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Analysis of pre-qualification criteria in contractor selection and their impacts on project success

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While construction industry practices are reasonably well developed, construction projects still witness widespread failures of many contractors due to varied reasons such as financial problems, poor management, over-commitment and or conflicts and disputes associated with construction activities. Pre-qualification of contractors is a common practice across projects, yet the investigation on the ability of the selected contractors in successful delivery of projects is not widespread. In an attempt to understand these pre-emptive qualification criteria and their links in contractors' performance in projects, a total of 43 influencing technical attributes were identified through a systematic research approach. The relative significance and impacts of the attributes have been determined based on a structured questionnaire survey in selected construction projects. By performing the factor analysis, a total of seven factors significant to contractors' performance were extracted, namely (1) soundness of business and workforce; (2) planning and control; (3) quality management; (4) past performance; (5) risk management; (6) organizational capability; and (7) commitment and dedication. Multiple linear regression models reveal that technical expertise, past success, time in business, work methods and working capital significantly impact on contractors' performance across time, cost and quality success. With a clear understanding of a contractor's performance, these findings could potentially contribute to development of a company's procedures or enhance existing knowledge in relation to the pre-qualification practices in contractor selection in projects.

Keywords: Pre-qualification, contractor selection, project performance, factor analysis, regression modelling.

Introduction

Increasing complexity in design and the involvement of a multitude of stakeholders in modern construction projects add significant challenges for both clients and contractors in matching the required skills and capabilities to deliver the project successfully at the tender process. Selection of an inappropriate contractor for the job increases the chance of the client being dissatisfied. Consequently, the results potentially leave contractors with a bad legacy of the failure consequences such as poor business practices or bankruptcy (Uher and Runeson, 1984; Holt *et al.*, 1995). While the contractor's pre-qualification is one of the widely published topics in construction industry research (Russell *et al.*, 1992; Hatush and Skitmore, 1997; Pongpeng and Liston, 2003; Lam *et al.*, 2009), the criteria for pre-qualification in relation to the contractor's ability to meeting the client's requirements and achieving success in projects is still a topic for investigation (Holt, 1998; Mbachu, 2008). Anecdotally, the lowest bid price alone has been one of the most heavily weighted criteria, yet the prime cause of problem for selection of contractors in most jobs (Holt *et al.*, 1995; Ng and Luu, 2008). The recent growth of public–private partnerships (PPP) around many countries including Australia has given rise to significant criticism of contractors' ability in successful delivery of projects (Raisbeck, 2008). The increasing focus on the success dynamics (such as the value for money) of PPP projects requires not only a competitive price but also the unique contractor's capability in delivering state-of-the-art facilities and optimal operational performance over the project life cycle (Akintoye *et al.*, 2003).

The importance for a closer examination of the existing practices awarding construction contracts to candidate contractors and achieving success through

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meeting the target performance is increasingly being recognized across the industry (Singh and Tiong, 2006; Raisbeck, 2008; Wong *et al.*, 2008). Although many researchers and industry practitioners have been proposing different methods and procedures for contractor selection, most of them have shortcomings in drawing a clear link between the selection criteria and the project success leading to a win-win situation to all parties. Contractors' ability to succeed in the project must be assessed through diverse inherent attributes ranging from project complexity, technical expertise to organizational capability and risk management practices (Raisbeck, 2008). Thus, a robust pre-qualification process at the tender evaluation stage in selecting the right contractor is an important first step for ensuring success in candidate projects. The intent of the investigation is to provide a clear understanding of such factors incorporating the client's, design team's and contractor's viewpoints. Identification of these underlying factors from the project delivery perspective and their relationships to the project functions should help both clients and contractors to achieve successful project outcomes.

The study examined mainly the effectiveness of pre-qualification criteria in contractor selection from a successful project delivery perspective. The objectives of the research are (1) first, to identify the critical attributes associated with contractor selection; (2) secondly, to analyse the latent properties and the degree of criticality of these attributes in relation to success in project delivery; and finally (3) to establish the predictive models on contractor selection attributes influencing target performance and overall success in projects. The first objective is important in order to understand the critical attributes associated with the selection of contractors in the Australian context and then develop a benchmark against international practices. The second objective attempts to create a better understanding of the effects of pre-qualification criteria in contractor selection in both project development and delivery contexts. This objective is particularly important for all the parties (namely main contractors, client and consultants) to prioritize the attributes in terms of their criticality for developing contractual arrangements and assuming responsibilities in order to obtain the desired outcomes in projects. The final objective is significant in establishing a comprehensive predictive model to highlight the relational links between the selected critical attributes and degree of impacts on time, cost and quality performances in the context of successful project outcomes. It is anticipated that the overall results will provide a clear insight as to the effect of the contractor selection process focusing on the products, needs, motivations and strategic business intents. By increasing each discipline's knowledge in meeting requirements and expectations of all the stakeholders, it may be possible to overcome the shortfalls of current contractor-related problems within the construction industry.

Contractor's pre-qualification in construction

Over the past few decades, numerous studies have reported various approaches for dealing with contractor's pre-qualification problems across different project types (Holt, 1998). This section summarizes the review of a few selected researches with an emphasis on types of problems and the adopted approaches related to the current study. In the US, Russell *et al.* (1992) investigated the industry evaluation of the perceived impacts of 20 decision factors and 67 sub-factors for contractors' pre-qualification across 78 public owners, 72 private owners and 42 construction managers. Based on Spearman Rank Correlation analysis, the research asserted financial stability, experience and past performance of the contractors as the three major criteria for making decisions across the owners in all three categories. While the needs for identification of domain knowledge for further evaluation of customized decision rules were highlighted, the research did not attempt to address any link of the decision criteria to the overall project success.

In the UK, Holt *et al.* (1995) undertook a comprehensive review of the background, prime influences of the available methods of contractor selection and trends of overall tendering practices. Based on the critics of a number of available reports in the UK, the research recommended the inclusion of contractor's pre-qualification practice as one of the key criteria in the tendering process. Over-reliance of clients on contractors' success based on subjective analysis was a major criticism across current industry practices. While the need for contractor's evaluation in the contexts of time, cost and quality success in projects was clearly identified, the findings were not very useful in articulating any structural pathways describing clear links between contractor selection and overall project success. However, based on the review of several decisional methodologies applied in the contractor evaluation and selection process, Holt (1998) articulated the necessity of a two-phased assessment approach, contractor's desirability for the job being the first criterion and contractor's suitability for the project being the second.

In Australia, Hatush and Skitmore (1997) studied the perceived relationship between 20 contractor selection criteria under three main project success categories in terms of time, cost and quality. Adopting an extended interview questionnaire approach, a total of eight construction industry experts were interviewed in the project. The *expected mean* and *variance* values of each criterion in terms of time, cost and quality impacts were analysed and 90%, 95% and 99% confidence intervals were calculated. Past failures were reported to be the single most critical factor across all three project success categories. Similarly, management safety accountability was identified as the least contributing factor in contractor selection across all three success measures. While this research represents an important first step towards quantifying the effects of all selected criteria on project success factors, non-identification of the critical attributes influencing time, cost and quality success made the usefulness of the research incomplete.

Kumaraswamy and Matthews (2000) examined the potential of partnering principles for subcontractor selection and improvements in overall project outcomes. Based on 20 separate debriefing interviews with both successful and unsuccessful subcontractors, the research revealed that the partnering approach produces at least 10% cost reduction in the tender price and increase in the cost, time and quality performances in the project. While the importance of partnerships between the contractors and subcontractors has been elicited as one of the most important subcontractor selection criteria, the research did not provide any insights on the owners' perceptions in the main contractor selection process. In a separate study in Hong Kong, Cheng and Li (2004) investigated the independent influence on a range of contractor selection criteria based on analytical network process (ANP). Adopting an analytical hierarchy model from Fong and Choi (2000) and incorporating expert opinions of five construction professionals, a total of nine key criteria namely, tender price, financial capability, past performance, past experience, resources, current workload, past relationship and safety management were used to rank the selected contractors based on their relative overall weights. While the ANP model advances a theoretical basis for incorporating interdependent influences among the criteria and sub-criteria in the modelling hierarchy, the research is considered insignificant due to the inability to establish the criticality of the criteria and their links to the successful outcomes in projects.

Focusing on the design-build procurement projects, Palaneeswaran and Kumaraswamy (2000) developed a scoring model for assessing contractor selection based on a range of criteria established through a knowledge mining process. The comprehensive checklist developed for assessing pre-qualification of contractors in design-build projects was not found to be useful in establishing quantitative impacts on target project outcomes.

Sacks and Harel (2006) investigated the allocation of resources by subcontractors across multiple projects undertaken simultaneously and the impact in achieving project success. By developing a theoretical predictive model for investigating subcontractor resources allocation scenarios and the impacts on work flow stability using gaming theory, the research asserted that unrealistic planning and over-commitments of subcontractors in multiple projects jeopardize the relationships between the project managers and the subcontractors and thus, achieving success in projects. The research recommended taking into consideration subcontractors' behaviours across social, organizational and technical aspects as pre-qualification criteria in order to determine potential success in projects.

Singh and Tiong (2006) studied a total of 102 industry-based contractors' selection criteria and their perceived importance among the practitioners in the Singaporean construction industry. A total of 128 questionnaire responses were collected from quantity surveyors, developers, contractors and public and private clients. Based on the observed degree of importance of the criteria, their research reported that a contractor's experience in similar projects is one of the most important factors for ensuring a contractor's success in projects. Qualification and experience level of project managers and other management staff and their track records of working in similar projects over the last three years and working capital were reported to be significant in assessing the capabilities of the candidate contractors. However, the findings were found to be unconstructive in the contexts of identifying the most critical factors and quantifying a meaningful link associated with the project success criteria.

Based on lean principles and partnering practices, Maturana *et al.* (2007) proposed a model for main contractors for onsite subcontractor selection. From survey-based responses from 29 specialty subcontractors, focus-group brainstorming and two case studies, their research found support for previous performance as the sole criterion for ensuring subcontractors' performance in projects. While the subcontractors' evaluation criteria were analysed from the viewpoint of improving contractors' support and overall productivity on site, the model fails to identify any links between such criteria and the client's success in the project. Addressing the issues of fairness and reliability in the subcontractor selection process, Ng and Luu (2008) developed a case-based reasoning model for assessing the capabilities and likely performance of the selected subcontractor in the project. The model is considered to be a significant contribution for allowing performance-based reasoning and decision-making in the selection process. However, greater emphasis on the subjective assessment in the criteria formulation made the model deficient for articulating the overall success measures in quantitative terms. In order to address the non-linear nature of contractor pre-qualification problems, a number of models have reportedly been developed based on neural network and fuzzy techniques (Li *et al.*, 2007; Juan *et al.*, 2009). While development of such models overcomes the shortcomings of the manual decision process, precise understanding of the selected contractor's ability in relation to ensuring success in candidate projects remains questionable.

From the above brief literature review, similarities of the generic issues are well evident in pre-qualification criteria in contractor selection. However, a clear consensus on the contractor selection criteria and their links and quantitative impacts on the successful time, cost and quality outcomes in projects could not be drawn decisively. A large proportion of the existing research in the field of contractor's pre-qualification notes the difficulties faced by the owners (Russell *et al.*, 1992; Holt *et al.*, 1995; Alarcon and Mourgues, 2002). Numerous methodologies have also been developed over the past few decades to assess criteria for selecting best contractors for the job (Cheng and Heng, 2004; Sacks and Harel, 2006; Maturana *et al.*, 2007; Ng and Luu, 2008; Wong *et al.*, 2008). While the above research aimed to identify many key issues in a disjointed manner, the grounds for the selection of contractors and their ability to meet the client's expectations in the context of successful project delivery remain unexplored. The selection of lowest bid in assessing the contractors is a widely used practice, yet this is found to be a significant cause for project failure (Hatush and Skitmore, 1997). Addressing the shortcomings, this research steered towards identifying the inherent attributes associated with the contractor selection process and investigating their relative importance, significance and quantitative links from a successful project implementation perspective.

Adopted approach

In order to develop a complete understanding of the effectiveness of contractor selection criteria and quantification of their impacts in overall project success, the research required a large amount of documented data on completed projects. Owing to non-accessibility of documented data on locally completed projects for this study, a questionnaire survey approach was considered as the most efficient tool (Kumaraswamy and Matthews, 2000; Doloi, 2008). By undertaking the survey of selected professionals practising in medium-sized design and construction firms, the impact of various attributes on the contractor selection practice and the overall outcomes of the projects have been established (Palaneeswaran and Kumaraswamy, 2000; Islam and Faniran, 2005).

Identification of attributes

While the published reports show a significant similarity in identifying the critical success factors in contractor and subcontractor selection, preparation of a list of comprehensive attributes was a critical first step for the success of this study. In this research, the attributes refer to the variables representing a range of capabilities impacting on contractors' performance in the context of overall success in projects. Appropriate identification of these attributes and a clear understanding of the capabilities of the contractors at the pre-tender stage allow the project owners to successfully complete the projects. By conducting a systematic background review, the significant attributes associated with contractor selection that impact on the overall project outcomes have been identified (Holt *et al.*, 1995; Hatush and Skitmore, 1997; Kumaraswamy and Matthews, 2000; Alarcon and Mourgues, 2002; Cheng and Heng, 2004). For an in-depth understanding of the current practices and a further refinement of the selected attributes in contractor selection, a pilot study was also conducted with a client, a senior project manager and a head contractor of a medium-sized construction project. A set of questions covering 39 key attributes were designed to clearly identify the contractor selection practice and to analysis the impacts over three predominant success measures namely time, cost and quality performance in projects. To guide the respondents for better understanding of the questions and appropriate structuring of their responses across the issues, these 43 key attributes were categorized into 10 broad headings namely: respondent details; project specific; management expertise; quality control systems; flexibility; experience/past projects; success and failures; financial viability; relationships; and tender price and quality. It is worth mentioning that the literature review was also clustered across these ten categories and respective salient features were analysed to identify the overall attributes in the contractor pre-qualification process. Categorization of the attributes and their descriptions are presented in Table 1. A sample questionnaire showing the question types under each category has been included in Appendix A. Though the list of this 43 attributes may not be considered exhaustive due to the vast magnitude and fragmented nature of the construction industry and construction contracts, the list covered most attributes pertaining to contractor selection practices in construction projects (Uher and Runeson, 1984; Russell *et al.*, 1992; Okoroh and Torrance, 1999; Palaneeswaran and Kumaraswamy, 2000; Alarcon and Mourgues, 2002; Singh and Tiong, 2006). The base data were then gathered to facilitate the quantitative analysis on the responses to work out a meaningful relationship among the attributes.

Preparation of the questionnaire

The questionnaire survey was designed to capture the respondents' responses and perform the standard statistical methods using the Statistical Package for Social Sciences (SPSS) software package. In most cases, a five-point Likert scale (1 = strongly agree, 2 = agree, 3 = neither agree/disagree, 4 = disagree, 5 = strongly agree) was adopted where respondents were presented with a statement or question and then requested to provide their responses with varying degrees of agreement or disagreement. This scale enabled the respondents to provide a magnitude to their response for each question, thus enhancing the ability to analyse and produce a meaningful outcome.

The overall research project was designed to use primarily two standard statistical methods, namely

Table 1 Categorization of attributes and descriptions associated with contractors' performance

Category of attributes	Description
1. Project specific	The project-specific attributes refer to the personnel availability and interest of the subcontractors with reference to the project types, complexity and site specific issues (Holt *et al.*, 1995; Cheng and Heng, 2004).
2. Management expertise	This refers to the overall management expertise in the trade and possession of specialist knowledge about the project development environment, local regulations and other governing bodies such as unions. The subcontractors are able to understand the scope of the project and deploy appropriate resources including assuming full responsibility for seamless development under the direction and management of the client (Holt *et al.*, 1995; Cheng and Heng, 2004).
3. Quality control systems	Contractor's ability in planning, controlling and ensuring high quality standards is an important attribute for successful delivery of project. Appropriate quality control systems including relevant quality control and assurance programmes, plant maintenance programmes and work method statements must be in place to ensure value engineering process across the life cycle of the project (Okoroh and Torrance, 1999; Fong and Choi, 2000).
4. Flexibility	Flexibility refers to the ability of subcontractors in adapting changes in the project timeline and willingness to accept non-standard payment terms over the currency of projects (Kumaraswamy and Matthews, 2000).
5. Experience/past projects	This refers to the overall experience of the subcontractors including their personnel in the team and their ability to work in new project environments. This also includes the types and sizes of past projects completed by the subcontractors and retention of their team members in progressive projects with adequate organizational capability to undertake challenges in new projects (Uher and Runeson, 1984; Fong and Choi, 2000).
6. Success and failures	The attribute category 'Success and failures' refers to the success and failure events across a range of issues in the project which may include supply of materials and workmanship for meeting the specifications and scope, critical deadlines and adaptability in adjusted programmes, site safety requirement, filing the progress payments and variations and timely payment of liquidated damages (Kumaraswamy and Matthews, 2000). The project level success and failure is particularly measured through cost, time and quality performance indices (Hatush and Skitmore, 1997).
7. Financial viability	Financial viability refers to the issues surrounding the working and operating capitals, yearly turnover, labour force turn around and retention rates, recruitment process and overall employee's wellbeing (Cheng and Heng, 2004).
8. Relationships	This refers to the issues surrounding the long-term working relationships and the behavioural implications such as organizational behaviour, defects liability attitudes, stress and impacts of working relationships among parties in the projects (Cheng and Heng, 2004).
9. Tender price and quality	This refers to the issues associated with the tender process including realistic price estimations, quality and robustness of tender in the context of project scope, realistic estimation on complying with the timelines and proactive response to the tender-specific questions (Holt *et al.*, 1995; Holt, 1998; Fong and Choi, 2000).

factor analysis (Field, 2005) and regression modelling (Aibinu and Pasco, 2008; Wong *et al.*, 2008). In addition, descriptive analysis was also performed to evaluate the perceived importance of the attributes for comparing and contrasting with the statistical results. Relative Important Index (RII) is proven to be a good representation in identifying the perceived importance in the order of relative criticality indicated by the respondents (Kumaraswamy and Matthews, 2000). Factor analysis is primarily used to examine the relationships between the large number of significantly correlated variables and reduce to a manageable level for appropriate interpretation (Doloi, 2008). The results form a solid basis for explaining the criticality of the attribute groupings on the target measures and hence meeting the second objective. However, the analysis is unable to depict the relationships of the underlying attributes with overall project success as targeted in the third objective. Although a number of studies were conducted to predict the contractors' performance at project level, they were merely modelling the relationships between contractor selection criteria and contractors' success in the projects (Hatush and Skitmore, 1997; Kumaraswamy and Matthews, 2000; Alarcon and Mourgues, 2002). The contractor selection criteria in relation to project success were rarely assessed by researchers in relation to whether and to what extent they achieved the desired outcomes in projects. In attempting to fill this gap, multiple linear regression analysis was considered the most suitable technique to derive the relationships between the attributes and establish the relevant predictive models (Wong *et al.*, 2008).

Respondents' profiles

The respondents for the questionnaire were selected from a wide range of design and construction teams engaged as contractors as well as clients for developing medium-sized building projects in Melbourne. The medium-sized projects have been categorically defined with a total value of up to $150 million. All the respondents identified had experience working with contractors and subcontractors in projects. The sample consisted of project managers, contract administrators, design managers and clients. Table 2 shows a typical profile for the respondents used in the study. As seen, the mix of disciplines was well proportioned in the sample. A total of 155 questionnaires were mailed out and 67 completed responses were received with a response rate of 43.2%. In order to get the best possible response commensurate by the experience and expertise, introductory conversations and e-mail contacts were made to each respondent to explain and make the objectives of the research clear. Following this introduction, the questionnaire was issued either in hard copy format or electronically via e-mail. Though the sample size is relatively small, the quality of the responses was considered to be highly reliable for the analysis due to relevant industry experience, personal level interactions and clear understanding of the questionnaires among the respondents (Vaus, 2001). As seen, among the respondents, the highest proportion (39%) comprised project managers from clients including developers; the second highest proportion (30%) comprised contract administrators. Respondents from the roles of contractor and design managers were 16% and 15% respectively. The average experience of the respondents was about 10 years with 32% over 20 years.

In regard to the project success variables namely cost, time and quality, the mean project was early or late by one month, under and above budget by less than 5% and constructed to a quality better than expected as perceived by all three parties. As seen from Table 2 under the column 'Performance of completed projects in last 5 years', 25.4% of respondents have had experience in meeting the time performance in fewer than two projects. A similar time performance was perceived to have been achieved in two to three projects by 42.0%, four to five projects by 19.4% and over five projects by only 13.2% respondents. Similarly, while 21.0% of respondents have had experience in meeting the cost performance over five projects, 31% of respondents experienced such performance in four to five projects. In the quality performance measure, only 9% have had experience achieving the target over five projects, while 59.7% experienced meeting such target in only two to three projects.

Table 2 Summary of respondents' profiles and project delivery success

Field of work		Experience (years)		Performance of completed projects in last 5 years			
				No.	Time	Cost	Quality
Project manager	39%	<5	12.5%	<2	25.4%	21.0%	13.4%
Contract administrator	30%	6–10	25.4%	2–3	42.0%	27.0%	59.7%
Contractors	15%	11–15	17.9%	4–5	19.4%	31.0%	17.9%
Design management	16%	16–20	11.9%	>5	13.2%	21.0%	9.0%
		>20	32.3%				

Data analysis

Besides the finding of the summary statistics such as means, standard deviations and frequencies using basic statistical methods, a typical first step in determining the relative importance of the numerous quantitative variables would involve a multivariate regression analysis of the data. However, outcomes of the multivariate regression analysis alone cannot be considered decisive due to considerable multicollinearity in the data (Ling *et al.*, 2004). This is because many of the identified attributes and questionnaires were closely related. Thus, the factor analysis technique was adopted to overcome the multicollinearity problem in this research (Ling *et al.*, 2004; Doloi, 2008).

Ranking of attributes

In order to determine the order of criticality of the attributes, the mean scores of responses (μ) for different project attributes were calculated from the five-point scale used in the questionnaire. Chan and Kumaraswamy (1997) suggested that the mean and standard deviation of each individual attribute are not reliable statistics to assess the overall rankings. The relative ranking of the attributes is thus based on the Relative Importance Index (RII) which is evaluated using the following formula (Doloi, 2008).

$$\text{Relative Importance Index } RII = \frac{\sum W}{AxN} \quad (1)$$

where 'W' is the weight given to each attribute by the respondents within ranges from 1 to 5 using the same Likert scale as earlier, '*A*' is the highest weight and '*N*' is the total number of respondents.

Table 3 shows the ranking of the project attributes in descending order based on their relative importance calculated using Equation 1 above. The mean scores are also presented in the column alongside the RII scores. The highest RII values indicate the most critical attributes and the lowest values indicate the less significant attributes. For the sake of a meaningful interpretation of the ranking of these attributes, they are grouped into four categories, top three highest ranked attributes with RII ≥ 0.900, five second highest ranked attributes with 0.900 > RII ≥ 0.800), 13 middle order attributes with 0.700 > RII > 0.800 and remaining 22 low ranked attributes with RII < 0.700.

Among all the respondents, the attribute 'failure in on-time project delivery' scored the highest rank with RII of 0.970 followed by the attributes 'failure to comply with the quality specifications' and 'failure to perform to safety requirements' with RIIs of 0.916 and 0.910 respectively. While on-time project delivery and meeting quality specifications are linked to the traditional project success in time and quality management aspects, non-compliance to safety standards potentially leads to total failure in projects (Cheng and Heng, 2004). All three failure attributes are perceived to be the most critical contributing factors related to overall project outcomes (Holt, 1998).

Among the second group, sound site safety records (with RII of 0.851) and ability to accommodate schedule compression (with RII of 0.833) clearly demonstrate the project management capability in projects (Cheng and Heng, 2004). A sound project management framework enables the contractors effectively to manage and control uncertainties and meet the key performance indicators in projects. Personnel availability (with RII of 0.812), similar work experience (with RII of 0.809) and overall experience (with RII of 0.800) refer to the organizational capability and relevance of contractor's experience for achieving success in projects. The revelation of the importance of possessing relevant experience and adequacy in technical skills among the senior management in contractor selection is consistent with the findings reported by Hatush and Skitmore (1997) and Singh and Tiong (2006).

Among the middle order attributes, adequacy of tender price and estimations are perceived to be critical with a RII of 0.794. A cooperative constructor's attitude over defects liability (RII = 0.779) is perceived to be significant in pre-qualification process. Continuity of labour force from one project to another is found to be an important attribute (RII = 0.776) to achieving successful project outcomes. Selection of an appropriate work method statement (RII = 0.758), meeting the tender timeline (RII = 0.743) and quality of tender (RII = 0.737) are perceived to linked to the contractor's ability in effective planning and controlling of a project. Post-contract attitude (RII = 0.731), safety initiatives (RII = 0.728), willingness (RII = 0.728), time compliance (RII = 0.713) to the overall tender process link to the contractor's commitment and dedication for the job, which are found to be the important drivers in achieving success in projects. Contractors' relationships with clients (RII = 0.707), QA/QC plans and flexibility to the construction programme (RII = 0.704) are found to have influence in a conducive working environment in the project.

Among the bottom order attributes, technical expertise with RII = 0.690 is perceived to have the highest impact followed by knowledge on construction regulation and plant maintenance and repair programmes.

Table 3 Ranking of the project attributes based on relative importance

Attributes ID	Description	Mean	RII	Rank
A.24	Failure in on-time project delivery	4.851	0.970	1
A.23	Failure to comply with the quality specifications	4.582	0.916	2
A.25	Failure to perform to safety requirements	4.552	0.910	3
A.20	Site safety records	4.254	0.851	4
A.12	Flexibility in critical activities	4.164	0.833	5
A.01	Personnel availability	4.060	0.812	6
A.16	Similar work experience	4.045	0.809	7
A.05	Overall experience	4.000	0.800	8
A.19	Tender price and estimates	3.970	0.794	9
A.38	Defects liability attitude	3.896	0.779	10
A.15	Labour force retention	3.881	0.776	11
A.11	Work method statement	3.791	0.758	12
A.42	Tender timeliness	3.716	0.743	13
A.41	Tender quality	3.687	0.737	14
A.39	Post-contract attitude	3.657	0.731	15
A.21	Safety initiatives record	3.642	0.728	16
A.40	Willingness to tender	3.642	0.728	17
A.43	Query response timeliness	3.567	0.713	18
A.35	Relationships with the client	3.537	0.707	19
A.09	QA/QC programmes	3.522	0.704	20
A.13	Flexibility in the non-critical activities	3.522	0.704	21
A.32	Technical expertise	3.448	0.690	22
A.07	Knowledge of construction regulations	3.403	0.681	23
A.10	Onsite plant maintenance and repair programmes	3.403	0.681	24
A.26	Failure in timely progress claims	3.373	0.675	25
A.22	Time in business	3.358	0.672	26
A.27	Past record of conflicts and disputes	3.358	0.672	27
A.36	Successful past projects	3.358	0.672	28
A.17	Adaptability to new project environment	3.343	0.669	29
A.03	Realistic work commitments	3.328	0.666	30
A.31	Labour force turn around	3.284	0.657	31
A.08	Union knowledge	3.104	0.621	32
A.06	Local knowledge	3.090	0.618	33
A.33	Appropriate recruitment programme	2.955	0.591	34
A.37	Volume of work committed	2.896	0.579	35
A.18	Onsite punctuality	2.821	0.564	36
A.30	Working capital	2.776	0.555	37
A.34	OHS and employee well-being	2.507	0.501	38
A.28	Yearly turnover	2.433	0.487	39
A.14	Flexibility in payment terms and conditions	2.328	0.466	40
A.29	Degree of vulnerability in business	2.284	0.457	41
A.02	Ongoing work commitments	2.060	0.412	42
A.04	Site proximity	1.761	0.352	43

This finding is similar to the findings reported by Hatush and Skitmore (1997) in the context of time performance. On the other hand, the issue of proximity to the site was found to have the least influence on contractor's performance with the RII = 0.352. The rest of the other attributes have not been discussed for the sake of brevity.

Factor analysis

As a first step to performing the factor analysis, the adequacy of the survey data has been examined by conducting the Kaiser-Meyer-Olkin (KMO) test and the Bartlett's Test of Specificity (Zhang, 2005). The KMO represents the ratio of the squared correlation between variables to the squared partial correlation between variables. The KMO statistics vary between 0 and 1. A value close to 1 indicates that patterns of correlations are relatively compact and so factor analysis should yield distinct and reliable factors. A recommended bare minimum value of KMO for a satisfactory factor analysis is greater than 0.50 (Field, 2005). In this analysis, of the possible 43 attributes, a total of 24 attributes were found to have sizeable correlation with one another with a KMO value of 0.687. The 19 attributes were found to have not significantly correlated with any other attributes and thus were excluded in the factor analysis. In order to test the null hypothesis that the correlation matrix is an identical matrix, the principal component analysis requires the probability associated with Bartlett's Test of Sphericity to be less than the level of significance (Zhang, 2005). The probability associated with the Bartlett test is <0.001, which satisfies this requirement. The details of factor analysis are well documented in many literatures including Field (2005), Doloi (2008) and thus not discussed in this manuscript.

Component extracted

The principal components analysis is adopted to reduce the highly correlated project attributes into a smaller number of key factors of the contractor pre-qualification approach. As stated above, the factor analysis was performed on the selected 24 attributes and seven principal components (factors) were extracted as shown in Table 4. These principal components were extracted by specifying the minimum initial eigenvalue of 1.0. A scree plot to graph the eigenvalues

Table 4 Factor profile of pre-qualification attributes in construction selection

Descriptions of factors and the attributes	Factor loading	Variance explained
Factor 1: Soundness of business and workforce		
A.32 Technical expertise	0.945	**17.80%**
A.38 Defects liability attitude	0.883	
A.20 Site safety records	0.878	
A.36 Successful past projects	0.837	
A.28 Yearly turnover	0.816	
Factor 2: Planning and control		
A.23 Failure to comply with quality specifications	0.934	**12.70%**
A.24 Failure in on-time project delivery	0.911	
A.11Work method statement	0.707	
A.30 Working capital	0.560	
Factor 3: Quality management		
A.42 Tender timeliness	0.944	**11.90%**
A.41 Tender quality	0.939	
A.21 Safety initiatives record	0.862	
Factor 4: Past performance		
A.29 Degree of vulnerability in business	0.954	**11.70%**
A.39 Post-contract attitude	0.950	
A.27 Past record of conflicts and disputes	0.863	
Factor 5: Risk management		
A.07 Knowledge on construction regulations	0.850	**9.80%**
A.05 Overall experience	0.816	
A.12 Flexibility in critical activities	0.603	
A.09 QA/QC programmes	0.591	
Factor 6: Organizational capability		
A.16 Similar work experience	0.813	**8.90%**
A.15 Labour force retention	0.714	
A.19 Tender price and estimates	0.664	
Factor 7: Commitment and dedication		
A.22 Time in business	0.840	**7.90%**
A.43 Query response timeliness	0.777	
Cumulative variance explained = 80.70%		

against the number of total components was generated in the data reduction process (Field, 2005). It was seen that the graph is almost flat from the seventh component, indicating that each successive component accounts for decreasing amounts of the total variance. The first seven components, which cumulatively explain 80.70% of the total variances as shown in Table 4 have been kept and other components that accounted for less than 19.30% were dropped. The interpretation of these factors is presented below.

Discussion on the critical attributes

The factor loadings shown in column 2 of Table 4 indicate which attribute belongs to which factor. The first factor (*soundness of business and workforce*) that has the largest total variance of 17.80% explains the five most important attributes associated with contractor selection. The first attribute (with factor loading = 0.945) that contributes to the contractor's success is *technical expertise*, found to be driven by relevancy of workforce and management capability in dealing with the complexity in projects. This supports the innovation of a well-equipped management team for achieving better outcomes in projects (Greenwood, 2001; Singh and Tiong, 2006). The second attribute, *defects liability attitude* with a factor loading of 0.883 is found to have significant impact in terms of supporting the post-construction maintenance in projects. Acceptance of the terms and conditions of comprehensive defects liability provisions potentially reduces the client's risks at the post-construction period and hence increases chances for success. The remaining three attributes under this component namely, *site safety records* (factor loading 0.878), *successful past projects* (factor loading 0.837) and *yearly turnover* (factor loading 0.816) refer to the soundness of the contractor's business which were found to have direct correlation to the success in projects. A track record of an uninterrupted cash flow in past projects along with high safety standards were found to be the critical requirements in the contractor's ability to succeed (Cheng and Heng, 2004). Thus, this factor highlights technical capacity, management ability and financial strengths as the most critical factor in contractor selection (Hatush and Skitmore, 1997). Consequently, this reduces the possibility of delivering the project by the contractor without any disputes (Holt *et al.*, 1995).

The second factor (*planning and control*), which is independent of the first factor and contains four key project attributes with the second largest variation of 12.70% explained the criticality of the contractor's planning and control capability in construction implementation. *Failure to comply with quality specifications* (with a factor loading = 0.934) would result in not only an undesirable outcome but also potential disputes between the contractor and the client on cost and time overruns in projects (Holt *et al.*, 1995). Consequently, the criticality of the next attribute, *failure in on-time project delivery* (with a factor loading = 0.911) becomes important in the context of not meeting the target performance in projects (Hatush and Skitmore, 1997). The attribute *work method statement* with a factor loading = 0.707 indicates a clear exposition of selection of efficient construction methodology that reflects the technical competency of the contractor relevant to the project. *Working capital* (with a factor loading = 0.560) was found to be critical within the *planning and control* factor due to the fact that undisruptive cash flow potentially contributes to seamless operation in implementation of the project. Russell *et al.* (1992) asserted the criticality of both of these last attributes from private and public owners' perspectives.

The third factor (*quality management*), containing three key attributes with a total variance of 11.90% explained the significance of the tender quality in the contractor selection process. *Tender timeliness* (factor loading = 0.944) is an important consideration associated with contractor's ability and efficacy in the project (Okoroh and Torrance, 1999). Quality of tender (with a factor loading = 0.939) was found to be one of the most significant attributes in the tender selection process. A high quality tender in terms of clarity and comprehensiveness provides not only a realistic understanding of the foreseeable challenges but also a clear basis for developing effective plans and change control processes by the contractor (Lo *et al.*, 1998; Mbachu, 2008). While the attribute, *safety initiative records* (factor loading = 0.862) was found to have a high correlation with *quality of tender* potentially influencing the overall quality performance, this finding contradicts the findings reported by Hatush and Skitmore (1997) that a contractor's safety provision has the least influence in cost, time and quality performance in projects.

The fourth major factor related to *past performance* comprising three project attributes with a total variance of 11.70%, emphasizes the criticality of contractor's success and failure records in the pre-qualification process. Contractor's vulnerability in business (with a factor loading = 0.954) was found to have significant influence for optimal performance in projects. Similarly, contractor's uncooperative *post-contract attitude* (factor loading = 0.950) and poor records of any *past conflicts and disputes* (factor loading = 0.863) were found to have adverse impacts on achieving success in candidate projects. All three attributes within this factor are supported by the past literature including Uher and Runeson (1984); Palaneeswaran and Kumaraswamy (2000); Singh and Tiong (2006).

The fifth factor (*risk management*, with a total explained variance 9.80%) consisting of four distinct attributes signifies the contractor's risk management attitude in the target project. The first attribute *knowledge on construction regulations* shows a significant impact (with a factor loading of 0.850) of contractor's ability in managing regulatory risks that directly affect the project outcomes. The remaining three attributes, namely *overall experience*, *flexibility* and *QA/QC programmes* (with a factor loading of 0.816, 0.603 and 0.591 respectively) were found to give a clear representation of the contractor's overall risk taking capacity and management capability that ensures meeting the expectations of clients and achieving overall success in projects. The importance of all these four attributes and overall impacts of risk management for successful project outcomes have been supported by the findings reported in Uher and Runeson (1984); Kumaraswamy and Matthews (2000); Greenwood (2001).

The sixth factor extracted (*organizational capability*) with total variance of 8.90% explains the significance of a contractor's organization in the contexts of three important attributes: *relevancy of past projects*, *stability of labour force* and *realistic estimating and pricing* for effective delivery of projects. Relevant experience of past projects and lessons learnt are the two key elements of potential influence in realistic estimation of cost and time required in the project (Singh and Tiong, 2006). An established but specialized contractor with a proven track record was found to have a better chance of meeting clients' expectations and effective management of underlying complexities in the candidate project. This is perhaps due to adequate support by the tacit knowledge of the contractor's organization in clarifying the design and easing out the constructability issues in the project implementation process (Holt *et al.*, 1995; Lo *et al.*, 1998; Fong and Choi, 2000; Sacks and Harel, 2006).

The seventh factor (*commitment and dedication*), with a total variance of 7.90% explained the significance of two key attributes associated with contractor's aspirations and dedication in steering the success in projects. This shows a clear link between a contractor's desire and motivation for seamless delivery without compromising the client's requirements and successfully completing the project (Lo *et al.*, 1998; Palaneeswaran and Kumaraswamy, 2000).

Mathematical validity and reliability

Validity analysis examines whether what is expected to be measured is truly measured (Zhang, 2005), i.e. whether the attributes grouped under a certain factor (or component) in the data reduction process collectively explain the same measure within the target dimensions. If the attributes truly explain the measure of the factor identified in the factor analysis, they should significantly correlate with one another. By taking the Pearson correlation (r), we can interpret the amount by which the two variables affect one another. Using the SPSS, the Pearson bivariate correlation analysis was performed to examine the relationships between the measured attributes within all the seven extracted factors as listed in Table 4. Table 5 shows the correlations between the attributes in factors 1 to 7. As expected, most of the attributes were found to be correlated in the range of 0.420 to 0.989 with two-tailed correlation significant at 0.01 level. Only two attributes in factor 2 and factor 6 were found to have correlations of 0.376 and 0.496 with two-tailed correlation significant at 0.05 level respectively. These results ensure that all the attributes grouped under the seven factors in Table 4 depict the influences and criticality associated with contractor selection and obtaining successful outcomes in projects.

Reliability is an important measure to ensure the consistency of the construct over time. The internal consistency of the measured attributes as perceived among the respondents within the Likert scale (0–5) is explained by the reliability coefficient that is based on the average correlation among the attributes and the number of total attributes in the sample. In order to examine the internal consistency of the scale, the Cronbach's alpha (C_α) test was performed on the attributes under each factor (as in Table 4) and on all the attributes. The value of C_α is anywhere in the range of 0 to 1 where a higher value denotes the greater internal consistency and vice versa. The value of C_α is inflated by a large number of variables, so there is no set interpretation as to what is an acceptable limit (Zhang, 2005). However, a rule of thumb applies to most situations with the following ranges: $C_\alpha > 0.9$ denotes excellent, $0.9 > C_\alpha > 0.8$ as good, $0.8 > C_\alpha > 0.7$ as acceptable, $0.7 > C_\alpha > 0.6$ as questionable, $0.6 > C_\alpha > 0.5$ as poor, and $0.5 > C_\alpha$ denotes unacceptable (Doloi, 2008).

Table 6 shows the values of the Cronbach's alpha (C_α) for the attributes under each factor which measure different dimensions of the contractor selection criteria. The results indicate a good overall reliability and internal consistency of the measured attributes in the analysis.

Regression modelling of contractor's attributes influencing project success

As stated earlier, the contractor's attributes identified in factor analysis were further investigated with the

Table 5 Correlation coefficients of the attributes within the factors

	Factor 1					Factor 2				Factor 3		
	A.20	A.28	A.32	A.36	A.38	A.11	A.23	A.24	A.30	A.21	A.41	A.42
A.20	1.000											
A.28	0.627[a]	1.000										
A.32	0.855[a]	0.776[a]	1.000									
A.36	0.645[a]	0.616[a]	0.741[a]	1.000								
A.38	0.798[a]	0.674[a]	0.883[a]	0.732[a]	1.000							
A.11						1.000						
A.23						0.739[a]	1.000					
A.24						0.616[a]	0.916[a]	1.000				
A.30						0.531[a]	0.588[a]	0.496[b]	1.000			
A.21										1.000		
A.41										0.806[a]	1.000	
A.42										0.780[a]	0.967[a]	1.000
A.27												
A.29												
A.39												
A.05												
A.07												
A.09												
A.12												
A.15												
A.16												
A.19												
A.22												
A.43												

Table 5 (*Continued*)

	Factor 4			Factor 5				Factor 6			Factor 7	
	A.27	A.29	A.39	A.05	A.07	A.09	A.12	A.15	A.16	A.19	A.22	A.43
A.20												
A.28												
A.32												
A.36												
A.38												
A.11												
A.23												
A.24												
A.30												
A.21												
A.41												
A.42												
A.27	1.000											
A.29	0.740[a]	1.000										
A.39	0.752[a]	0.989[a]	1.000									
A.05				1.000								
A.07				0.625[a]	1.000							
A.09				0.474[a]	0.489[a]	1.000						
A.12				0.561[a]	0.501[a]	0.523[a]	1.000					
A.15								1.000				
A.16								0.604[a]	1.000			
A.19								0.376[b]	0.420[a]	1.000		
A.22											1.000	
A.43											0.714[a]	1.000

Notes: [a] Correlation is significant at the 0.01 level (2-tailed). [b] Correlation is significant at the 0.05 level (2-tailed).

Table 6 Reliability analysis

Attributes	Cronbach's alpha (C_α)
Attributes in Factor 1	0.931
Attributes in Factor 2	0.896
Attributes in Factor 3	0.939
Attributes in Factor 4	0.930
Attributes in Factor 5	0.865
Attributes in Factor 6	0.852
Attributes in Factor 7	0.828
All attributes in Table 4	0.888

traditional multiple linear regression technique using the SPSS software. The independent or predictor variables are the attributes grouped under the seven factors listed in Table 4. Three dependent variables associated with the project success are time (Y_1), cost (Y_2) and quality (Y_3) performance which were measured separately through the questionnaire survey (please refer to Appendix A). The reduced attributes under the seven factors as listed in Table 4 were entered stepwise as categorical variables in the regression model. Thus the multiple regression models developed to determine the quantitative impacts of the attributes on the performance measures may be expressed by the following equation:

$$Yi = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots\ldots\ldots\ldots\ldots + \beta_j x_{ji} + \varepsilon_i \quad (2)$$

where Y = value of dependent valuables (one of three success criteria of time, cost and quality); β_0 = constant and the intercept at the Y axis; β_1 to β_j = estimated regression coefficients; x_1 to x_j = values of the independent or predictor variables; ε_i = error term, which is a random variable with mean 0; i = index of the performance variable being predicted; and k = number of independent or predictor variables.

As a result of the smaller sample size and the possibility of weaker predictive models being produced in regression analysis, it was necessary to reduce the number of predictor variables from a total of 24 variables listed in Table 4. As a first step, the Spearman's correlation analysis was performed to identify the predictor variables that had a significant correlation ($p \leq 0.05$) with the three success criteria: time, cost and quality (Ling *et al.*, 2004). In the second step, Spearman's correlation coefficients between every two significant predictor variables were calculated to identify instances of multicollinearity among the variables. When multicollinearity is present, the variances of the estimated coefficients are exaggerated and thus the predictive capacity of the regression models may be compromised (Ling *et al.*, 2004). By adopting the trial and error method, correlations between the selected attributes were further tested for addressing the multicollinearity issue in the model. When significant correlations were found among the predictor variables, based on trial and error technique, only one variable was included in the regression model development. The respective correlated variables were then entered stepwise as categorical independent variables against the dependent variables of time, cost and quality in the regression analysis. The optimum models were then

Table 7 Results of multiple regression analysis

Variable	β Coefficient	SE	t-value	Sig. (p)	R^2/Adjusted R^2
Time performance					
Constant	2.406	0.258	2.620	0.001	0.3842/0.3892
A.32 Technical expertise	0.407	0.022	2.929	0.035	F = 6.933
A.21 Safety initiatives record	0.366	0.115	1.844	0.046	p = 0.0001
A.16 Similar work experience	0.461	0.025	1.246	0.048	Dublin-Watson = 1.956
A.30 Working capital	0.466	0.014	1.836	0.037	
Cost performance					
Constant	2.239	0.269	2.377	0.001	0.3556/0.3601
A.36 Successful past projects	0.456	0.025	1.858	0.036	F = 7.545
A.11 Work method statement	0.439	0.020	2.198	0.048	p = 0.0001
A.22 Time is business	0.417	0.018	2.201	0.023	Dublin-Watson = 1.925
A.19 Tender price and estimates	0.394	0.130	2.201	0.036	
Quality performance					
Constant	2.964	0.238	2.507	0.001	0.3460/0.3508
A.11 Work method statement	0.353	0.015	2.011	0.031	F = 7.573
A.32 Technical expertise	0.476	0.016	1.565	0.012	p = 0.0001
A.21 Safety initiatives record	0.330	0.117	1.762	0.045	Dublin-Watson = 1.898

Note: Variables are significant at $p < 0.05$.

selected based on strength of the correlation (R^2), which is a measure of the goodness of fit for the model. As the value of R^2 changes rapidly with the addition of new independent variables in the model, a good measure of strength in the model is *adjusted* R^2 values. The adjusted R^2 values and the change from R^2 values give the idea of how well the model generalizes the predictive strength of the dependent variable (Field, 2005). Ideally, the adjusted R^2 values and R^2 values should be same or very close for model acceptance. The results in Table 7 show that all three derived models for cost, time and quality are acceptable with reasonable strengths.

The final regression model for time success may be expressed as follows:

$$\textbf{\textit{Time Sucess}} = 2.406 + 0.406\,(\textit{technical expertise}) + 0.366\,(\textit{safety initiatives record}) + 0.461\,(\textit{similar work experience}) + 0.466\,(\textit{working capital}) \qquad (3)$$

As seen, technical expertise of the contractors (β = 0.407) plays a significant role in achieving time success in projects. While this finding is consistent with the findings from factor analysis, this is somewhat a contrast to the previous assertions (Hutush and Skitmore, 1997) that technical personnel is one of the least critical criteria influencing time performance in projects. However, Hutush amd Skitmore (1997) revealed that management personnel do pay a critical role in the time management aspect and thus the technical expertise in the current study is assumed to have aligned more towards the management expertise. Contractor's safety site record and safety initiatives (β = 0.366) are found to result in seamless project implementation without accident-related disruptions and hence impact on overall time management success. The findings in relation to similar work experience (β = 0.461) and working capital (β = 0.466) are supported by a few previous researches including Hatush and Skitmore (1997); Kumaraswamy and Matthews (2000); Singh and Tiong (2006). These findings clearly suggest that contractors' ability to control time depends on their possession of relevant expertise and robust cash flow in projects (Singh and Tiong, 2006).

The final regression model for cost success may be expressed as follows:

$$\textbf{\textit{Cost Success}} = 2.239 + 0.456\,(\textit{successful past project}) + 0.439\,(\textit{work method statement}) + 0.417\,(\textit{time in business}) + 0.394\,(\textit{tender prices and estimates}) \qquad (4)$$

The past track record of a contractor (β = 0.457) in achieving success certainly increases the probability of controlling the budget effectively in the candidate project. The successful past projects attribute was found to have a strong link with the time in business attribute (β = 0.417) that was found to have influence in successful cost management outcomes (Holt, 1998; Cheng and Heng, 2004). One of the most significant findings in this study is that appropriate work method statements (β = 0.394), which is related to project planning and programming expertise of the contractors, was found to have significant influence in overall cost management success. This finding is consistent with a past finding by the author that appropriate planning and programming has a significant impact on increased productivity (Doloi, 2008), which eventually contributes to achieving higher cost performance in construction projects.

The final regression model for quality success may be expressed as follows:

$$\textbf{\textit{Quality Success}} = 2.964 + 0.353\,(\textit{work method statement}) + 0.476\,(\textit{technical expertise}) + 0.330\,(\textit{safety initiatives record}) \qquad (5)$$

The appropriateness of the work method statement (β = 0.353) and safety initiatives record (β = 0.330) of the contractors was found to have significant influence on quality outcomes in the candidate project. The existence of relevant technical expertise (β = 0.476) required in the project certainly allows the contractors to understand the quality specification and comply with the specified quality standards. While these findings accord with the findings reported in Ling *et al.* (2004) and Singh and Tiong (2006), the findings by Hatush and Skitmore (1997) suggest that safety accountability has the least impact on contractors' ability to achieve quality success. However, as this study reveals, the author is convinced that safety initiatives of the contractor is an important consideration in meeting the construction regulations onsite and thus it does play a crucial role in quality performance in project (Cheng and Heng, 2004).

Results and discussions

The results of the research indicate that soundness of business and strength of workforce of the contractor are the most critical factors impacting on contractors' ability to achieve time, cost and quality success in projects. The five key attributes under this factor reveal that contractors' ability to achieve time, cost and quality success in projects depends on their technical expertise, defects liability attitudes, site safety records, successful past projects and yearly turnover. Realistic planning and appropriate control measures were found to have the second highest influence on contractors' effective project management capability. Failure to comply with quality requirements and poor control of delivery deadlines in past projects links to a contractor's inability to achieve success in the next project. A relevant work method statement and track record of availability of adequate working capital were found to have positive influences on successful project outcomes. Contractors' quality management capabilities in terms of tender timeliness, tender quality and safety initiative records were found to be the third critical influence in the contractor selection process. Unlike the assertions by Hatush and Skitmore (1997) that the overall past performance of contractors is one of the most dominating contractor selection criteria affecting project success, this research put the importance of this factor in fourth position. Contractors' risk-taking attitudes along with the overall risk management capability is an important factor contributing to successful project outcomes. Contractors' knowledge of construction regulations and supporting attitudes in managing risks and uncertainties play a significant role in managing projects effectively. Contractors' organizational capability in terms of experience, retention of key personnel and realistic pricing was found to have only moderate influence in the successful project delivery. The seventh factor, commitment and dedication, which comprises 'time is business' and query response attributes, reveals the link between behavioural attitudes of contractors and successful project outcomes. This finding is similar to the findings reported by Sacks and Harel (2006).

The results of regression modelling highlighted the relational links between key selected attributes and the project outcomes in terms of time, cost and quality success. Technical expertise, safety records, relevant experience and adequacy of cash flow were found to have the strongest links to both time and quality success in projects. Similarly, past success, efficient project planning, time is business and realistic tender estimates were found to have significant influence on the cost performance. Based on the regression modelling, it has been evident that cost, time and quality functions in projects should be assessed through the above attributes rather than adopting the traditional bird's eye views (Singh and Tiong, 2006) in the contractor selection process. These findings are expected to be the significant contributions for industries to improving the contractor selection practices and achieving successful project outcomes.

Limitation of the research

While all the above findings are highly significant for filling the stated knowledge gap, the research is not completely exempt from any limitations. First, the sample size of 67 datasets for constructing regression models is a bit small. Secondly, the mix of respondents among the four distinct professions may have resulted in some bias in the responses. The model may be further refined based on brainstorming with industry focus groups for specific industry types and tested using data collected separately from client groups in both public and private sectors. In addition, the measure of project success should be further expanded in relation to increased productivity on site which it is intended to address in the author's future research in the domain.

Conclusions

By investigating the quantitative impacts of contractor selection criteria, the findings highlight a clear relationship between contractor selection attributes and project success measures in the context of delivering successful project outcomes. Among many known pre-qualification criteria available from published literature and industry practices, 43 key attributes were selected for this study. Based on the initial correlation analysis, 19 attributes with insignificant correlation coefficients were excluded and only 24 attributes were selected for performing statistical factor analysis that resulted in a reduction to the seven important factors.

The data analysis revealed that although past performance and financial status are widely used determinants for contractors' pre-qualification generally, when the factors are tested in relation to a project's end results, technical expertise, success in past projects and sound programming capability were found to have significant influence in achieving overall success. Addressing the first objective, the perceived importance of the influencing attributes among the respondents indicated that on-time delivery, complying with quality specifications, safety performance, site safety records and flexibility in work schedule are the five most important criteria for contractor selection. However, factor analysis revealed that soundness of business and workforce in terms of technical expertise, a positive attitude toward defects liability, site safety records, successful past projects and sound financial position are the most influencing factors for contractors in achieving greater success in projects. It was also found that planning and controlling skills of contractors have a significant influence in managing projects effectively. The results show that the impact of contractors' past performance is relatively moderate when it is measured with technical requirements such as planning and controlling and quality management in projects. As set out in the second objective, these outcomes highlight that there are significant differences in opinions regarding the degree of importance assigned to some of the common contractor selection factors across the firms.

The firms need to pay greater attention to improving the widely used practice of lowest price being the primary criterion for contractors in projects. As the modern construction projects increasingly become challenging with innovative design and complex procurement systems (such as PPP), traditional criteria for assessing a contractor's qualification may not be adequate in devising satisfactory outcomes for the multitude of stakeholders in projects. It has been proved that lowest price in tender bid has no credibility for contractors achieving success in projects. Rather, emphasis must be given to assessing technical strengths and management capabilities of the contractor in the context of underlying challenges in projects. Although firms are using on-time and within budget delivery as the prime targets for measuring contractors' success, contractors' accountability over an extended defects liability period appears to be linked to the high quality outcomes in projects. In order to improve value for money and overall satisfaction, clients should engage the contractor with relevant technical ability, clear organizational maturity and proven risk management capability for the project.

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Appendix A

Sample questionnaires associated with the contractor's selection criteria

Questionnaire

(Likert scale used: 1 = Strongly agree; 2 = Agree; 3 = Neutral; 4 = Disagree; 5 = Strongly disagree)

Part 1: Project specific

A.01 Current availability of personnel resources require for the project
A.02 The amount of work the contractor is contracted to
A.03 The amount of work the contractor has tendered for
A.04 How close the contractor is located from the work site

Part 2: Management expertise

A.05 Number of years in the trade
A.06 Any specialist knowledge about the local environment including source of material and area specific conditions
A.07 Any previous specialist knowledge such as BCA requirements, material specifications, etc.
A.08 Any previous specialist knowledge about the unions and industrial relations issues

Part 3: Quality control systems

A.09 The level of QA/QC programmes implemented in past projects
A.10 The plant maintenance and repair programmes in projects
A.11 The thoroughness of work method statements

Part 4: Contractor's flexibility

A.12 The ability of the contractors to adapt changes in the protected timeline (critical paths)
A.13 The ability of the contractors to adapt changes in the unprotected timeline (non-critical paths)
A.14 The willingness of the contractor to accept a non-standard payment term such as progress payment in arrears

Part 5: Team experience/relevancy

A.15 The amount of similar work done by the contractor's team
A.16 The amount of similar work done by the contractor's organization
A.17 How well the contractor has adapted the new work methods and materials used?
A.18 Attentiveness and activeness of the contractors in site meetings
A.19 The quality of previous work particularly defect claims
A.20 The onsite safety records
A.21 Adherence to Job Safety Analysis (JSA) worksheets
A.22 The length of time the company has been in business

Questionnaire

(Likert scale used: 1 = Strongly agree; 2 = Agree; 3 = Neutral; 4 = Disagree; 5 = Strongly disagree)

Part 6: Contractor's success/failures
A.23 Failure to supply material and workmanship to required specifications and scope
A.24 Failure to meet critical deadlines and adjusted programmes
A.25 Failure to meet site safety requirements such as scaffolding, visual markers, traffic control, etc.
A.26 Failure to file on time progress payments and variations
A.27 Failure to pay liquidated damages on time and the extents

Part 7: Financial viability
A.28 The yearly turnover of the company
A.29 Positive/negative trends of turnover based on past 5 years' figures
A.30 The net working capital of the contractor
A.31 Trend of turnaround and numbers of staff
A.32 The ability of contractors to retain the personnel
A.33 The ability of contractors to recruit high quality personnel
A.34 The types of contracts offered by the contractor to the labour force

Part 8: Relationships with the subcontractors
A.35 The length of time working with subcontractors
A.36 The number of jobs working with subcontractors
A.37 The number of jobs tendered with subcontractors
A.38 The willingness of subcontractors to support the contractor over defects liability period
A.39 The willingness of subcontractors to support the contractor for follow ups after the defects liability period

Part 9: Tender quality
A.40 Willingness to provide a price during the tender phase
A.41 The quality and depth of a tender suitable for a detailed comparison
A.42 Meeting tender deadlines
A.43 How quickly tender specific questions are answered and changes to the scope re-measured

Part 10: Overall project performance
A.Y1 Less than one month early or late on the agreed time period
A.Y2 Less than 5% over and below the allocated budget
A.Y3 All parties satisfied with the quality of the delivered project facility