Criticality of project knowledge and experience in the delivery of construction projects

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Disclosure statement

No potential conflict of interest was reported by the authors.

Acknowledgements

This research was funded by UTAR Research Fund (UTARRF) (Project Number: IPSR/RMC/UTARRF/2019-C2/J01), supported by UTAR Global Research Network Program (International Collaborative Partner) and the National Natural Science Foundation of China Grant Nos. 71390523 & 71501142. The authors would also like to thank the anonymous reviewers for their constructive and insightful comments, which have helped improve the quality of this paper.
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Abstract

Purpose - Poor project knowledge and inadequate experience are frequently linked to construction time-cost overruns. This paper expounds on the criticality of project knowledge and experience in the successful delivery of projects in the construction industry.

Design/methodology/approach – Following a detailed literature review, a quantitative positivist approach with a questionnaire survey involving industry professionals is employed to appraise the 30 prevalent causes of time-cost overruns according to frequency, effectiveness and importance indices. The data are then subjected to Spearman’s rank correlation tests and exploratory factor analysis.

Findings - Using the importance index (IMP.I), which assimilates both frequency and effectiveness indices, the criticality of knowledge and experience in the overall context is seen as fundamental for addressing the contractor’s faulty planning and scheduling, construction mistakes and defective work, site management and supervision, delayed/slow decision making, incomplete drawings and design documents, and change/variation orders. Spearman’s rank correlation tests indicate a good consensus of perceptions among the key parties involved. Next, an exploratory factor analysis uncovers six underlying knowledge-based factors affecting construction performance, relating to inaccurate resource estimates, design changes, resource shortages, lack of experience, incompetence and mistakes and defects.

Originality/value - The study draws out the repercussions of the hitherto limited research into the deficiencies in knowledge and experience in undertaking construction projects to enhance performance using knowledge management functions.
Keywords: Knowledge management, project management, cost overruns, schedule delays, construction, factors

Introduction

“The success of projects depends heavily on the right combination of knowledge and experience.”

(Disterer, 2002, p. 519)

Despite the significant development of project management tools and techniques to facilitate project delivery over the years, schedule delays and cost overruns are still very common in the global construction industry. In Malaysia, for example, Shehu et al.’s (2014) analysis of 359 completed projects found that more than half experienced cost escalation. In another Malaysian study, Nurul et al.’s (2016) examination of National Audit Reports for public construction projects revealed poor management to be the most frequently reported reason for underperformance.

Given the persistent recurrence of construction time-cost overruns, identifying the causative factors involved has attracted considerable attention in recent decades. Zidane and Andersen (2018), for example, in identifying universal delays factors, appraise 104 existing studies published over the last 30 years (from 1990 to 2017), covering 45 countries to reveal that completion delay is an inherent risk in most construction projects and that the root causes need to be recognised before effective preventive actions can be devised. In the context of the developing world, Trigunarsyah and Islam (2017) reviewed 28 relevant studies published between 2006 to 2016 to conclude that, while project delay is a common phenomenon, most of the studies failed to provide constructive guidance for effectively managing the salient issues involved. Likewise, Alsehaimi et al.’s (2013) critical evaluation of 16 construction delay
studies in developing countries across Asia and Africa found that failure to use appropriate project management practices and controls is the most cited reason for late completion, and that a clear shortcoming of these studies is the failure to prescribe realistic means for removing the common causes of delay. Moreover, these studies do not solve the problems they identify, as little research has been carried out to discover the underlying causes involved. In addressing existing shortcomings, Yap et al.'s (2019a) factor analysis of 23 salient problems plaguing the management of construction projects in the developing world discloses that a sizeable proportion of these problems is human- and management-related.

Both tacit and explicit knowledge are needed to improve performance (Addis 2016). In this respect, Kanjanabootra and Corbitt (2016) argue that the reproduction of knowledge and expertise development are critical in construction. A plethora of previous studies also indicate that managerial predicaments are often related to poor knowledge and lack of competence (Agyekum-Mensah and Knight 2017; Al-Kharashi and Skitmore 2009; Nguyen and Chileshe 2015). However, how much the shortfall in competencies affects project outcomes remains largely unknown. As Abdul-Rahman et al. (2008) highlight, previous delay management studies do not incorporate the elements of knowledge and learning as part of the human-based effort to mitigate project delay. There is limited evidence associating the prevalent causes of time-cost overruns with project knowledge and relevant prior experience.

Recognising that time-cost overruns are a common feature of construction projects, the present study investigates the criticality of project knowledge and experience in construction project delivery. The specific objectives are to: (1) appraise the perception of knowledge management (KM) practices by construction professionals; (2) recognise the causes of time-cost overruns related to project knowledge and experience; and (3) uncover the underlying knowledge-based factors affecting construction performance.
Causes undermining construction schedule and cost performance

Table 1 presents a list of 30 major causes identified in previous studies that inhibit the effective schedule and cost management of construction projects. The majority of these are managerial shortfalls associated with a lack of knowledge and project management capabilities, suggesting that KM practices are likely to have an important role in improving the situation.

[Please insert Table 1 here]

Relating project knowledge and experience to project performance

As Gasik (2011, p. 23) asserts, “knowledge is the most important resource needed for project management”, the management of which is said to be “the process of using existing knowledge and creating new knowledge to achieve the project’s objective and contribute to organisational learning” (Project Management Institute, 2017, p. 98). As Carrillo et al. (2013, p. 538) explain, “lessons learned are the intellectual assets used to create value based on past experience”, making it vital to leverage the knowledge and experience from previous projects to support organisational operations and improve the outcomes of future projects (e.g., Disterer, 2002). As such, KM principles and practices play a pivotal role in yielding organisational competitiveness by creating a culture of continuous improvement and learning, preventing the repetition of mistakes and wheel-reinvention (Eltigani et al. 2019; Tan et al. 2010; Reich, Gemino, and Sauer 2014; Koskinen 2012; Sense 2008).

Paradoxically, the limited use of KM practices means that all the cumulated valuable knowledge, skills and experience of the project team are not fully capitalised in construction project delivery (Carrillo et al. 2013; Forcada et al. 2013). This often results in inefficiencies, repeated mistakes, poor skills, inadequate working knowledge, wrong decision making and a lack of learning from project experience (Suresh et al. 2017), which then entail rework, delays and wastage (Kakitahi et al. 2016). In response, Abdul-Rahman et al. (2008), for instance,
integrate KM and learning management with delay management to conceptualise a delay mitigation model based on a project learning approach. Experiential learning and personal constructs, therefore, form the foundation for developing the competencies and capabilities needed to minimise construction time-cost overruns (Yap and Shavarebi 2019).

**Research method**

Uncovering the relevant knowledge and experience needed to deal with the causes of time-cost overruns would normally involve an analysis of documents from completed projects. However, as such documents are commercially sensitive for construction projects, survey research is a particularly useful alternative as it is cost-effective, quick to administer and can be easily coded and analysed (Doloi 2009). This involved the distribution of a questionnaire to a large sample of construction professionals, using closed questions to secure confidential answers.

**Data collection instrument**

The questionnaire was designed to solicit the perceptions of contractors, consultants and developers in the Malaysian construction industry to obtain an all-around assessment of the main stakeholders involved. The questionnaire comprises three sections: A, B and C. Section A deals with the respondents’ general background information. Section B contains three statements concerning KM practices, to which responses are solicited on a 5-point Likert scale from 1 (“strongly disagree”) to 5 (“strongly agree”), with 3 being classed as “neutral”. Section C consists of the 30 causes identified in Table 1. Two questions are posed for each cause: (1) *How often do you use knowledge and experience to influence the outcome of the following causes of time-cost overruns in a construction project?* and (2) *How effective is the implementation of knowledge management practices in reducing or mitigating the effect of the*
following causes of time-cost overruns in a construction project? Both of these are also rated on a 5-point Likert scale of 1 (“never”) to 5 (“always”) for (1) and (“not at all effective”) to 5 (“extremely effective”) for (2).

Data collection

The sampling frame comprises professionals in contractors, consultants and developers organisation from Malaysia’s construction industry. Non-probability techniques of purposive and convenience sampling are used to select respondents, akin to Bagaya and Song (2016) and Yap et al. (2019a) to yield reasonable responses. In this study, the unit of analysis is construction professionals as they are the actors directly involved in project delivery. The questionnaire was distributed by email to 140 professionals working in Malaysia’s Klang Valley region, and 97 (69.3%) were returned completed after follow-up reminders. The characteristics of the respondents are summarised in Table 2, indicating over half (55.7%) are contractors, with roughly equal numbers of consultants and developers; the majority (84.5%) are upper and middle management with 10 years of working experience, and hold Bachelor or higher degrees (81.4%); and nearly half (46.4%) of the largest project undertaken exceeds MYR 500 million (10^9). They are therefore predominantly highly qualified professionals with sufficient relevant knowledge and experience to provide sound judgements.

[Please insert Table 2 here]

Analysis

The internal consistency of the measured variables is evaluated by Cronbach’s alpha, with data analysed using index techniques modified from Le-Hoai et al. (2008), Bagaya and Song (2016) and Yap et al. (2019a). This involves three indices. (1) The frequency of using knowledge and experience expressed as the frequency index
where $a$ represents the Likert frequency weighting for each response, $n$ is the frequency of responses and $N$ is the total number of responses. (2) The effectiveness index (EI) of KM practices, with

$$EI = \sum_{i=1}^{5} \frac{b_i n_i}{5N}$$

where $b$ represents the Likert effectiveness weighting for each response. (3) Combination of both the frequency and effectiveness indices to gauge the significance of knowledge and experience-based practices in addressing the causes of time-cost overruns – computed as the importance index

$$IMP.I = F.I. \times E.I.$$  

Assessing how knowledge and experience can influence project delivery using the indices as explained above is a first among studies in construction project management.

Finally, an exploratory factor analysis is carried out – a data reduction statistical technique widely used in previous construction management studies to group correlated variables (e.g., Le-Hoai, Lee, and Lee 2008; Ye et al. 2014; Doloi et al. 2012) – comprising principal components analysis with orthogonal (varimax) rotation. This firstly involves the use of KMO and Bartlett’s tests to ensure the data are suitable for this kind of treatment and to establish the adequacy of the correlation matrix (not being an identity matrix) where the variables are strongly correlated (Hair et al. 2010; Nguyen, Ogunlana, and Lan 2004).

**Results**

**Perceptions of KM**

Relative important index (RII) is a good representation in prioritising perceived important in the order of relative criticality as rated by the respondents (Doloi 2009). Of the three
statements made in this section, “knowledge management is important in construction industry” (RII = 0.926) and “effective management of the organisation’s knowledge is a critical factor to enhance the company’s competitive edge and organisational performance” (RII = 0.924) are the most highly rated, indicating that the respondents appear to have a very good awareness of the topic in principle. Furthermore, a large proportion also agree that “knowledge management practices are important for construction company to prevent the loss of knowledge gained in the construction projects” (RII = 0.885), suggesting the respondents appear to show a keen understanding of the practicalities involved.

**Analysis and ranking of the causes**

Cronbach’s alpha values are 0.955 and 0.972 for the frequency of using knowledge and experience and effectiveness of KM practices respectively, which, being over 0.70, indicates a high degree of measurement reliability (Hair et al. 2019).

**Frequency of the use of knowledge and experience**

The most frequent use of knowledge and experience to influence the outcome of the 30 prevalent causes are presented in Table 3. Overall, the FI ranges from 0.635 to 0.814. From the contractors’ perspective, the five most highly considered causes of overrun are the contractor’s improper planning and scheduling (0.819), construction mistakes and defective work (0.819), delayed/slow decision making (0.819), the contractor’s poor site management and supervision (0.800), incomplete drawings and design documents (0.793) and change/variation orders. The equivalent for consultants are delayed/slow decision making (0.818), the contractor’s poor site management and supervision (0.800), the contractor’s improper planning and scheduling (0.791), change/variation orders (0.791) and incomplete drawings and design documents (0.782). For developers, these are the contractor’s improper planning and scheduling (0.829),
construction mistakes and defective works (0.800), inadequate contractor experience (0.790),
design/scope changes (0.790), the contractor’s poor site management and supervision (0.781)
and incomplete drawings and design documents (0.781).

[Please insert Table 3 here]

**Effectiveness of the use of knowledge and experience**

The five most effective uses of knowledge and experience in reducing or mitigating the
effect of these causes are shown in Table 4. Overall, EI ranges from 0.627 to 0.802. According
to the *contractors*, the five most highly perceived causes to be effectively mitigated or reduced
by KM practices relate to the contractor’s improper planning and scheduling (0.804),
construction mistakes and defective work (0.778), delayed/slow decision making (0.774),
incomplete drawings and design documents (0.767), the contractor’s poor site management and
supervision (0.763) and change/variation orders (0.763). For *consultants*, these are construction
mistakes and defective work (0.818), the contractor’s improper planning and scheduling
(0.809), inadequate contractor experience (0.791), delayed/slow decision making (0.782),
change/variation orders (0.782) and design mistakes/errors (0.782). As for *developers*, these
are the contractor’s improper planning and scheduling (0.790), construction mistakes and
defective work (0.781), the contractor’s poor site management and supervision (0.771),
delayed/slow decision making (0.752), incomplete drawings and design documents (0.752),
design/scope changes (0.752) and lack of communication between parties (0.752).

[Please insert Table 4 here]

**Importance of knowledge and experience in construction project management**

Table 5 shows the most significant causes in terms of their potential to effectively
minimise or mitigate their impact on time-cost overruns by using knowledge and experience.
Given that IMP.I is calculated as a function of both FI and EI, there are no major differences in terms of the rankings compared to the above (FI and EI). Overall, IMP.I ranges from 0.398 to 0.653.

“The contractor’s improper planning and scheduling” is ranked highest (0.653), and is therefore the most crucial problem arising from low aptitude, skills and knowledge as well as lack of prior work experience. Intriguingly, this cause is reported in the top 10 list in 64 studies and ranked highest in six studies in developing countries, namely Botswana, Jordan, Lebanon, Libya, Malaysia and South Africa (Zidane and Andersen 2018). In Malaysia, Sambasivan and Soon (2007) attributed this predicament to the contractor’s inexperience. Likewise in Jordan, most managerial and operational predicaments are attributed to the lack of training or education in planning and control, although some of the personnel have good work experience (Odeh and Battaineh 2002). According to Kang et al. (2018), deficiencies in construction management capabilities is a major risk for poor performance in developing countries. However, qualified personnel is hard to hire and retain (El-Sayegh 2008). In India, Doloi et al.'s (2012b) factor analysis found the attributes for improper planning are related to lack of contingency measures for inclement weather conditions, poor labour and equipment planning, inefficient use of equipment, poor coordination among parties and failure to recognise the lead time for material delivery. Sun and Meng (2009, p. 560) elucidate project planning and scheduling as “the task of defining all the activities/processes and their inter-relationship. It is done at the start of a project when many input parameters are uncertain and assumptions have to be made”. Given the complex make-to-order construction supply chain, coordination planning and control are difficult (Sun and Meng 2009), particularly when numerous and fragmented subcontractors are awarded through lowest bid (Taggart et al. 2014). As such, technical competency, prior experience and risk management are crucial within the framework of planning and scheduling.
to reflect operational reality and actually achieve schedule, cost and performance goals (Doloi et al. 2012a).

“Construction mistakes and defective work” is second highest in the overall ranking (0.624). Sambasivan and Soon (2007) assert that such mistakes arising during the implementation stage are attributable to accidents, poor planning and communication breakdown between the contracting parties. In this light, “quality deviation, quality failure, non-conformance and defects” are in the nature of re-doing work or simply termed rework (Love and Smith, 2018, p. 181), which relates to “the unnecessary effort of redoing a process or activity that was incorrectly implemented the first time” (Love, 2002, p. 19). At the individual level, errors can be categorised into action errors (unintentional deviation from goals, rules and standards), violations (a conscious intention to break rules or not conform to a standard) and judgement and decision-making errors (arising due to cognitive biases and heuristics) (Love and Smith 2018). Most notably, construction errors are often manifested because of poor communication and lack of reflective learning (Love 2020). To ameliorate time and cost performance, Yap and Skitmore (2020) develop a knowledge-based project control model that comprises four strategic enablers of learning situations, effective communication, project learning and reusable project knowledge. They also assert that using the “right” methods, techniques, technologies, practices, processes or even people are important for successful project execution.

“Delayed/slow decision making” is ranked as the third most critical cause (0.622). Effective problem-solving and decision making very much depend on the right information being available to the right people at the right time. In providing accurate and timely information for project managers to select the most appropriate controls for variation orders for institutional buildings in Singapore, Arain and Low (2006) propose a knowledge-based decision support system (KBDSS) – developed based on information gathered from previous
completed projects and feedback from experienced professionals through in-depth interviews. In another study, Thomson et al. (2006) propose a ‘Value Adding Toolbox’ capable of supporting value delivery for construction design decisions – underscoring the need to capture the lessons learned from completed projects and form links between various projects so that value-adding tools can be reused repeatedly in the future. As highlighted by Yap and Shavarebi (2019), the expert judgement of construction personnel is influenced by their project experience and personal constructs. Considered in this light, the analysis of past decisions is complementary to decision making for current events.

“Contractor’s poor site management and supervision” is ranked in fourth place (0.617). Deficiencies in site planning, implementation and controls expose projects to unpredicted high risks and negatively affect site productivity (Alaghbari et al. 2007; Sambasivan and Soon 2007). According to Doloi et al. (2012), the causes of inefficient site management are related to ambiguity in specifications, inefficient management skills and inexperienced personnel. According to Kazaz et al. (2008), inexperienced and untrained workers are more likely to engender an additional waste of resources and damage to equipment. They also note that site supervisory personnel with sufficient capacity and job experience are key to the efficient planning, organising, leading and coordination of resources. As highlighted by Al-Kharashi and Skitmore (2009), contractors in Saudi Arabia lose control of the management of sites due to their unfamiliarity with the project requirements. In this connection, Toor and Ogunlana’s (2008) interviews with project managers in Thailand found that many site-related problems could be avoided by having experienced construction managers and seasoned site supervisors at the site.

“Incomplete drawings and design documents” is ranked fifth (0.601). This design-related problem has been linked to a poor brief, errors and omissions, as well as inadequate design team experience (Sun and Meng 2009). Poor documentation, missing information, engineering
errors and poor-quality design can result in excessive changes during construction. In this connection, Zidane and Andersen's (2018) intensive literature review also reported ‘design changes’ as the uppermost reason for the late completion of construction projects. In this vein, the attributes influencing the task performance of construction professionals can be operationalised into cognitive ability, job knowledge, task proficiency and job experience (Ling 2002). As such, contractors and consultants with strong positive reputations based on their proven track record and related experience with similar projects are more likely to deliver better outcomes for their future projects (Ling and Ma 2014).

[Please insert Table 5 here]

**Homogeneity of ranking between parties**

Recalling that it is the *ranks* of scores and not the scores themselves involved, Spearman’s non-parametric rank correlation is used to reveal the strength and direction of the link between the two sets of data (Hwang et al. 2014). The results presented in Table 6 indicate a good consensus between the respondent groups on the ranking of causes with respect to FI, EI and IMP.I. Regardless of the pairing involved, the respondents tended to have a higher degree of agreement on the *frequency* of using knowledge and experience compared to their *effectiveness*, with an average FI and EI of 81.1% and 77.5% respectively. This consensus further implies the regular use of knowledge and experience in the project management aspects, but their associated effectiveness varies between the parties. For IMP.I, the highest agreement is between the contractors and developers (86.5%) while the lowest is between the consultants and developers (76.2%). The strong correlations between parties corroborate the significance of KM practices in the efficient and effective management of construction problems associated with project delivery.

[Please insert Table 6 here]
Factor analysis for underlying groupings

The KMO value of 0.865 and Bartlett’s significance of 0.000 is better than the 0.5 and 0.05 needed for a reliable factor analysis. Table 7 presents the factor profile – the factor analysis generating a six-factor solution that satisfies the latent root criterion (Eigenvalues > 1.0) and accounts for 72.31% of the total variance explained – greater than the 60% needed to establish construct validity (Hair et al. 2019). To increase correlation, each factor retained items with loadings greater than 0.5 (Nguyen, Ogunlana, and Lan 2004). Each cause has high loading on one factor only. The six-factor solution is internally consistent as the Cronbach’s $\alpha$ ranges from 0.816 to 0.912. The six knowledge-based factors can be meaningfully interpreted and are labelled as: (1) inaccurate estimates of resources, (2) design changes, (3) resource shortages, (4) lack of experience, (5) incompetence and (6) mistakes and defects, as detailed in the following.

[Please insert Table 7 here]

Factor 1: Inaccurate estimates of resources

This first factor has the largest total variance of 15.47%, explaining the five most crucial causes triggering incomplete or incorrect construction estimating, which comprise “inaccurate estimates of materials/quantity take off”, “inaccurate prediction of equipment production rate”, “inaccurate prediction of labour production rate”, “inaccurate bill of quantities” and “exceptionally low bids”. The factor loadings range from 0.625 to 0.853, indicating a good correlation between the causes. If untrained or inexperienced project personnel carry out resource estimation, there is a huge risk that the estimates are overly optimistic and/or unrealistic. For example, one of the most significant risks in the UAE is an unreasonably tight schedule imposed on construction activities by the owners (El-Sayegh 2008). Likewise in Saudi
Arabia, failure in schedule forecasting and inadequate early planning contribute to construction delays (Al-Kharashi and Skitmore 2009). As highlighted by Flyvbjerg et al. (2003), almost 90% of global transport infrastructure projects are completed with inordinate cost increases whereby the severity of overruns are more profound in developing countries – asserting that “cost escalation today is in the same order of magnitude as it was 10, 30 or 70 years ago…. No learning seems to take place” (p. 83). Subsequently, in a more recent study, Flyvbjerg et al. (2018) highlight that reliable and de-biased construction estimation is crucial to improve the quality of decision making, suggesting that the best way to avoid cost overrun is by staffing projects with professionals with a proven record in the successful completion of a similar type of project. However, there has been some debate over the plausible untruths of cost underestimation in transport infrastructure projects (see Love et al. 2019; Love and Ahiaga-Dagbui 2017). Against this background, Olawale and Sun's (2015) appraisal of the UK’s prevailing inadequacies in existing project time and cost control practices observed that a combination of technical know-how and experience is required to accurately estimate construction duration, with the Gantt chart and critical path method (CPM) being the most popular tools. However, the major deficiency is that time and cost are separated although both are usually intrinsically connected. As such, project evaluation and control are ineffective (Olawale and Sun 2010). Moreover, Sullivan et al. (2010) hold that the best value delivery model can significantly minimise technical risk, with only high-performance experts with the right expertise and experience being engaged on the project from beginning to end.

**Factor 2: Design changes**

This factor accounts for the second-largest variation of 13.70% and comprises the largest number of causes (seven) that explain the predicaments associated with design and documentation-related issues. The leading cause in this group is “design/scope changes” with
a factor loading of 0.802. In the UK, Olawale and Sun (2010) reported design changes as the most popular reason for time-cost overruns. A design change is a scope creep defined as “any uncontrolled and unexpected change in project requirements that extend the initial boundaries of the project” (Amoatey and Anson, 2017, p. 396). As such, the potential impacts are rarely reviewed before the changes are instigated. Thence, scope creeps from client changes, and unclear scope and design errors cause schedule pressure and ultimately result in excessive time-cost overruns (Amoatey and Anson 2017; Han et al. 2013). In this connection, design-related change orders are observed as the most significant factor causing rework in Singaporean construction projects (Hwang and Yang 2014). In a separate study, Yap et al.’s (2018) exploratory factor analysis of the causes of design changes found eight underlying dimensions of incompetence, poor quality conformance, safety and health aspects, regulatory requirements, active rework, inadequate collaboration between parties, changes in end-user requirements and construction operational risk management. Subsequently, their validation using structural equation modelling (SEM) shows that competency-related causes have the strongest impact on design changes.

**Factor 3: Resource shortages**

Factor 3 is formed of four causes with a total variance of 13.26%. According to the PMBOK Guide, project resource planning entails both team and physical components. Team resources are personnel assigned as part of the project team, while physical resources include facilities, materials, tools and equipment and infrastructure (Project Management Institute 2017). The performance of a project can be affected by the quality and quantity of the workforce and equipment (CIDB Malaysia 2015). Construction labour productivity is influenced by the skillsets and attitudes of the workers. Given the rapid development and poor participation from locals due to unfavourable working conditions, this labour-intensive sector
in Malaysia is facing an acute labour shortage and is highly dependent on low-skilled foreign workers (Yap et al. 2019a). The industry also suffers from low efficiency, low productivity and backward technology due to the slow update of technology and modern practices. According to El-Sayegh (2008), the significant risks associated with resources in the UAE include the supplier’s late delivery of materials, labour shortages, attrition of qualified personnel and unavailability of materials. Materials planning includes determining and quantifying material requirements, ordering and scheduling. As such, the poor planning of materials can affect productivity due to late deliveries and schedule delays (Alaghbari et al. 2007). Moreover, Kaming et al. (1997) note that price escalation due to shortages will have a high impact on cost overruns in tall building construction, as materials comprise approximately 65% of the total cost. Regarding construction equipment management, many contractors do not own heavy construction equipment, as it is a common practice to rent the equipment as and when needed. However, during a peak season with high demand, the delivery of equipment may be delayed due to a short supply and beleaguered with frequent breakdowns owing to inadequate preventive maintenance (Sambasivan and Soon 2007). In this regard, a knowledge of market conditions and close interaction with suppliers is vital for effective resource management.

Factor 4: Lack of experience

The fourth factor accounts for a total variance of 12.81%, which explains the importance of field knowledge and prior experience for recognising the associated risks and understanding construction project environments. The most influential cause in this group is “lack of experience of local requirements” (factor loading = 0.828). As the PMBOK Guide explains, “enterprise environmental factors (EEFs) refer to conditions, not under the control of the project team, that influence, constrain, or direct the project” (Project Management Institute, 2017, p. 38). In this context, expertise, skills, competencies and specialised knowledge of the
project personnel are internal to the organisation, whereas legal restrictions related to laws and regulations are external to the organisation (Project Management Institute 2017). In exploring the types of reusable knowledge for effective time and cost control, Yap and Skitmore (2020) observe that familiarity with the authority’s requirements and submission guidelines is needed to plan for timelines, administer the submission processes and execute the handover of a completed facility. Notably, lack of experience in issues related to EEFs is a significant factor affecting construction schedules and cost management (Olawale and Sun 2010; Alaghbari et al. 2007). These EEFs are also major contributors to excessive rework and frequent changes during the construction stage (Yap et al. 2018; Ye et al. 2014). Nonetheless, such problems can be reduced through effective contract and risk management (Sullivan et al. 2010; Ye et al. 2014). To improve competency, necessary training can be provided for capability-building, while it is crucial to allocate the right person with the right level of experience and expertise to undertake the right tasks to ensure that pre-defined project objectives are attained (Eltigani et al. 2019; Yap et al. 2019a).

**Factor 5: Incompetence**

“Inadequate contractor experience” (factor loading = 0.850), “contractor’s improper planning and scheduling” (factor loading = 0.738) and “construction mistakes and defective work” (factor loading = 0.724) create this fifth factor, with a total variance of 9.10% explaining the significance of the contractor’s experience and skillsets in the delivery of successful projects. In the context of project management, these are associated with the organisational process assets (OPAs) of the performing organisation, which include plans, processes, policies, procedures and knowledge bases (Project Management Institute 2017). In Vietnam, for instance, poor construction management skills of contractors contribute significantly to project failures (Le-Hoai et al. 2008). In Saudi Arabia, contractor inexperience is a critical problem
causing delays (Al-Kharashi and Skitmore 2009). Intriguingly, in Cambodia, project information management is perceived as the least important construction management function followed by project planning and scope management and contract management (Kang et al. 2018). According to Toor and Ogunlana (2008a, p. 400), the four pillars for project success are “COMprehension, COMpetence, COMmitment and COMmunication” – terming these as the “critical COMs”. In a later study in Malaysia, contractor’s competence and experience are identified as the most influential fundamental essentials for successful construction management (Yong and Mustaffa 2013). According to Le-Hoai et al. (2008), there is a misalignment in the training and development in the construction industry due to the vast demand of human capital in developing countries – creating many competency gaps. In this light, the quality of training and continuous development is crucial to bridging skills and competency gaps rather than simply filling positions (Kang et al. 2018).

**Factor 6: Mistakes and defects**

The sixth factor accounts for 7.96% of the total variance explained, consisting of three distinct causes contributing to mistakes and defects in construction: “construction mistakes and defective work” (factor loading = 0.780), “delayed/slow decision making” (factor loading = 0.665) and “lack of communication between parties” (factor loading = 0.609). Construction mistakes and defective work can significantly undermine project monitoring and control processes (Alaghbari et al. 2007; Kaliba et al. 2009). In this context, the failure to detect errors or mistakes by the site supervision team may result in defective work, which then need rework to make-good non-compliance (Wan et al. 2013). The rate of error generation is closely related to aptitude, relevant experience, craftsmanship and physical working conditions (Wan et al. 2013). Poor communication and adversarial attitudes inhibit collaborative coordination between the various stakeholders, often resulting in such predicaments as haphazard decision
making, frequent design changes, excessive rework, operational inefficiencies, disputes and, finally, project failure (Wang et al. 2019; Yap et al. 2019b). In Nigeria, for example, the critical barriers inhibiting effective communication relate to ambiguity of project objectives, and poor project status reporting and leadership (Ejohwomu et al. 2017). Love et al. (2018) highlight open communication as a key to engender coaching, learning, and to anticipate what might go wrong to mitigate the precursors of errors. As such, communication and knowledge sharing are needed between the project personnel to detect and prevent errors (Eltigani et al. 2019; Love et al. 2018b). To manage action errors in construction better, Love et al. (2018a) emphasise the need to use the occurrence of errors as a learning opportunity – transforming the present error prevention mindset (zero error tolerance) to one that supports error management (acceptance of human error), which focuses on communication, sharing knowledge, error assistance, analysing, coordinating and handling and culture. Thus, project learning and communication management are essential for capitalising on reusable knowledge assets to prevent the recurrence of mistakes and exploit best practices to improve time and cost control (Yap and Skitmore 2020).

Discussion and concluding remarks

Previous studies have found that the effective implementation of KM strategies can provide such benefits as access to expertise and best practices to enhance productivity, efficiency and smarter working by not ‘reinventing the wheel’. In the context of the construction industry, failure to capitalise on project knowledge and experience is contributing to the repetition of project management mistakes, poor decision-making skills and lack of learning through reflection, which has led to the prevalence of schedule delays and cost overruns. Despite recognising the potential of KM in construction, empirical studies that analyse the criticality of knowledge and experience for controlling the time-cost overrun
factors of projects are still limited. In response, this study appraises the perceptions of KM by
construction professionals, gauges the significance of knowledge and experience in
overcoming the causes of time-cost overruns and uncovers the knowledge-based factors
affecting construction performance. Taken together, these results can enable the construction
industry to improve project performance, as a considerable proportion of time-cost overruns
can be attributed to the poor capitalisation of practical knowledge and valuable past
experiences. It is evident that capability-building through KM is of strategic importance for
enhancing organisational efficiency and effectiveness. The findings reveal that the benefits of
KM practices for construction are acknowledged and recognised. Problem-solving, decision-
making and professional judgement are closely related skills, and rely quite heavily on
accumulated knowledge, experience and expertise. Within this framework, KM is regarded as
a highly valuable activity to minimise waste, prevent duplication of work, avoid repeating past
mistakes and improve future performance through better decision making. Mistakes are
avoided by learning from previous projects and sharing with other team members how they
dealt with problems in the past and therefore improve work efficiency.

Using the importance index (IMP.I), which assimilates both frequency and effectiveness
indices, the criticality of knowledge and experience in the overall context is seen as
fundamental for addressing the contractor’s improper planning and scheduling, construction
mistakes and defective work, delayed/slow decision making, incomplete drawings and design
documents, the contractor’s poor site management and supervision and change/variation
orders. A consensus over the significance ranking by the key parties is statistically confirmed
by rank correlation. Another objective of this study is that the relationship between the causes
of time-cost overruns should be assessed to derive a reduced set of underlying factors that can
be readily used to understand how knowledge and experience affects construction performance.
Accordingly, the exploratory factor analysis extracted six knowledge-based factors relating to
(1) inaccurate resource estimates, (2) design changes, (3) resource shortages, (4) lack of experience, (5) incompetence and (6) mistakes and defects. These largely explain the key knowledge- and experience-related issues that trigger construction project overruns.

This study makes an important contribution by highlighting the criticality of project knowledge and experience in undertaking construction projects. Notwithstanding the significant amount of research into overrun factors and KM in construction project management, no previous work provides a detailed insight into the key dimensions of knowledge-based factors in the delivery of construction projects. Against this background, the underlying factors uncovered here have bridged a significant knowledge gap to gain a better understanding of the critical problems undermining project performance and potentially enable the industry to devise long-term strategic measures to enhance the skills, competencies and knowledge of project personnel. Thence, to steer an industry-wide transformation, the fusion of project management (PM) and knowledge management (KM) within the components of people, process and tools are needed to improve project success rates. KM linked with PM is a sustainable competitive advantage, where construction organisations can build capabilities by institutionalising continuous organisational learning from project experience, benchmarking the best practices of others, making problem-solving experience reusable, sharing high-quality knowledge assets and applying the knowledge to future projects. Fusing KM techniques to PM practices can also result in richer communication and enhanced work synergy to reduce the risks of failure within project-based organisations in a construction setting.

The study is limited by being restricted to the Malaysian construction industry. The mono-method of data collection also precluded the use of triangulation. Future studies would benefit by including such qualitative approaches as in-depth case studies to provide deeper and more holistic insights into the root causes of incompetence and inadequacies in the management of projects generally in Malaysia and beyond.
Disclosure statement

No potential conflict of interest was reported by the authors.

Acknowledgements

TBA

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**Table 1. Summary of major causes undermining schedule and cost performance from previous studies**

| No. | Description                                                                 | (Sambasivan and Soon 2007) | (Oman et al. 2010) | (Alaghbari et al. 2007) | (Tan et al. 2018) | (Azis et al. 2013) | (Wang et al. 2018) | (Le-Hoai et al. 2008) | (Kaming et al. 1997) | (Zidane and Andersen 2018) | (Assaf and Al-Hejji 2006) | (Faridi and El-Sayed 2006) | Frequency |
|-----|------------------------------------------------------------------------------|-----------------------------|---------------------|--------------------------|-------------------|-------------------|---------------------|--------------------------|------------------------|--------------------------|--------------------------|--------------------------|-----------|
| 1   | Client/contractor finance and payment problems                               | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 9         |
| 2   | Contractor's poor site management and supervision                           | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 8         |
| 3   | Shortage in materials, delays in delivery and price fluctuations             | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 8         |
| 4   | Design/scope changes                                                         |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 7         |
| 5   | Contractor's improper planning and scheduling                                | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 6         |
| 6   | Lack of experience of local regulations                                      | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 6         |
| 7   | Inadequate contractor experience                                            | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 5         |
| 8   | Lack of experience of the type of project                                    | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 5         |
| 9   | Incomplete drawings and documents/delays in producing design documents        | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 5         |
| 10  | Problems with subcontractors (delay, incompetence)                           | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 4         |
| 11  | Delayed/slow decision making; slow in giving instruction                      | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 4         |
| 12  | Labour supply shortages                                                      |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 4         |
| 13  | Design mistakes/errors                                                       |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 3         |
| 14  | Equipment availability/shortage and failure                                   | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 3         |
| 15  | Exceptionally low bids                                                       |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 3         |
| 16  | Poor labour productivity/poor skills                                        |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 3         |
| 17  | Construction mistakes and defective works                                    | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 2         |
| 18  | Change/variation orders                                                      |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 2         |
| 19  | Locational restrictions of the project/delay in obtaining approval from the authorities |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 2         |
| 20  | Lack of communication between parties                                        | ✓                            | ✓                   | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 1         |
| 21  | Lack of consultant experience                                                |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 1         |
| 22  | Delays caused by nominated subcontractor                                     |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 1         |
| 23  | Client interference                                                          |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 1         |
| 24  | Inaccurate bills of quantities                                               |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 1         |
| 25  | Unforeseen site conditions                                                   |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 1         |
| 26  | Unpredictable weather conditions                                             |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 1         |
| 27  | Inaccuracy of materials estimates                                            |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 1         |
| 28  | Inaccurate prediction of craftsman production rates                           |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 1         |
| 29  | Inaccurate prediction of equipment production rates                           |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 1         |
| 30  | Labour cost increases due to environment restriction                          |                             |                     | ✓                        | ✓                 | ✓                 | ✓                   | ✓                        | ✓                      | ✓                       | ✓                       | ✓                      | 1         |
| Parameter                      | Category                                | Frequency | Percent |
|-------------------------------|-----------------------------------------|-----------|---------|
| Organisation type             | Contractor                              | 54        | 55.7    |
|                               | Consultant                              | 22        | 22.7    |
|                               | Developer (client)                      | 21        | 21.6    |
| Largest project undertaken    | Less than MYR 10 million                | 10        | 10.3    |
| (based on contract value)     | Exceeding MYR 10 million -100 million   | 16        | 16.5    |
|                               | Exceeding MYR 100 million - MYR 500     | 26        | 26.8    |
|                               | More than MYR 500 million               | 45        | 46.4    |
| Occupational level            | Non-executive                           | 1         | 1.0     |
|                               | Executive                               | 9         | 9.3     |
|                               | Manager                                 | 35        | 36.1    |
|                               | Senior manager/principal                | 52        | 53.6    |
| Working experience            | Less than 5 years                      | 6         | 6.2     |
|                               | 6 - 10 years                            | 9         | 9.3     |
|                               | 11 - 15 years                           | 7         | 7.2     |
|                               | 16 - 20 years                           | 15        | 15.5    |
|                               | More than 20 years                      | 60        | 61.9    |
| Education level               | Secondary/high school                   | 2         | 2.1     |
|                               | Certificate/diploma                     | 16        | 16.5    |
|                               | Bachelor degree                         | 59        | 60.8    |
|                               | Postgraduate (Master/PhD)               | 20        | 20.6    |
Table 3. Frequency Index (FI) and ranking of causes

| Cause                                           | Overall | Contractor | Consultant | Developer |
|-------------------------------------------------|---------|------------|------------|-----------|
| Contractor’s improper planning and scheduling    | F.I. 0.814 Rank 1 | F.I. 0.819 Rank 1 | F.I. 0.791 Rank 3 | F.I. 0.829 Rank 1 |
| Construction mistakes and defective works        | F.I. 0.806 Rank 2 | F.I. 0.819 Rank 1 | F.I. 0.782 Rank 5 | F.I. 0.800 Rank 2 |
| Delayed/slow decision making                     | F.I. 0.806 Rank 2 | F.I. 0.819 Rank 1 | F.I. 0.818 Rank 1 | F.I. 0.762 Rank 7 |
| Contractor’s poor site management and supervision| F.I. 0.792 Rank 4 | F.I. 0.800 Rank 4 | F.I. 0.782 Rank 5 | F.I. 0.781 Rank 5 |
| Incomplete drawings and design documents         | F.I. 0.792 Rank 5 | F.I. 0.793 Rank 5 | F.I. 0.782 Rank 3 | F.I. 0.762 Rank 7 |
| Change/variation orders                          | F.I. 0.786 Rank 6 | F.I. 0.793 Rank 5 | F.I. 0.791 Rank 3 | F.I. 0.762 Rank 7 |
| Inadequate contractor experience                 | F.I. 0.771 Rank 7 | F.I. 0.774 Rank 9 | F.I. 0.782 Rank 5 | F.I. 0.790 Rank 3 |
| Design/issue with site changes                   | F.I. 0.763 Rank 9 | F.I. 0.763 Rank 12 | F.I. 0.736 Rank 10 | F.I. 0.790 Rank 3 |
| Lack of communication between parties            | F.I. 0.761 Rank 10 | F.I. 0.781 Rank 7 | F.I. 0.745 Rank 8 | F.I. 0.724 Rank 12 |
| Lack of consultant’s experience                  | F.I. 0.744 Rank 11 | F.I. 0.770 Rank 10 | F.I. 0.727 Rank 11 | F.I. 0.695 Rank 20 |
| Lack of experience of type of project            | F.I. 0.742 Rank 12 | F.I. 0.756 Rank 14 | F.I. 0.709 Rank 13 | F.I. 0.743 Rank 10 |
| Client interference                              | F.I. 0.738 Rank 13 | F.I. 0.741 Rank 18 | F.I. 0.727 Rank 11 | F.I. 0.743 Rank 10 |
| Inaccurate bills of quantities                   | F.I. 0.730 Rank 14 | F.I. 0.778 Rank 8 | F.I. 0.627 Rank 24 | F.I. 0.714 Rank 16 |
| Material shortages, delays in delivery           | F.I. 0.726 Rank 15 | F.I. 0.756 Rank 14 | F.I. 0.655 Rank 20 | F.I. 0.724 Rank 12 |
| Delays in obtaining permits/approvals from authorities| F.I. 0.724 Rank 16 | F.I. 0.730 Rank 20 | F.I. 0.700 Rank 15 | F.I. 0.695 Rank 20 |
| Problems with subcontractors                     | F.I. 0.724 Rank 16 | F.I. 0.744 Rank 16 | F.I. 0.709 Rank 13 | F.I. 0.724 Rank 12 |
| Client/contractor finance and payments problems  | F.I. 0.718 Rank 18 | F.I. 0.737 Rank 19 | F.I. 0.682 Rank 17 | F.I. 0.705 Rank 17 |
| Poor labour productivity/skills                  | F.I. 0.711 Rank 19 | F.I. 0.711 Rank 24 | F.I. 0.700 Rank 15 | F.I. 0.724 Rank 12 |
| Delays caused by nominated sub-contractors       | F.I. 0.699 Rank 20 | F.I. 0.715 Rank 22 | F.I. 0.655 Rank 20 | F.I. 0.705 Rank 17 |
| Inaccuracy in estimate take-off                  | F.I. 0.697 Rank 21 | F.I. 0.759 Rank 13 | F.I. 0.582 Rank 27 | F.I. 0.657 Rank 24 |
| Exceptionally low bids                          | F.I. 0.693 Rank 22 | F.I. 0.744 Rank 16 | F.I. 0.636 Rank 22 | F.I. 0.619 Rank 29 |
| Lack of experience of local regulations          | F.I. 0.691 Rank 23 | F.I. 0.719 Rank 21 | F.I. 0.673 Rank 18 | F.I. 0.638 Rank 27 |
| Inaccurate prediction of labour production rates | F.I. 0.689 Rank 24 | F.I. 0.696 Rank 26 | F.I. 0.673 Rank 18 | F.I. 0.686 Rank 22 |
| Unforeseen site conditions                       | F.I. 0.676 Rank 25 | F.I. 0.685 Rank 27 | F.I. 0.627 Rank 24 | F.I. 0.705 Rank 17 |
| Labour supply shortages                          | F.I. 0.668 Rank 26 | F.I. 0.715 Rank 22 | F.I. 0.573 Rank 28 | F.I. 0.648 Rank 25 |
| Labour costs increased due to environment restrictions| F.I. 0.666 Rank 27 | F.I. 0.704 Rank 25 | F.I. 0.636 Rank 22 | F.I. 0.686 Rank 22 |
| Inaccurate prediction of equipment production rates| F.I. 0.666 Rank 27 | F.I. 0.685 Rank 27 | F.I. 0.555 Rank 30 | F.I. 0.648 Rank 25 |
| Equipment shortages and failures                 | F.I. 0.649 Rank 29 | F.I. 0.674 Rank 30 | F.I. 0.609 Rank 26 | F.I. 0.629 Rank 28 |
| Unpredictable weather conditions                 | F.I. 0.635 Rank 30 | F.I. 0.681 Rank 29 | F.I. 0.573 Rank 28 | F.I. 0.581 Rank 30 |
| Causes                                                        | Overall E.I | Overall Rank | Contractor E.I | Contractor Rank | Consultant E.I | Consultant Rank | Developer E.I | Developer Rank |
|--------------------------------------------------------------|-------------|--------------|----------------|----------------|----------------|----------------|---------------|----------------|
| Contractor’s improper planning and scheduling                 | 0.802       | 1            | 0.804          | 1              | 0.809          | 2              | 0.790         | 1              |
| Construction mistakes and defective works                     | 0.788       | 2            | 0.778          | 2              | 0.818          | 1              | 0.781         | 2              |
| Delayed/slow decision making                                  | 0.771       | 3            | 0.774          | 3              | 0.782          | 4              | 0.752         | 4              |
| Contractor’s poor site management and supervision             | 0.765       | 4            | 0.763          | 5              | 0.764          | 8              | 0.771         | 3              |
| Incomplete drawings and design documents                      | 0.765       | 4            | 0.767          | 4              | 0.773          | 7              | 0.752         | 4              |
| Change orders/variation orders                               | 0.761       | 6            | 0.763          | 5              | 0.782          | 4              | 0.733         | 10             |
| Inadequate contractor experience                             | 0.759       | 7            | 0.752          | 8              | 0.791          | 3              | 0.743         | 8              |
| Mistakes and errors in design                                | 0.759       | 7            | 0.759          | 7              | 0.782          | 4              | 0.733         | 10             |
| Design/scope changes/change of scope                         | 0.740       | 9            | 0.733          | 9              | 0.745          | 9              | 0.752         | 4              |
| Lack of communication between parties                        | 0.730       | 10           | 0.719         | 18             | 0.736          | 11             | 0.752         | 4              |
| Lack of consultant’s experience                              | 0.730       | 10           | 0.722         | 15             | 0.745          | 9              | 0.733         | 10             |
| Lack of experience of type of project                        | 0.726       | 12           | 0.726         | 13             | 0.736          | 11             | 0.714         | 15             |
| Client interference                                          | 0.718       | 13           | 0.730          | 10             | 0.682          | 18             | 0.724         | 14             |
| Inaccurate bills of quantities                               | 0.715       | 14           | 0.730         | 10             | 0.682          | 18             | 0.714         | 15             |
| Material shortages, delays in delivery                       | 0.713       | 15           | 0.730         | 10             | 0.655          | 23             | 0.733         | 10             |
| Problems with subcontractors                                 | 0.711       | 16           | 0.722          | 15             | 0.691          | 15             | 0.705         | 18             |
| Delays in obtaining permits/approvals from authorities        | 0.707       | 17           | 0.719         | 18             | 0.645          | 24             | 0.743         | 8              |
| Client/contractor finance and payments problems              | 0.703       | 18           | 0.704         | 23             | 0.691          | 15             | 0.714         | 15             |
| Poor labour productivity/skills                              | 0.701       | 19           | 0.696          | 25             | 0.709          | 13             | 0.705         | 18             |
| Delays caused by nominated sub-contractors                   | 0.697       | 20           | 0.711          | 20             | 0.700          | 14             | 0.657         | 27             |
| Inaccuracy in estimate take-off                              | 0.697       | 20           | 0.726          | 13             | 0.664          | 20             | 0.657         | 27             |
| Exceptionally low bids                                      | 0.693       | 22           | 0.700          | 24             | 0.691          | 15             | 0.676         | 22             |
| Lack of experience of local regulations                      | 0.691       | 23           | 0.711          | 20             | 0.664          | 20             | 0.667         | 24             |
| Inaccurate prediction of labour production rates             | 0.689       | 24           | 0.711          | 20             | 0.636          | 26             | 0.686         | 21             |
| Unforeseen site conditions                                  | 0.689       | 24           | 0.722          | 15             | 0.645          | 24             | 0.648         | 29             |
| Labour supply shortages                                      | 0.687       | 26           | 0.689          | 26             | 0.664          | 20             | 0.705         | 18             |
| Labour costs increased due to environment restrictions        | 0.666       | 27           | 0.681          | 27             | 0.627          | 27             | 0.667         | 24             |
| Inaccurate prediction of equipment production rates          | 0.662       | 28           | 0.674          | 29             | 0.618          | 28             | 0.676         | 22             |
| Equipment shortages and failures                             | 0.662       | 28           | 0.678          | 28             | 0.618          | 28             | 0.667         | 24             |
| Unpredictable weather conditions                             | 0.627       | 30           | 0.648          | 30             | 0.600          | 30             | 0.600         | 30             |
Table 5. Importance Index (IMP.I) and ranking for causes

| Causes                                           | IMP.I | Rank | IMP.I | Rank | IMP.I | Rank | IMP.I | Rank | IMP.I | Rank |
|--------------------------------------------------|-------|------|-------|------|-------|------|-------|------|-------|------|
| Contractor’s improper planning and scheduling    | 0.653 | 1    | 0.658 | 1    | 0.640 | 2    | 0.655 | 1    |       |      |
| Construction mistakes and defective works         | 0.624 | 2    | 0.616 | 4    | 0.655 | 1    | 0.610 | 3    |       |      |
| Delayed/slow decision making                      | 0.622 | 3    | 0.634 | 2    | 0.640 | 2    | 0.573 | 6    | 0.617 | 2    |
| Contractor’s poor site management and supervision | 0.617 | 4    | 0.624 | 3    | 0.597 | 6    | 0.617 | 2    | 0.573 | 6    |
| Incomplete drawings and design documents          | 0.601 | 5    | 0.607 | 5    | 0.611 | 5    | 0.573 | 6    | 0.573 | 6    |
| Change orders/variation orders                    | 0.598 | 6    | 0.605 | 6    | 0.618 | 4    | 0.559 | 8    |       |      |
| Inadequate contractor experience                  | 0.590 | 7    | 0.593 | 7    | 0.576 | 9    | 0.595 | 4    |       |      |
| Mistakes and errors in design                     | 0.577 | 8    | 0.588 | 8    | 0.590 | 7    | 0.538 | 11   |       |      |
| Design/scope changes/change of scope             | 0.563 | 9    | 0.556 | 11   | 0.583 | 8    | 0.559 | 8    |       |      |
| Lack of communication between parties             | 0.557 | 10   | 0.548 | 12   | 0.542 | 10   | 0.595 | 4    |       |      |
| Lack of consultant’s experience                   | 0.536 | 11   | 0.538 | 14   | 0.536 | 11   | 0.531 | 12   |       |      |
| Lack of experience of type of project            | 0.536 | 11   | 0.535 | 16   | 0.529 | 12   | 0.545 | 10   |       |      |
| Client interference                              | 0.534 | 13   | 0.562 | 9    | 0.496 | 13   | 0.503 | 15   |       |      |
| Inaccurate bills of quantities                   | 0.518 | 14   | 0.543 | 13   | 0.477 | 15   | 0.497 | 17   |       |      |
| Material shortages, delays in delivery           | 0.516 | 15   | 0.559 | 10   | 0.405 | 24   | 0.531 | 12   |       |      |
| Problems with subcontractors                     | 0.514 | 16   | 0.529 | 17   | 0.490 | 14   | 0.502 | 16   |       |      |
| Delays in obtaining permits/approvals from authorities | 0.507 | 17   | 0.519 | 19   | 0.458 | 17   | 0.531 | 12   |       |      |
| Client/contractor finance and payments problems  | 0.500 | 18   | 0.537 | 15   | 0.417 | 23   | 0.496 | 21   |       |      |
| Poor labour productivity/skills                   | 0.497 | 19   | 0.516 | 20   | 0.452 | 18   | 0.497 | 17   |       |      |
| Delays caused by nominated sub-contractors        | 0.493 | 20   | 0.508 | 23   | 0.452 | 18   | 0.497 | 17   |       |      |
| Inaccuracy in estimate take-off                  | 0.484 | 21   | 0.490 | 25   | 0.465 | 16   | 0.490 | 22   |       |      |
| Exceptionally low bids                           | 0.481 | 22   | 0.522 | 18   | 0.446 | 20   | 0.419 | 26   |       |      |
| Lack of experience of local regulations          | 0.474 | 23   | 0.477 | 28   | 0.445 | 21   | 0.497 | 17   |       |      |
| Inaccurate prediction of labour production rates  | 0.464 | 24   | 0.487 | 26   | 0.445 | 21   | 0.426 | 25   |       |      |
| Unforeseen site conditions                       | 0.461 | 25   | 0.507 | 24   | 0.399 | 26   | 0.413 | 29   |       |      |
| Labour supply shortage                           | 0.461 | 25   | 0.515 | 22   | 0.360 | 28   | 0.438 | 24   |       |      |
| Labour costs increased due to environment restrictions | 0.460 | 27   | 0.516 | 20   | 0.370 | 27   | 0.419 | 26   |       |      |
| Inaccurate prediction of equipment production rates | 0.449 | 28   | 0.479 | 27   | 0.404 | 25   | 0.419 | 26   |       |      |
| Equipment shortages and failures                 | 0.441 | 29   | 0.474 | 29   | 0.343 | 30   | 0.464 | 23   |       |      |
| Unpredictable weather conditions                 | 0.398 | 30   | 0.442 | 30   | 0.344 | 29   | 0.349 | 30   |       |      |
Table 6. Spearman’s rank correlation coefficients

| Respondent group          | FI  | EI  | IMP.I |
|---------------------------|-----|-----|-------|
| Contractors-Consultants   | 0.804 | 0.01 | 0.794 | 0.01 | 0.862 | 0.01 |
| Contractors-Developers    | 0.773 | 0.01 | 0.768 | 0.01 | 0.865 | 0.01 |
| Consultants-Developers    | 0.856 | 0.01 | 0.762 | 0.01 | 0.762 | 0.01 |
### Table 7. Factor profile

| Causes                                                                 | F1  | F2  | F3  | F4  | F5  | F6  |
|-----------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|
| Inaccurate estimates of materials/quantity take-off                   | 0.853 |     |     |     |     |     |
| Inaccurate prediction of equipment production rates                   | 0.807 |     |     |     |     |     |
| Inaccurate prediction of labour production rates                      | 0.798 |     |     |     |     |     |
| Inaccurate bills of quantities                                        | 0.747 |     |     |     |     |     |
| Exceptionally low bids                                               | 0.625 |     |     |     |     |     |
| Design/scope changes                                                 |      | 0.802 |     |     |     |     |
| Incomplete drawings and design documents                              |      | 0.753 |     |     |     |     |
| Mistakes and errors in design                                        |      | 0.683 |     |     |     |     |
| Change/variation orders                                              |      | 0.609 |     |     |     |     |
| Client interference                                                  |      | 0.571 |     |     |     |     |
| Delays caused by nominated sub-contractors                            |      | 0.555 |     |     |     |     |
| Consultant’s lack of experience                                      |      | 0.523 |     |     |     |     |
| Labour supply shortages                                              |      | 0.843 |     |     |     |     |
| Equipment shortages and failures                                     |      | 0.782 |     |     |     |     |
| Client/contractor finance and payments problems                      |      | 0.637 |     |     |     |     |
| Material shortages, delays in delivery                               |      | 0.612 |     |     |     |     |
| Lack of experience of local regulations                               |      |     | 0.828 |     |     |     |
| Unpredictable weather conditions                                     |      |     | 0.682 |     |     |     |
| Lack of experience of type of project                                |      |     | 0.676 |     |     |     |
| Unforeseen site conditions                                           |      |     | 0.632 |     |     |     |
| Labour costs increased due to environment restrictions                |      |     | 0.622 |     |     |     |
| Delays in obtaining permits/approvals from authorities               |      |     | 0.569 |     |     |     |
| Inadequate contractor experience                                     |      |     |     | 0.850 |     |     |
| Contractor’s improper planning and scheduling                         |      |     |     | 0.738 |     |     |
| Contractor’s poor site management and supervision                    |      |     |     | 0.724 |     |     |
| Construction mistakes and defective work                              |      |     |     |     | 0.780 |     |
| Delayed/slow decision making                                         |      |     |     |     | 0.665 |     |
| Lack of communication between parties                                 |      |     |     |     | 0.609 |     |
| Cumulative variance explained (%)                                     | 15.47 | 13.70 | 13.26 | 12.81 | 9.10 | 7.96 |
| Cronbach’s α                                                         | 0.911 | 0.892 | 0.858 | 0.912 | 0.837 | 0.816 |

Note: Extraction method = principal component analysis; rotation method: varimax with Kaiser normalization. Rotation converged in 7 iterations.