in international EPC projects

Over the past two decades, partnering has become increasingly important to the construction industry, which seeks to create a win–win philosophy among project participants to maximize the effectiveness of the resources contributed by each organization (Hong et al. 2012; Li et al. 2000). The use of the partnering approach is particularly critical for EPC contractors in pursuing international competitive advantages because they must address complex relationships among clients, designers, creditors, consulting engineers, suppliers, subcontractors, central government, local authorities, and local residents/communities (Cho et al. 2010; Chen and Orr 2009; Ozorhon et al.2007). Failing to cooperate with stakeholders will hinder success project outcomes (Cleland 1988). To establish partnering relationships with these stakeholders in overseas markets, EPC contractors need to improve the extent to which they apply partnering critical success factors (CSFs), such as mutual objectives, attitude, commitment, equity, trust, openness, effective communication, teambuilding, timely responsiveness, and problem resolution (Eriksson and Westerberg 2011; Tang et al. 2006; Cheng and Li 2002; Black et al. 2000). These partnering CSFs can aid contractors in creating the trust among project participants that facilitates open communication in sharing ideas, knowledge, skills, and technologies for resolving problems that are frequently encountered by contractors in various stages (Tang et al. 2009 and Tang et al., 2006; Rahman and Kumaraswamy 2008; Kadefors 2004; Cheng et al. 2001; DeVibiss and Leonard 2000; Growley and Karim 1995). This can explain the role of partnering in improving risk management during project delivery, e.g., the contingency value of partnered projects was only 3% instead of the historical trend of 5% (Warne 1994), and the effectiveness of open communication risk management in the Three Gorges project (Tang et al. 2013).

2.3. Risk management

Construction activities in international markets are much riskier than in the domestic market due to diverse variables that are affected by the complex international environment (Gunhan and Arditi 2005). International EPC contractors must address a variety of risks that arise from uncertainties in estimating, contracting, design, procurement of equipment and materials, construction, economic and political circumstances, technology issues, and the use of management techniques (Park et al. 2009; Rosner et al. 2009; Migliaccio et al. 2009; Chan et al. 2002). Essentially, risk management consists of informed decision making (Kliem and Ludin 1997). Partnering enables the project participants to share added information by improving open communication, which allows external organizations to frequently provide valuable insight regarding the functioning of risk management (COSO, 2004). The added information that flows from partnering can eliminate elected uncertainties and therefore assists contractors in making optimal decisions that reduce lost opportunities in dealing with EPC project risks (Tang et al. 2007; Rahman and Kumaraswamy 2002). Thus, partnering can enable more collaborative and integrated risk management processes among project participants, with information derived from both internal and external sources, which facilitate the effective use of risk management techniques in the identification, analysis, response, and monitoring steps (Lehtiranta 2014; Zou et al. 2010), e.g., effective cooperation can promote design flexibility and reduce the costs and risks of adapting the design to accommodate additional changes (Gil and Tether, 2011). A further partnering advancement in the management of the project delivery processes involves the use of clearly defined risk/reward allocations that originate from the partnering CSF of equity

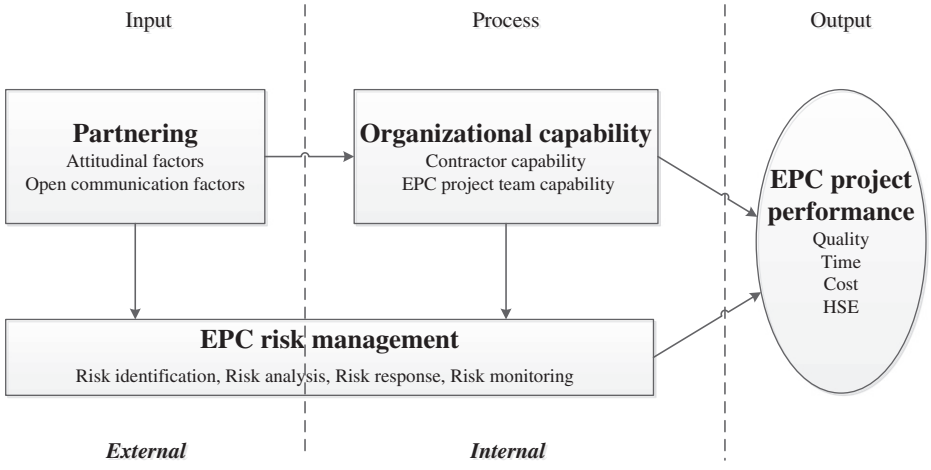


Fig. 1. Conceptual model for delivering EPC projects.

(Love et al. 2011; Chan et al. 2010; Yeung et al. 2009; Bresnen and Marshall 2000). Equitable risk/reward allocations can create a powerful motivation by aligning the objectives of participants and provide necessary resources for joint risk management to achieve better project performance (Tang et al. 2008; Bower et al. 2002; Bresnen and Marshall 2000).

2.4. Organizational capability

To meet the needs of all stakeholders in high-risk international environment, contractors are required to have competent capabilities to process diverse organizational activities in fulfilling the EPC project tasks (as shown in Fig. 1). Capability refers to the extent to which companies are organized to achieve the set objectives (Salaman and Asch 2003), which creates value for stakeholders and brings competitive advantage for themselves (DeSarbo et al. 2005). Specifically, the dimensions of organizational capability include obtaining scarce and valued resources from external environment, transforming the obtained resources by integrating and managing them, and learning and innovation for continuously improving organizational competitiveness (Daft 2010; Chew et al. 2008; Nadler and Tushman 1997).

Compared to in domestic markets, the capability of contractors to obtain the necessary resources for EPC project delivery can be significantly restricted in international environment with high risk (Isik et al. 2010; Zhao et al. 2009; Chen and Orr 2009; Ozorhon et al., 2007; Jaafari 2000). Scarce and valued resources that are essential to EPC contractors exist in various stakeholders (Yuan et al. 2010; Yang et al. 2010; Dikmen et al. 2005). The partnering approach can assist contractors in establishing channels with different stakeholders to effectively solve the problems of resource restriction (Daft 2010; Wethyavivorn et al. 2009; Nadler and Tushman 1997), and this approach can also help contractors in transforming the resources into value added output by maximizing the effectiveness of each participant's contribution (Isik et al. 2010; Xu et al. 2005; Anderson et al. 2001). These effects are attributed to EPC contractors' operating processes being largely reciprocal interdependence inside and outside the organizations (Park et al. 2009; Ancona et al. 2005). From a broad view of partnering's effectiveness, contractors can appropriately allocate their organizational resources for adaption to external environment by optimizing their human resources, organizational infrastructure, information management, construction technology, and financing, thereby enhancing the contractors' capabilities in these aspects (Regan et al. 2011; Skibniewski and Ghosh 2009; Tatari et al. 2008; Cheng et al. 2001).

Partnering requires contractors to integrate and manage diverse organizational activities by considering how well they perform from the viewpoints of other key project participants, which is the essence of external benchmarking (Tang et al. 2009). Because EPC contractors' partners are frequently experienced in cooperating with similar contractors, the trust-based relationship in partnering can encourage the partners to point out weaknesses of the contractors, which forms a foundation of inter-organizational learning (Wong et al. 2009; DeVibiss and Leonard, 2000). Open communication in partnering also assists project participants in sharing their ideas, experience, and recognition of project problems, and this knowledge exchange represents an important innovation driver of a better understanding of the projects and optimal decision making for the achievement of design, procurement, and construction objectives (Mao et al. 2009; Bossink 2004). Thus, partnering can also play an important role in facilitating organizational learning and innovations of the respective EPC contractors for improving their competitiveness in complex international markets. Continuous enhancement of organizational capabilities can help contractors appropriately deal with various risks originated from both external environment and internal organizations on a holistic view (Lehtiranta 2014).

2.5. Empirical research questions arising from development of the conceptual model

The constructed model (see Fig. 1) demonstrates the relationships among partnering, organizational capability, and risk management, which result in the EPC project outputs on cost, quality, time, occupational health, and safety and environment (HSE) (Ozorhon et al.2010; Hale et al. 2009; Yuan et al. 2010; Skibniewski and Ghosh 2009; Yeung et al. 2009; Wong et al. 2009; Dainty et al. 2005). To test these cause–effect relationships, the relevant themes worthy of further investigation have been transferred into specific questions:

- To what degree has partnering been achieved by international EPC contractors?
- What is the status of international EPC contractor risk management?
- What are the strengths and weaknesses of the international EPC contractor's capabilities?
- What is the ultimate international EPC project performance in terms of cost, time, quality, and HSE?
- What are the relationships among these themes?

3. Research method

3.1. Selection of Chinese contractors

Chinese contractors have become active participants in international construction markets (Chen and Orr, 2009), and there were 51 Chinese contractors listed among the Engineering News-Record (ENR) top 225 international contractors in 2011 (Reina and Tulacz, 2011). The turnover in overseas business for these contractors had a value of US$ 57.162 billion, a quantity that increased by 12.99% during the year 2011. The share from the 51 Chinese contractors is the largest of all participating countries, accounting for 14.9% of the total amount from overseas turnover of the 225 contractors (Zhang and Sun, 2011). Hence, the model testing in this study was based on the data collected from the Chinese contractors with experience in delivering international EPC projects.

3.2. Data collection using a triangulated approach

By using both quantitative and qualitative data collection methods, triangulated data collection approach facilitates an deeper understanding of a given research topic (Love et al. 2002); thus, it was decided that this research adopted a triangulated data collection approach combining with questionnaires, interviews, direct observations, and a case study.

The questionnaire was chosen as the principal survey method. On the basis of literature review, the questions are derived from the conceptual model of delivering EPC projects, and a five-point Likert scale was applied in the questions to extract the data on partnering, capability, risk management, and project performance. Questionnaire survey via the postal service can reduce logistical burdens but frequently suffers from low response rate, leading to biased survey results (Thomas 1996; Akintoye and Macleod 1997). To avoid this, the questionnaire survey was fulfilled during eight field trips, including two international trips to EPC project sites in Indonesia and Ghana, and six trips to the headquarters of Chinese construction companies with relevant background. Based on a specific EPC project abroad, each questionnaire was filled by a respondent who had years of experience in delivering international EPC project. The questionnaire contains four groups of questions: application of partnering, risk management, organizational capabilities, and project performance. The total number of respondents was 124, and the distribution of samples was as follows: 15 (Indonesia), 11 (Ghana), 24 (Equatorial Guinea), 28 (Pakistan), 11 (Fiji), 6 (Iran), and 29 (Zambia). These countries were chosen because the regions of Africa and Asia-Pacific account for the largest share of Chinese contractors' international business. The direct contacts with respondents during the fieldtrips ensured all sent questionnaires being collected back.

After questionnaires were completed, semi-structured interviews with respondents, who held senior positions such as CEO of companies, chief engineer, project manager, and head of department, were immediately conducted. The four groups of questions in the questionnaire formed the framework of interview topics, and the respondents chose specific questions that they were interested in. In total, 63 respondents from six construction companies and three design companies were interviewed to learn the experience dealing with the issues related to their management scopes, covering contract, financing, design, procurement, construction, and HSE. Direct observations during site visits in Indonesia and Ghana enhanced the researchers' understanding how natural environment, social conditions, and local markets influence EPC project implementation processes. In addition, a case study of the thermal power station project in Indonesia was conducted during 2 weeks of fieldwork. Data of the case were not only gathered by using the above-mentioned data collection techniques but also extracted from project documents, which were collectively used to further confirm and illustrate the constructed relationships among partnering, risk management, organizational capability, and project performance. Given the geographic diversity and variety of the respondents, potential bias in the collected data could be reasonably reduced.

3.3. Data analysis techniques

The data collected from the questionnaires were analyzed using the Statistical Package for Social Science (SPSS 19.0). The selected techniques appropriate to this study include estimation of the sample population mean, ranking of cases, internal consistency (reliability) test, and path analysis. Cronbach's α is calculated to measure the internal consistency, following the hurdles: $0.7 \leq \alpha < 0.8$ (acceptable), $0.8 \leq \alpha < 0.9$ (good), and $\alpha \geq 0.9$ (excellent). The path analysis has been adopted for inferential analysis with the results tested using a significance level, which follows the typical level for statistical significance of 0.05, with a level of 0.01 considered highly significant. The data from the interviews and direct observations are used to explain and confirm the cause–effect relationships. The case study is used to further demonstrate and validate the established casual relationships among partnering, organizational capability, risk management, and project performance.

4. Survey results

4.1. Application of partnering

The respondents were asked to rate the importance of partnering with other involved organizations on the 1–5 scale, where 1 = the least important and 5 = the most important. The results are shown in Table 1.

The results show that clients were most important to the Chinese construction companies as EPC contractors, which is not surprising because their market shares are largely determined by the clients. The second most important relationship was between the EPC contractors and designers, and this is attributed to that design can largely decide the costs of EPC projects. The third important relationship was with creditors, indicating the significance of financial management for construction companies in undertaking EPC projects with large capital requirements. The scores of importance between contractors and the other partners are higher than 3.9, demonstrating that they are also important to the EPC contractors.

Thompson and Sanders (1998) indicated partnering can be viewed and described as different degrees. In the questionnaire, respondents were given statements on the ten CSFs of partnering concerning the degree to which they were applied

Table 1
Importance of partnering with involved organizations in EPC projects.

	Mean	Ranking	Cronbach's α
Clients	4.74	1	0.852
Designers	4.60	2	
Creditors	4.40	3	
Consulting engineers	4.38	4	
Suppliers	4.24	5	
Central government	4.24	5	
Local authorities	4.22	7	
Subcontractors	4.15	8	
Local residents and communities	3.97	9	
Overall	4.33	–	

in EPC projects, using a five-point scale where 1 = the lowest degree, and 5 = the highest degree. The results are shown in Table 2.

The average rating for the 10 factors was 4.17, suggesting that partnering has been applied in EPC projects by construction companies to some extent. The results in Table 2 show that the scores for attitudinal factors (commitment, mutual objectives, equity, trust, and attitude) are higher than those for open communication factors (effective communication, openness, team building, timely responsiveness, and problem resolution), demonstrating that open communication factors have a larger room to improve, particularly for problem resolution.

4.2. Risk management

Respondents were asked to identify the importance of 74 possible EPC project risks in international markets on a scale of 1–5, where 1 represents a negligible risk and 5 represents an extreme risk. This analytical approach is the combination of checklist analysis and expert judgment by senior project management staff who had worked on projects in the related areas (PMI, 2013). The top 15 risks (top 20% of the 74 risks) are listed in Table 3.

The results in Table 3 show that procurement-related risks were most important to EPC contractors, including "lack of materials, and equipment in the locality" (1st), "price increase of materials and equipment" (7th), "immature local markets for goods" (8th), and "inconvenient business trading" (14th), which are related to local manufacture technology, maturity of markets, and the natural environment for providing raw materials. Political risks were second most important, as evidenced in such categories as "inefficiency of government" (2nd), "unstable political situation in the project-located country" (4th), and "local existence of hostile organizations" (15th). Finance-related risks were also critical to EPC contractors, including "unstable financial markets" (3rd), "inflation" (5th), "delay of client's payment" (10th), and "currency restrictions" (13th). "Occupational health, safety, and environment (HSE)" is the 6th risk, which is not surprising because EPC projects normally contain complex work processes. One specific risk is "inefficient processing of client" (9th), which should not be ignored by EPC contractors. Design risks of "delay of drawings supply" and "inadequate or incorrect design" were ranked as 11th and 12th respectively, demonstrating the importance of construction companies' choosing and managing designers. The above risks confirms that the contractor's risks come from a wide range of sources as specified in EPC contracts (FIDIC, 1999), in which the contractor bears the risks arising out of/in the course of/by reason of the design, execution, and completion of the works. Comparatively, the client mainly takes the consequence of force majeure according to EPC contracts (FIDIC, 1999). Notably, although "local existence of hostile organizations" belongs to the client's risk on force majeure, the contractors still rated this risk as an important concern. This clearly demonstrates that even if project risks have been allocated in EPC contracts, in real life all the risks can be concerns of both the contractor and the client, which provides a sound basis for establishment of partnering relationship between them.

Table 2
Application of partnering CSFs in the EPC projects.

	Mean	Ranking	Cronbach's α
Commitment	4.44	1	0.954
Mutual objectives	4.28	2	
Equity	4.26	3	
Trust	4.23	4	
Attitude	4.18	5	
Effective communication	4.14	6	
Openness	4.08	7	
Team building	4.05	8	
Timely responsiveness	4.04	9	
Problem resolution	3.96	10	
Overall	4.17	–	

Table 3
Perceptions of the respondents on the importance of risks.

Risks	Mean	Ranking	Cronbach's α
Lack of materials and equipment in the locality	3.57	1	0.976
Inefficiency of government	3.39	2	
Unstable financial markets	3.38	3	
Unstable political situation in project-located country	3.32	4	
Inflation	3.31	5	
Occupational health, safety, and environment	3.30	6	
Price increase of materials and equipment	3.28	7	
Immature local markets for goods	3.28	8	
Inefficient processing of client	3.28	9	
Delay of client's payment	3.26	10	
Delay of drawings supply	3.21	11	
Inadequate or incorrect design	3.20	12	
Currency restrictions	3.20	13	
Inconvenient business trading	3.17	14	
Local existence of hostile organizations	3.17	15	

Risk management levels of EPC contractors range from informal approach to formal approach. Informal risk management approach views the risks in a subjective manner with risk management techniques being used in low frequency, whereas formal risk management approach consists of a set of structured techniques being used in high frequency by any member of the organization, which enables risk management process to be more objective than informal approach (Smith 1999). To investigate the risk management levels of the EPC contractors, respondents were asked to assess the extent to which risk management techniques were used in their EPC projects by grading them on a scale of 1–5, where 1 = low level of application (least frequently used), and 5 = high level of application (most frequently used). The results are provided in Table 4.

As shown in Table 4, "brainstorming" for risk identification, "joint evaluation of key participants" for risk analysis, "risk reduction (reduce the likelihood of occurrence/consequences)" for risk response, "periodic document reviews" for risk monitoring are the most frequently used techniques in risk management. Notably, "risk reduction" in response strategies being the first priority demonstrates contractors' emphasis of mitigating EPC project risks, which shifts from the traditional

strategy to transfer as much of risks as possible to others by legal instruments, e.g., claims (Tang et al. 2007). Nevertheless, "transfer the risk" has a moderate to high rating (3.82), indicating that legal issues specified in the EPC contracts (FIDIC, 1999) are still contractors' important concerns, such as risk and responsibility allocation, insurance, force majeure, claims, disputes, and arbitration.

To better understand the barriers to risk management, certain factors that may affect risk management were further investigated. The respondents were asked to give judgments on the listed barriers to risk management on a scale of 1–5, where 1 represents the least important barrier and 5 represents the most important barrier. The results are given in Table 5.

The results in Table 5 show that "lack of incentive for better risk management" and "lack of joint risk management mechanisms by parties" have the highest ratings, suggesting the need to improve collaborative risk management by project participants. Other barriers had scores ranging from 3.13 to 3.50, suggesting that the influence of these barriers also should not be ignored.

4.3. Organizational capabilities

To understand the strengths and weaknesses of the contractors in undertaking EPC projects, the respondents were asked to judge their organizational capabilities by responding on a scale of 1–5, where 1 = very weak to 5 = very strong. The results are provided in Table 6.

As shown in Table 6, the capabilities of "project management" and "construction technology" are ranked highest, demonstrating the strengths of construction companies as EPC contractors in these aspects. The average score is 3.52, suggesting that there is much room for improvement in contractors' capabilities.

Table 4
Application level of risk management techniques.

Techniques of risk management	All	Rank	Cronbach's α
Risk identification			0.909
Checklists	3.96	6	
Personal assessment	3.54	15	
Brainstorming	4.29	2	
Consulting experts	3.34	17	
Risk analysis			
Qualitative analysis	3.93	8	
Semi-quantitative analysis	3.63	13	
Quantitative analysis	3.64	12	
Personal analysis	3.57	14	
Joint evaluation of key participants	4.32	1	
Use of consulting experts	3.37	16	
Use of computers and other modeling methods	2.64	19	
Risk response			
Avoid the risk	3.89	9	
Reduce the likelihood of occurrence	4.05	5	
Reduce the consequences	4.12	3	
Transfer the risk	3.82	10	
Retain the risk	2.79	18	
Risk monitoring			
Periodic document reviews	4.05	4	
Periodic risk status reporting	3.95	7	
Periodic trend reporting	3.74	11	
Overall	3.72	–	

Table 5
Barriers to risk management.

Factors affecting risk management	Mean	Ranking	Cronbach's α
Lack of incentive for better risk management	3.59	1	0.925
Lack of joint risk management mechanisms by parties	3.56	2	
Ineffective monitoring	3.50	3	
Shortage of knowledge/techniques of risk management	3.47	4	
Lack of formal risk management system	3.46	5	
Different recognition of risk control strategies	3.42	6	
Lack of historical data for risk trend analysis	3.40	7	
Ineffective implementation of risk control strategies	3.35	8	
Insufficient ongoing project information for decision making	3.29	9	
Inappropriate risk allocation	3.23	10	
Lack of risk consciousness	3.13	11	
Overall	3.40	–	

4.4. Project performance

To understand the outcomes of the EPC projects, project performances on time, cost, quality, and HSE were measured on a scale of 1–5, where 1 = poor performance and 5 = good performance. The results are shown in Table 7.

The results show that cost performance is rated lowest. This result is consistent with previous survey results (see Table 3), which found that the finance-related risks are critical to EPC contractors.

5. Testing the model

To test the relationships among partnering, risk management, organizational capability, and project performance as established in the model (see Fig. 1), path analysis has been conducted. Because the mean is the "best estimate" of the value of the population and is the most frequently used measure of central tendency in behavioral studies (Jaccard and Becker 1997), the mean of the 10 partnering CSFs (average of Column

Table 6
Perceptions of organizational capabilities.

Organizational capabilities	Mean	Ranking	Cronbach's α
Project management	3.72	1	0.933
Construction technology	3.69	2	
Obtaining scarce and valued resources	3.63	3	
Learning	3.60	4	
Organizational infrastructure	3.54	5	
Information management	3.40	6	
Human resource	3.38	7	
Financing	3.35	8	
Innovation	3.34	9	
Overall	3.52	–	

2 in Table 1), the mean of 19 risk management techniques (average of Column 2 in Table 4), the mean of 11 organizational capabilities (average of Column 2 in Table 6), and the mean of 4 aspects of project performance (average of Column 2 in Table 7) are used as indicators to calculate the relationships among them, with the results as shown in Table 8.

The above results indicate three significant paths from partnering to project performance. The first path is partnering → organizational capability → project performance, the second path is partnering → risk management → project performance, and the third path is partnering → organizational capability → risk management → project performance. These confirm that partnering cannot only directly facilitate organizational capability and risk management, which are significantly related to project performance, but also exert its influence on risk management through enhanced organizational capability. In general, the cause–effect relationships established in the conceptual model for delivering EPC projects have been tested (see Fig. 2.), which are interpreted as below with the support of the data collected from questionnaires, interviews, direct observations, and case study.

5.1. Relationship between partnering and risk management

Risk management is significantly predicted by partnering with the standardized regression coefficient being 0.295 ($p < 0.01$), confirming the close linkage between partnering and risk management level in international EPC projects. The survey results on the application level of risk management techniques (see Table 4) can explain the role of partnering in assisting risk management. Partnering is suitable for improving the effects of the most frequently applied techniques (e.g., "brainstorming" for risk identification and "joint evaluation of key participants" for risk analysis) that rely on the joint efforts of project groups, thereby substantially reducing the risks of a project. The risk response priorities of "reduce the consequences," "reduce the likelihood of occurrence," and "avoid the risk" rather than "transfer the risk" also provide a sound basis for participants to collaboratively manage EPC project risks.

As to risk management barriers (see Table 5), partnering is suitable to deal with "lack of incentive for better risk management" and "inappropriate risk allocation" by equitable sharing rewards/risks among project participants. Such barriers to risk management as "lack of joint risk management mechanisms by parties," "shortage of knowledge/techniques on risk management," "different recognition of risk control strategies," "lack of historical data for risk trend analysis," and "insufficient ongoing project information for decision making" are exactly the type of barriers that partnering can remove by facilitating organizations to contribute their historical data, project teams to exchange their recognition of the project, and individuals to share their personal experiences within trust-based open communication risk management processes.

Table 7
Performance of EPC projects.

Performance	Mean	Ranking	Cronbach's α
HSE	4.18	1	0.788
Time	3.88	2	
Quality	3.79	3	
Cost	3.75	4	

Table 8
Test of mediated relationship among conceptual model factors.

Step	Predictors	Criteria	R	R^2	R_a^2	F	β	t
1	P	OC	0.387	0.150	0.142	18.895	0.387***	4.347
2	P	RM	0.564	0.319	0.306	24.542	0.295**	3.371
	OC						.380***	4.340
3	RM	PP	0.617	0.381	0.369	32.328	0.161*	1.827
	OC						0.521***	5.901

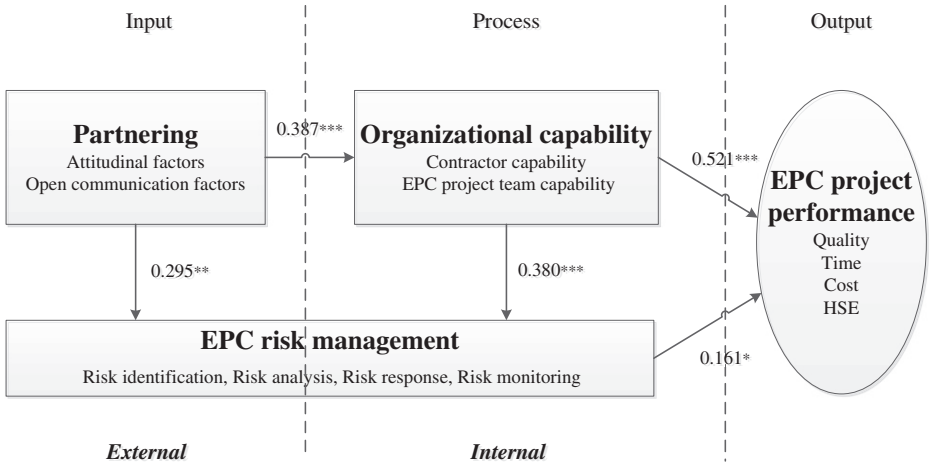
Note: R_a^2 = adjust R^2; β = standardized regression coefficient.
Abbreviations: P = partnering; OC = organizational capability; RM = risk management; PP = project performance.
*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

Interviews with contractor managers and direct observations at the sites during fieldtrips confirmed the role of partnering in the management of international EPC project risks, as shown in Table 3. For example, partnering with local suppliers and subcontractors is an effective method for mitigating the risks of "lack of materials and equipment in the locality," "price increase of materials and equipment," "immature local markets for goods," and "inconvenient business trading." Central government and local authorities are critical in dealing with political risks, such as "inefficiency of government," "unstable political situation in the project-located country," and "local existence of hostile organizations," which are also important risks to contractors. Contractors' assisting clients to obtain export credits rely on supports from governments and banks, which can significantly mitigate the contractors' financial risks. Contractors' collaborating with local communities by building infrastructures for their sustainable development and training/hiring indigenous labors are effective ways to obtain the supports from central government and local authorities, thereby reducing government/authority involved risks. Moreover, partnering with local expertise is important for reducing the risks of "delay of drawings supply" and "inadequate or incorrect design."

The interviewed project managers further pointed out that partnering facilitates equitable sharing risks/rewards among participants, which can not only create strong motivations for their joint efforts on managing risks, but also provide necessary resources for the participants to input in reducing various EPC risks. Equitable risks/rewards allocation is also the foundation of establishing long-term collaboration relationships among project participants for the sake of appropriately dealing with high uncertainties of future markets.

5.2. Relationship between partnering and organizational capability

As seen in Fig. 2, partnering significantly predicts organizational capability with the standardized regression coefficient being 0.387 ($p < 0.001$), verifying the strong influence of partnering on organizational capability in international EPC



Note: ***=p<0.01; **=p<0.01; *=p<0.05.

Fig. 2. Relationships among partnering, risk management, organizational capability, and project performance.

projects. Interviews with contractor managers at the sites during fieldtrips showed that obtaining scarce and valued resources is the first step for contractor development in international markets. In contrast to their domestic market experience, contractors must expand the overseas market share in a new environment that could significantly restrict their marketing capability. The managers indicated that partnering, which facilitates the establishment of channels to link with necessary resources, is an effective approach to enhance the capability of obtaining scarce and valued resources for solving the problems of marketing. For example, many contractor jobs were largely attributed to good relationships with clients. Governments and local authorities are important for attaining project approvals, use of lands, and dealing with political risks. Collaboration with local subcontractors can overcome labor shortfalls because contractors' use of their own fully trained labors generally is not cost-effective due to high international travel expenses. A project manager at the site said, "We have stable local labor forces that have been with us on different projects, and now they are fully skillful." Partnering with local suppliers is also important, and a specific method adopted by certain contractors is developing the necessary suppliers by transferring the relevant technologies to the potential suppliers, which can help the contractors to meet the needs for project materials and equipment. A common point indicated by the interviewed project managers is that selecting the right partner to appropriately design the work can significantly reduce the build cost, which can then improve the profit margin on the job. The roles played by the above partners in obtaining scarce and valued resources are in line with the previous survey results on the importance of partners (see Table 2).

The interviews confirm that partnering not only facilitates contractors' capability in taking inputs from external environment but also has important impacts on the contractors' functional processes for integrating and managing the obtained resources (see Fig. 2). The partnering approach encourages contractors to consider the effectiveness of integrating diverse activities at both the intra- and inter-organizational levels to reach the mutual goals of the project participants. For example, to meet the needs of clients, EPC project contractors should achieve project quality, cost, time, and HSE objectives in an optimal manner. This necessity requires the contractors to have competent capacities in project management, which can explain why the contractors' project management capability is the strongest (see Table 6). Partnering also enables contractors to allow external partners to provide valuable information for selecting a development strategy, which helps to determine whether the work of a project should be performed inside or outside of the organizations and then to allocate resources accordingly. For example, the surveyed construction companies normally undertake EPC projects by outsourcing design and manufacture with construction conducted by themselves. This result is consistent with the capability of construction technology as the strength of contractors (see Table 6).

The interviews with the project managers confirmed that partnering also plays an important role in facilitating contractor learning and innovation. Trust-based open communication processes encourage partners to note the weaknesses of contractors, e.g., clients and their consultants can identify the weak points of the contractor performance in design, procurement, and construction, which brings substantial improvements to the learning process for the contractors. Partnering is also critical to contractor innovations at all stages of project delivery because it allows project participants to share their experiences and recognition of project problems, which helps the contractors to better understand the projects and make optimal decisions in achieving design, procurement, and construction objectives.

5.3. Relationship between organizational capability and risk management

As shown in Fig. 2, organizational capability significantly predicts risk management with the standardized regression coefficient being 0.380 ($p < 0.001$), demonstrating the close

linkage between organizational capability and risk management level in international EPC projects. High capability of obtaining scarce and valued resources can ensure EPC contractors to have adequate market share, which enables the contractors to invest in improving risk identification, analysis, response, and monitoring. High capability on human resource can largely remove the barriers of "shortage of knowledge/techniques of risk management," "different recognition of risk control strategies," and "lack of risk consciousness" in risk management processes. Strong capability of information management can help to deal with the risk management barriers on "lack of historical data for risk trend analysis," "insufficient ongoing project information for decision making" and "ineffective monitoring." Organizational capabilities on project management, construction technology, organizational infrastructure, and financing are closely related to reducing/controlling likelihood and consequences of risks during project implementation. Strong learning and innovation capabilities can facilitate continuous improvement of risk management level by using advanced techniques, innovative technologies, and optimum management strategies.

5.4. Impacts of organizational capability and risk management on project performance

As shown in Fig. 2, organizational capability and risk management significantly predict project performance with the standardized regression coefficients being 0.521 ($p < 0.001$) and 0.161 ($p < 0.05$), respectively, demonstrating organizational capability's criticality of processing obtained resources into project outputs and risk management's important impact on project performance by appropriately handling risks from external environment and internal processes.

As established above, partnering is closely related with organizational capability and risk management, demonstrating that better implementation of partnering exert influences on organizational capability and risk management to assist in reaching higher project performance. How partnering approach assists EPC contractors taking input from external environment, enhancing their capability to process the obtained resources, and improving risk management level, thereby delivering a successful project as output, is illustrated below by a case study of an EPC project in Indonesia.

5.5. Case study: the thermal power plant project

The thermal power plant project in Indonesia comprises a power plant with two 110 MW generators and a harbor for transportation of coal; the total investment in the project is approximately US$ 250 million. The project was undertaken by a Chinese construction company as the EPC contractor, and the tasks of the contractor include design, procurement, and construction. The partnering approach in this project has successfully assisted the contractor dealing with a variety of project risks and substantially improved the capabilities for achieving superior project performance. The contractor successfully obtained the support of the client, governments, and local authorities in dealing with social and political risks, such as project approval attainment, land use, migrant resettlement, construction site security, and customs clearance. Good relationship with the Export–Import Bank of China enabled the contractor to successfully help the client obtaining export credits, which not only provided a strong impetus for client's developing the project but also largely reduced the contractor's financial risks. It was also confirmed that partnering with local subcontractors and suppliers was an effective method for the contractor to overcome the labor and material shortages, and to adapt to the complex societies with different culture in the project area location.

Because the contractor's core capabilities are largely related to construction, one key decision for the contractor is the choice of appropriate partners for the project design. Due to the complexity of marine and geological conditions, the design of the dock and breakwaters is a challenging task. The contractor thus chose a Chinese consultant and a local consultant as the designers. The Chinese consultant has strong expertise in the design of docks, and the local consultant is experienced in the design of breakwaters. The partnering between the contractor and the two consultants allowed each to provide valuable information regarding the function of the design processes, enabling the collective utilization of construction technology from the contractor and the expertise from the two consultants. These processes resulted in a reduction of the harbor build cost from US$100 million to approximately US$50 million, improved design quality, shortened construction time, and less impacts on local marine environment. This result demonstrates the role of partnering in improving the effects of the most frequently applied risk management techniques (e.g., "joint evaluation by key participants") that rely on the joint efforts of project participants, thereby reducing the technical and financial risks of the project. Partnering with the designers has enhanced the contractor's capabilities to deliver the project by effectively obtaining and managing the design resources, facilitating inter-organizational learning, and fostering innovative design options. This case practically illustrates how partnering effectively enhanced the contractor's capabilities in managing the encountered risks related to unforeseen marine environment, technical difficulties in design, shortage of labor and materials, complex social–political conditions, and financial pressures, thereby ensuring that the project has been successfully delivered and plays an important role in local economic development.

6. Discussions

The project success factors from strategic management perspective stress building cooperative relationships with stakeholders, enhancing the capabilities of the overall project team, and appropriately managing risks from the project and its relevant environment (Gareis 1991; Cleland 1988). On the basis of this, a conceptual model for delivering EPC projects has been developed and tested, illustrating how partnering, organizational capability, and risk management are interrelated to improve project performance from a systematic perspective.

Revealing the cause–effect relationships among them can not only advance multi-organizational dynamics research (Lehtiranta 2014), but also can help understand the whole value-creation process in delivering international EPC projects (Jacobssona and Rotha, 2014). The findings and their implications of this study are discussed below.

This study shows that partnering with all involved organizations, especially the client and the designer, are important to the contractors in the delivery of international EPC projects. This confirms that effective engagement with the stakeholders is key to a project's success (OGC, 2009). The client was ranked as the most important partner, which can largely be attributed to the norms of EPC contracts that explicitly require the contractor to cooperate with the client in project delivery (FIDIC, 1999). The criticality of the client can also be explained from strategic management perspective (Gareis 1991; Cleland 1988). Interviews supports that establishment of trust-based partnering relationship with the client can bring long-term strategic benefits to contractors such as wining more business opportunities to expand the market share. The designer was ranked as the second most important by the respondents, which can be attributed to that the designer can significantly affect the project profit. Since the EPC contractors are responsible to the design, execute, and complete the works as a single-entity (FIDIC, 1999), choosing an appropriate designer as the team member can help the contractor to fulfill the EPC tasks in cost-effective ways, e.g., optimizing design by value engineering.

The results confirm that the contractor's risks come from a wide range of sources as specified in EPC contracts (FIDIC 1999). Compared to domestic DBB projects (Tang et al. 2013, Tang et al., 2007), international EPC projects are riskier in procurement, political, financial, HSE, clients, and design. The key barriers to manage these risks involve both intra- and inter-organizational activities, supporting that there is a need for stakeholders to cooperatively manage project risks (Rahman and Kumaraswamy 2002). For instance, although "local existence of hostile organizations" belongs to the client's risk on force majeure, it is also considered as an important risk to contractors, providing a sound basis for the two parties to manage the risk by partnering approach.

The contractors' capabilities on "project management" and "construction technology" are rated as the strongest, whereas "innovation" obtains the lowest rating. The average capability score is 3.52, suggesting that there is much space for improvement in contractors' capabilities. These confirm that optimizing the capabilities of the overall project team by partnering is essential due to reciprocal interdependent nature of EPC tasks (Gareis 1991). The case study of the thermal power plant project in Indonesia demonstrates that the capabilities of the overall project team were effectively enhanced by partnering in dealing with social and political risks, shortage of labor and materials, and technical difficulties, e.g., with joint efforts of the contractor and the designer, the build cost was significantly reduced via promoting innovative design.

The above findings have broad implications in improving the fitness between intra- and inter-organizational activities. The insights of this study suggest that future research and practical emphases should be appropriately establishing linkages with involved stakeholders to obtain necessary resources, combining risk management with partnering principles, and effectively transforming various resources into deliverables with competent performance.

7. Conclusions

In general, the relationships demonstrated in the conceptual model for delivering EPC projects have been tested and confirmed based on the perspective of Chinese construction companies (see Figs. 1 and 2). The survey results outline the contractors' overall management status of international EPC project delivery. Path analysis indicates three significant paths from partnering to project performance: (1) partnering → organizational capability → project performance, (2) partnering → risk management → project performance, and (3) partnering → organizational capability → risk management → project performance. Partnering can facilitate the application level of risk management techniques (e.g., "brainstorming" for risk identification and "joint evaluation of key participants" for risk analysis) and remove such barriers as "lack of incentive for better risk management" and "lack of joint risk management mechanisms by parties" in dealing with diverse risks in complex international markets. Partnering can not only enhance organizational capability to effectively obtain and integrate valued project resources but also play an important role in facilitating contractors' organizational learning and innovation. High capability of obtaining scarce and valued resources can ensure EPC contractors to have adequate market share, which enables the contractors to invest in improving risk management. High capabilities on human resource, information management, project management, construction technology, organizational infrastructure, and financing can largely remove the barriers such as "shortage of knowledge/techniques of risk management" and "insufficient ongoing project information for decision making," and reduce the likelihood and consequences of risks during project implementation. Strong learning and innovation capabilities can facilitate continuous improvement of risk management level by using advanced techniques, innovative technologies, and optimum management strategies. Higher organizational capabilities and better risk management ultimately lead to contractors' superior project performance in delivering international EPC projects.

The above insights have significantly practical implications, suggesting broad project delivery strategies: (1) building necessary links with a variety of stakeholders to effectively resolve the problems related to resource restriction; (2) combining risk management with partnering principles, such as trust, equitable risk/reward allocation, and joint problem resolution, to facilitate optimal decision making in dealing with various risks; (3) improving contractors' capabilities from both intra- and inter-organizational perspectives according to their interdependent relationships; and (4) ensuring adequate inputs in promoting design innovations by collaboratively coping with technical challenges, thereby to improve profit margin in delivering international EPC projects.

The results of this study have confirmed the propositions and advanced the theories in the previous literatures related to effective engagement with project stakeholders, management of risks lying in internal or external to the organizations, and enhancing capabilities of the overall project team (PMI 2013; IPMA 2009; OGC 2009; FIDIC 1999; Gareis 1991; Cleland 1988). Study of partnering among participants in project delivery is particularly important to partly lift multi-organizational dynamics research to a state of the art (Lehtiranta 2014), but existing research has not mapped project performance on partnering, organizational capability, and risk management by drawing a holistic picture. This study builds interdisciplinary linkages among knowledge areas of the above themes through constructing and testing a conceptual model for delivering EPC projects, which can contribute to the body of knowledge on both theoretical and practical aspects. First, this study has established a systematic framework that theoretically demonstrates the reciprocally interdependent project delivery processes at both intra- and inter-organizational levels in dealing with high risks of international markets on a broad view. Second, it reveals that partnering can not only directly facilitate organizational capability and risk management but also exert its influence on risk management through enhanced organizational capability, thereby improving project performance. Third, it provides quantitatively and qualitatively empirical evidences on contractors' partnering application extent, strength, and weakness of organizational capabilities, overall picture of risk management, and project performance level, which form a sound basis for contractors' decision making during project implementation. Fourth, understanding the cause–effect relationships among the above themes and their management status can aid contractors in appropriately handling multiple or conflicting objectives in EPC projects on an informed basis, and help find broad practical strategies to obtain valued and scarce resources by partnering, to maximize effectiveness of the acquired resources with enhanced capability, and to correctly respond to risks related to both external environment and internal organizational functioning processes. Understanding the above drivers to improve international EPC project performance has also met the needs to rethink partnering purpose, outcome, and the role of project participants from focusing on traditional project success factors to the whole value-creation process in a cooperative manner (Jacobssona and Rotha, 2014).

8. Limitations and future research directions

The collective insights from this study only examine the delivery of international EPC projects from the perspective of Chinese construction companies as contractors. Nevertheless, the theories of this research have built up on experiences from other regions and different project delivery approaches via literature, and these insights appear transferable to different project delivery systems, such as Design-Bid-Build (DBB) and Build-Operation-Transfer (BOT)/Public-Private-Partnership (PPP), in both the domestic and international markets, and could be extended to the views of other project participants, e.g., designers as contractors. Further studies should be conducted to explore these extensions.

Future studies should be conducted to understand how contractors could (1) appropriately build partnering relationships with a variety of project stakeholders according to their different features, (2) correctly perceive and respond to the risks of external environment and internal project implementation processes, (3) ensure necessary resources flow efficiently across organizational boundaries based on win–win value, (4) effectively integrate and manage diverse resources in the organizational operation processes, and (5) facilitate sharing of knowledge among project participants to assist organizational learning and innovation, thereby to continuously enhance organizational competences. In addition, other aspects such as value engineering for innovative design, supply chain management in global markets, and project stakeholder management, which are also closely related to EPC project delivery, should also be studied in future.

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