Journal of Building Engineering 45 (2022) 103644

Contents lists available at ScienceDirect

Journal of Building Engineering

journal homepage: www.elsevier.com/locate/jobe

Establishment of pre-qualification criteria for the selection of subcontractors by the prime constructors for building projects☆,☆☆,☆☆☆

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ARTICLE INFO

Keywords:
Claim
Construction companies
Project performance
Procurement
Productivity

ABSTRACT

Prime contractors play a vital role in the successful delivery of construction projects. However, the success of the prime contractors depends on the performance of the subcontractors selected for the project. Therefore, inappropriate selection of subcontractors could lead to a claim, delay, cost overrun, litigation, loss of profit, and poor quality. This paper presents the findings of a survey on the prequalification criteria of subcontractors in Malaysia. The research developed a questionnaire instrument that comprised 26 prequalification criteria. The research revealed that 95% of the respondents rated the 26 criteria very important in the selection of subcontractors. The data revealed that 95% of the projects are subcontracted. The research revealed that the five main prequalification criteria are expected completion date, financial capacity/stability of subcontractors, health and safety records, previous performance of subcontractors, and tender price & quotations submitted. The factor analysis structured the 26 criteria into 7 components, which explained 60% of the total variance in the model. A regression model was developed for selecting subcontractors. The findings will be useful to policymakers, construction teams, design teams, and developers. The study provides a platform for prime contractors' decision-making process and provides guidance to the subcontractors as to whether to tender or not for a project.

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https://doi.org/10.1016/j.jobe.2021.103644
Received 10 April 2021; Received in revised form 10 November 2021; Accepted 10 November 2021
Available online 15 November 2021

1. Introduction

The key tasks of a prime contractor are to manage the day-to-day operations of the project on the construction site on behalf of the client. A prime contractor is the party that enters into a contract with the client. However, the prime contractors outsource all or part of the contract to other parties (e.g., subcontractors) to execute the work. Subcontractors are the specialists in specific trades and work. The extent of the size of work that the prime contractors' award or outsource to the subcontractors depends largely on the procurement system used. As much as 90% of the construction work is performed by subcontractors. In particular, the proportion of work executed by subcontractors is up to 90% in the USA and Australia [32]), 70% in the UK [53], 90% in Palestine [28], 90% in Hong Kong [41] and 90% in the Netherlands [30]. The proportion is similar in most economies [17,39,84]; and [59]. The reasons why prime contractors subcontract projects include profit maximization, meeting client schedules, and a shortage of resources [39,57]. Recognizing the roles of subcontractors, government-sponsored reports and research [23,26,47,81] and [20,21] have recommended strategic partnering between the prime contractors and the subcontractors to increase project performance and client satisfaction. If competent and suitable subcontractors are not selected [1,77]; and [40], subcontracting will result in poor quality, dispute, delay, reduced productivity, and profits [1,13]; and [53]. In fact, recent studies [3,5,8,35,42,71,79] and [2,3,46,48,73] found that subcontracting is the major cause of delay, cost overrun, dispute, poor quality, health and safety and payments problems in the Malaysian construction sector. However, these problems are global phenomena [56,57,77,78] and [40]. The major reason for the poor subcontracting is the prime contractor's evaluation instrument. The selection of competent and suitable subcontractors depends on prime contractors' evaluation instruments. The evaluation instrument entails multiple criteria that guide the prime contractor in selecting suitable subcontractor for a project. Unsuitable subcontractors may be selected or prequalified if the criteria are not adequate or if the assessment of the criteria are poorly evaluated.

Therefore, it is imperative to investigate the criteria that the prime contractors use to select the subcontractors. Although [48] and 2018 looked at subcontracting practise in the Malaysian construction sector by examining the selection criteria for subcontractors. However, many critical criteria were excluded in the previous studies. The exclusion of the critical criteria has a substantial impact on the contractor's and subcontractor's performance. Neglecting the key criteria would lead to the selection of incompetent subcontractors. Furthermore, the previous studies did not examine the contribution of each of the criteria. However, lack of establishment of weightage for each of the criteria would lead to the elimination of qualified and competent subcontractors, as [13] explained. Furthermore, although extant research outside of Malaysia on subcontracting selection examined the subcontractors' selection criteria, However, because of a country's specific construction culture, it is imperative to investigate the selection criteria in Malaysia. The need to consider country-specific selection criteria cannot be overemphasised [76]. Furthermore, because the criteria interact with other criteria, it is important to examine the relationship between the criteria. In a multi-criteria decision-making framework, attributes do not contribute equal weight to a decision [6,25,85]. Though [48] grouped the criteria for decision making, which is interesting, the study was based on confirmatory analysis, and the study is not specific to any specific segment of the construction sector. To close this gap in knowledge, this research identified, prioritized, and clustered the prequalification criteria for subcontractors' selection for building projects. Clustering the selection criteria will help to streamline and enhance decision making on the impact of the criteria on project performance and client satisfaction [69]. In fact, if there is no structure and grouping, ranking the prequalification may increase project risks. Because the data are not labeled, there are clustering issues with the prequalification criteria. The clustering problem is a situation where a machine is trained on unlabeled data without prior guidance. Some popular algorithms for unsupervised learning include K-mean, C-mean, and factor analysis. Factor analysis is used in this research. Factor analysis is used here because it is consistent with the aim of this research. Factor analysis is an unsupervised machine learning algorithm that finds relationships among constructs to enhance the decision-making process.

2. Subcontracting practices in the construction sector

The increasing complexity, heavy resource consumption, and changing landscape of construction procurement make the construction sector increasingly dependent on subcontractors for successful project completion. The prime contractors engaged the services of the subcontractors for various reasons [14,16,60,60,68,78]; and [77]. These include risk sharing, project location, funding and regulatory requirements. Subcontractors are also engaged due to a lack of competency in the prime contractor's organisation, subcontractors are also engaged to meet the project's cutoff date, reduce overhead costs, and meet client requirements. Furthermore, existing research has shown that when prime contractors engage subcontractors for projects, they can maximise their profits [52] and help prime contractors reduce their workforce [83]; cited in Ref. [16]. According to Ref. [50]; subcontractors can help the prime contractor reduce their estimating errors and delays in projects. Prime contractors subcontract work to maximise flexibility [80]. However, despite the importance of subcontractors, subcontracting has a negative impact on productivity [1,13], project quality [1, 61]; and [44], health and safety [33,53], profit [41,56] and client satisfaction. Although, multiple reasons are accountable for the poor performance of subcontracting projects, arguably the major reason for these problems is the inadequacies of the prequalification criteria.

Subcontracting is common in the Malaysian construction sector. For instance, the value of construction projects awarded to prime contractors was RM229.0 billion in 2016 for 6855 projects [18], and most of the contracts awarded to prime contractors are subcontracted [19]. About 50,000 construction subcontracts are awarded annually [15]; cited in Ref. [48]. A plausible implication of these statistics suggests that for every project awarded to a prime contractor, at least 8 subcontractors are involved. Based on the same analogy, each of the subcontractors may in turn award the project to about eight sub-subcontractors. This is multilayer subcontracting, which is rampant in the Malaysian construction sector. The chain of subtracting depends on the nature and size of the project. Although subcontracting in the construction sector has been recognised as the major problem or enabler of the Malaysian construction sector,

research on this topic is nascent. However, despite the huge amount of research on the Malaysian construction sector, there are very limited studies focusing on the selection criteria of subcontracting.

2.1. Prequalification criteria of subcontractors

Concern with the poor quality and the practise of subcontracting in the architecture, engineering, and construction sectors has led governments to develop various measures. For instance, the Singaporean construction industry developed a centralised subcontractor registration system list of trade subcontractors (SLOTS) to eliminate the submission of incompetent subcontractors. The system serves as the first stage screening process for subcontractors [50]. A similar system has been reported in South Africa [58], Australia, the UK, and Hong Kong. To reduce problems associated with the performance of subcontracting in Malaysia, CIDB (Malaysia) published a Model Terms for construction contracts between contractors and subcontractors [19]. The model terms are mainly between the prime contractors and their nominated subcontractors. Domestic subcontractors are not included because the prime contractors directly employ domestic subcontractors without the clients' involvement except for consent. The Model Terms of Construction Contract aim to enhance professionalism and improve project performance. Although the forms are developed primarily to be used as 'stand-alone' contract documents, they are flexible enough to be used in conjunction with reference to the main contractors. It specifies the subcontractors' obligations regarding the quality of work in accordance with the contract and laws regarding quality, safety, health, and the environment. Other requirements, obligations, and rights of the parties are described in the standard document. However, while there are several regulations to improve the relationship between the prime contractors and subcontractors in Malaysia, the relationship between the prime contractors and subcontractors weakens during the contract (Rosli, 2007 and Rahman et al., 2014). The major reasons for the negative relationship between the prime contractors and subcontractors are the selection of incompetent, unqualified, and unworthy subcontractors. None of the guidelines for subcontracting outline the prequalification process and procedures. In fact, there is no section in the model terms of the contract that involves the process of selecting subcontractors. Therefore, to enhance the relationship between prime contractors and subcontractors, this research investigated the criteria used by the main contractors for the prequalification of subcontractors in the Malaysian construction section. However, because some of the criteria in the regulatory framework are project specific, the research also offers opportunities for contractors to learn among themselves.

The selection of competent subcontractors is one of the most critical tasks in the construction sector. In order to ensure that suitable subcontractors are engaged, the prime contractors pre-qualify the subcontractors against a different benchmark. The prequalification of subcontractors by the prime contractor involves screening of the subcontractors based on defined or established criteria required to contribute to the success of the project. Table 1 contains a list of applicable criteria for the prequalification of subcontractors by prime contractors for construction projects. Primarily, the screening process seeks to determine if the subcontractor is competent, experienced, resourceful, qualified, and suitable for the project. However, the criteria contribute different weightages to the success of the project. The basic task is to assign weights to the many criteria that accurately reflect the project scopes. It is important for the prime contractors to know the extent to which the subcontractors' performance is relative to the criteria. The reason for this is that the other criteria would impact other aspects of the project or client's business case. Once the prime contractors receive the appointment from

Table 1
Summary of previous studies on subcontractors 'criteria.

Criteria	Main author
Availability of skilled labo ur	[2,5]; Ali and Wen, 2011, Hoonakker et al., 2010
Worker empowerment/incentive	Loushine and Hoonakker, 2002, Marosszeky et al., 002, [32]; Pheng and Wei, 1996,
Design complexity	Tang et al., 2009 and [17];
Client/customer focus	Hoonakker, 2006
Employee involvement/altitude	Hoonakker, 2006,
Management Commitment	Janipha and Ismail, 2013, Ogwueleka, 2013 Said et al., 2009, [34]; Husin and Adnan, 2008 Hoonakker, 2006 Jha and Iyer, 2005Hiyassat, 2000 and Arditi and Gunaydin, 1998
Method of communication	Mane and Patil, 2015, Janipha and Ismail, 2013 Adenuga and Afolarin, 2013 Ogwueleka, 2013 Ali and Wen, 2011Ofori, 2006 Hoonakker, 2006 and Arditi and Gunaydin, 1998
Tight project schedule	Husin and Adnan, 2008,
Coordination between project	(Ogwueleka, 2013, Tang et al., 2009, Husin and Adnan, 2008, Joaquin et al., 2008, Hoonakker, 2006 Jha and Iyer, 2006Arditi and Gunayalin, 1998,
Planning/scheduling process	Mane and Patil, 2015, Jamaludin, 2014, Ofori, 2006 and Chan and Tam, 2000,
Expertise knowledge or training system	Yung and Yip, 2010 Husin and Adnan, 2008 Hoonakker et al., 2003 and Arditi and Gunayalin, 1998,
Time management	Ali and Wen, 2011,
Quality assurance/Quality policy	Oyedele et al., 2015, Che Ali et al., 2010 and Abdul Rahman, 2010, Ogwueleka, 2013, Joaquin et al., 2008, Husin and Adnan, 2008 and Arditi and Gunayalin, 1998,
Project supervision	Adenuga and Afolarin, 2013, Janipha and Ismail, 2013, Ogwueleka, 2013, Husin and Adnan, 2008 and Arditi and Gunayalin, 1998,
Availability of resources	Joaquin et al., 2008 and Chan and Tam, 2000,
Project environment	Ogwueleka, 2013, Husin and Adnan, 2008 and Joaquin et al., 2008,
Uniqueness of the project	Ogwueleka, 2013, Joaquin et al., 2008 and Husin and Adnan, 2008,
Competency of project manager	Mane and Patil, 2015, Jamaludin, 2014 and Ofori, 2006)
Training policy	Mallawaarachchi and Senaratn, 2015, Ogwueleka, 2013, Abdul Rahman et al., 2012, Said et al., 2009, Husin and Adnan, 2008 and Joaquin et al., 2008,

the client, the prime contractors in turn invite tenders for the different aspects of the projects from subcontractors. Although [48], and 2018) looked at subcontracting practise in the Malaysian construction sector by examining the selection criteria for subcontractors. The studies also examine the criteria for monitoring subcontractors' work. But the studies did not establish a weightage for the individual criterion. Both in theory and in practice, it is systemic to establish weightage for each of the criteria for meaningful interpretation and practical application. This is an analytical analysis of the criteria because they are linear and individualistic. In support of this justification [57], opined that it is not helpful if weightage is not established for the selection criteria. Establishing weightage for the criteria is necessary because each of the criteria has a different impact on the selection of the subcontractors and, ultimately, on the project's performance [25]. also argued that in a multicriteria decision-making framework, attributes or criteria do not contribute equal weight to the decision. This is a systemic, or holistic, analysis of the criteria. Furthermore, though [48] grouped the criteria for the decision, it is interesting that the research was based on confirmatory analysis, which is helpful in validating a measurement theory only. However, critical criteria were not included in the model. Neglecting the key criteria, according to Ref. [57]; would lead to the selection of incompetent subcontractors. Earlier, Manoharan (2005) sought to develop a subcontractor's selection using the Analytical Hierarchy Process, but still remained inconclusive. The increasing importance of subcontractors in the Malaysian construction sector makes it necessary to establish a simple, easy, and effective prequalification framework for the selection of subcontractors. Therefore, this research aims to develop a framework of best practises for selecting suitable subcontractors. In order to achieve this aim, the following objectives have been set: to conduct an analytical examination of the selection criteria for subcontracting (1), to cluster the selection criteria using factor analysis.

3. Research design and data analytics

The primary data were collected through online survey questionnaires based on snowball sampling. Snowball sampling is a non-probability sampling technique that is used if there is less information on the potential respondents. However, one of the limitations of this technique is that the number of respondents will not be known to the researcher. The technique involves administering survey forms to available, accessible, and willing respondents. However, its findings may not be generalisable, but with a large sample size, the findings can be representative of the population. This premise is consistent with the central limit theorem (CLT). The theorem assumes that the distribution of sample means approximates a normal distribution as the sample size increases, and for the CLT principle to be valid, a sample size of 30 or more is presumed adequate. The survey forms were administered to the prime contractors only. There are 7 categories of contractors in Malaysia. Contractors are classified based on contract value and project type. The maximum amount of a single project that G1 contractors can undertake is RM200,000 RM200,000[1] and the maximum amount of a contract that the G6 contractor can execute is RM10 million. The G7 contractors undertake civil engineering and building engineering construction for an unlimited amount. In researching contractors' prequalification criteria, many of the studies placed considerable emphasis on heterogeneity in the unit of measurement [7,24,31,78]. Heterogeneity in data collection may increase coverage and ensure the diversity of the research findings. However, it will lead to clinical heterogeneity, which normally arises due to wide divergence in participants' characteristics. The major limitation of clinical heterogeneity is that it often leads to significant statistical heterogeneity, inaccurate summary, and a lack of specificity. The variability in the data may introduce systematic bias into the conclusion. Contrarily, homogeneity in the data collection will ensure specificity, increase validity, and consistency [12,82]. Homogeneity in data collection can be achieved if respondents with similar characteristics are surveyed.

The survey was launched on June 8, 2018 and was open until June 18, 2020. It may be observed that the criteria that were contained in Table 1 are not the same as the criteria that were presented to the respondents for evaluation. This is due to both ontological and epistemological reasons for the prequalification criteria in Malaysia. During the pilot survey, it was obvious that some of the criteria on the survey form were either not relevant to the respondents or that they would construe or interpret the criteria differently. Therefore, while some of the criteria were deleted, others were modified, and, in some cases, new criteria were formulated and included as suggested by the respondents during the pilot survey. During the main survey, respondents were required to include additional criteria they know have or will help the prime contractors make a sound decision on subcontractors' selection. The respondents were asked, based on their current evidence, to measure the extent to which each of the criteria had determined the selection of the subcontractors for the projects they were involved in. The estimation of the selection criteria is measured on a five-point Likert scale; where 1 = least important, 2 = less important, 3 = important, 4 = very important, and 5 = extremely important. The extent of the importance of the criteria of the selection criteria was measured by the Average Importance Index (AII) (Equation (1)) and standard deviation.

$$AII = \frac{\sum_{i=0}^{5} a_i x_i}{5\sum_{i=0}^{5} x_i} x100 \quad (1)$$

Where a_i is a constant that expresses the weight given to the group; xi was the frequency of the responses, i = 1, 2, 3, 4, and 5 and described as below: x_1, x_2, x_3, x_4, x_5 were the frequencies of the responses corresponding to $a_1 = 1, a_2 = 2, a_3 = 3, a_4 = 4, a_5 = 5$, respectively. For interpretation, an AII score of 1.00–20.00 denotes least important, 21.00–40.00 denotes less important, 41.00–60.00 denotes important, 61.00–80.00 denotes very important, and 81.00–100.00 denotes extremely important. There is a pooled difference of 1.0% between each of the scales. Thus, the criterion with the highest AII score is prioritized as the major criterion. All the criteria

[1] 1 USD = RM4.15 (as at 31st May 2021).

were positively worded.

In order to achieve the second objective of the research, an exploratory factor analysis was conducted. The primary objectives of factor analysis are to determine the number and nature of constructs that underlie responses to a set of observed variables [65]. Factor analysis is a very important dimensional reduction modelling technique for data analysis [22]. However, it is an unsupervised machine learning algorithm. Unsupervised machine learning can solve two main types of problems, namely association and clustering problems. However, the problem that this research seeks to solve is a clustering problem because the algorithm is trained with unlabeled data and the output model is grouped based on the similarity/dissimilarity among the input data. Clustering can be computed based on correlation or co-variance among the variables [69]. The other statistical tests that were computed are the Guttman Split-Half Coefficient, *t*-test, mode, validity, Kaiser-Meyer-Olkin Measure of Sampling Adequacy, Bartlett's test of sphericity, and standard deviation. The Guttman Split-Half Coefficient was used to test the validity of the Kaiser-Meyer-Olkin Measure of Sampling Adequacy, Bartlett's test of sphericity, and the goodness of fit of the criteria for the subcontractor's section. A Kaiser-Meyer-Olkin Measure of Sampling Adequacy was performed to examine if the results of the survey are indicative of the population. The mode was used to compute the frequency of the constructs. A standard deviation is computed to test the spread of the data from the average. The *t*-test was conducted to test if the criteria are used by the prime contractors for the selection of the subcontractors or not. For data analytics, all collected data were analysed using IBM SPSS 25.

4. Analysing the results of the survey

The details of the organisations were available on the CIBD Malaysia database. There are 8682 prime contractors (i.e., grade G7) in the database in 2021 (at July 24, 2021). For this population size, a sample size of 367 was recommended with ±10% sampling error and for 95% confidence level [72]. More than 4000 online survey forms were administered to respondents who were requested to forward the survey form to their colleagues that are competent to respond to the survey. Two hundred and twelve completed responses were received during the survey period, lasting more than one year.

4.1. Demographic of the respondents

The data revealed that 81% of the respondents obtained a minimum of a BSc degree, and most of the respondents held strategic positions (Table 2). Many (33%) of the respondents had degrees in civil engineering, quantity surveying, and construction management (Fig. 1). More than 70% had more than 5 years of work experience (Table 3). Most of the site engineers had diplomas. A diploma is a certificate issued by a tertiary institution and is lower than a bachelor's degree. A Pareto analysis shows that 86% of the respondents' organisations were involved in the construction of residential, industrial, and commercial construction projects. The results found that the dominant procurement strategy is the traditional design-tender and build/construct (39.2%). Many also used design and build (29.2%), construction management (20.8%) and management contracting (9.4%) strategies. Almost 60% of the responding organisations had between 50 and 400 employees, and 1% had more than 600 employees. The annual turnover of more than 60% of the companies was RM50 million to RM600 million each, and about 2% had a turnover of more than RM1 billion. More than 95% of the prime contractors subcontracted all or part of the projects on which they were involved in the construction (Fig. 2). The mean score of work subcontracted is 40%–50% and the standard deviation is 15%.

4.2. Analysing the taxonomy of the prequalification criteria

The reliability test results indicated that the Guttman Split-Half Coefficient was 0.803 (or 80%) and the correlation was very high

Table 2
Cross tabulation between Current position academic and qualification.

Current position	Academic qualification				Total
	PhD	MSc Degree	BSc Degree	Diploma	
Architect	0	4	6	4	14
Engineer	1	10	25	4	40
Quantity Surveyor	1	5	29	5	40
Project manager	3	9	12	3	27
Construction Manager	2	7	7	1	17
Site Supervisor	0	1	22	8	31
Site Manager	0	3	5	3	11
Site engineer	0	0	5	6	11
Assistant Architect	0	1	2	0	3
Safety officer	0	0	2	0	2
Contracts Manager	3	0	2	0	5
QA/QC Engineer	0	0	1	0	1
Director	0	1	0	1	2
CEO	1	0	1	0	2
Site Surveyor	0	0	0	2	2
Sales Officer	0	0	0	1	1
Administration	0	0	0	2	2
Procurement Executive	0	0	1	0	1
	11	41	120	40	212

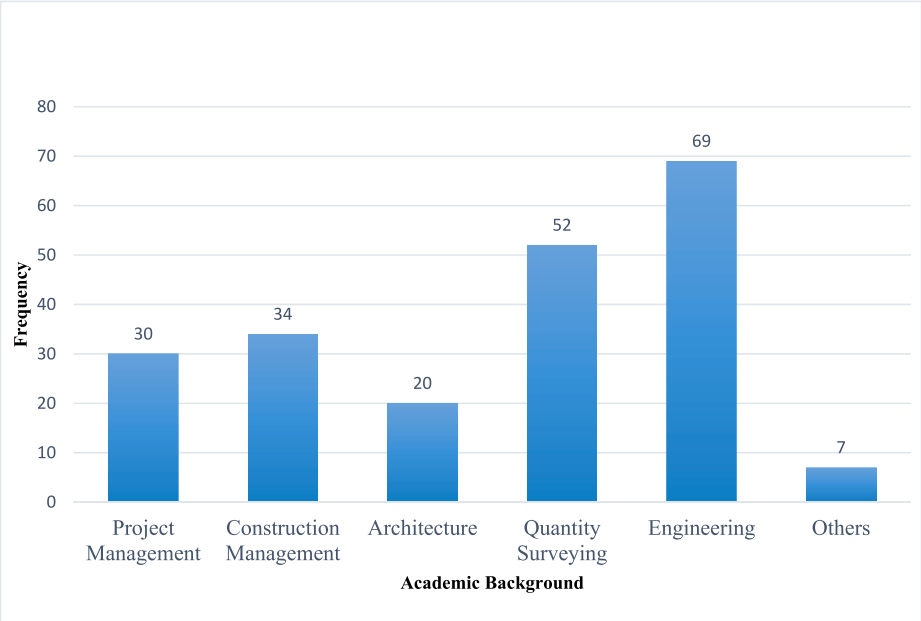

Fig. 1. Respondent's academic background.

Table 3
Respondent's working experience.

Year	Frequency	Percent
Less than 5 years	61	28.8
5–10 years	63	29.7
11–15 years	47	22.2
16–20 years	20	9.4
More than 20 years	21	9.9
Total	212	100.0

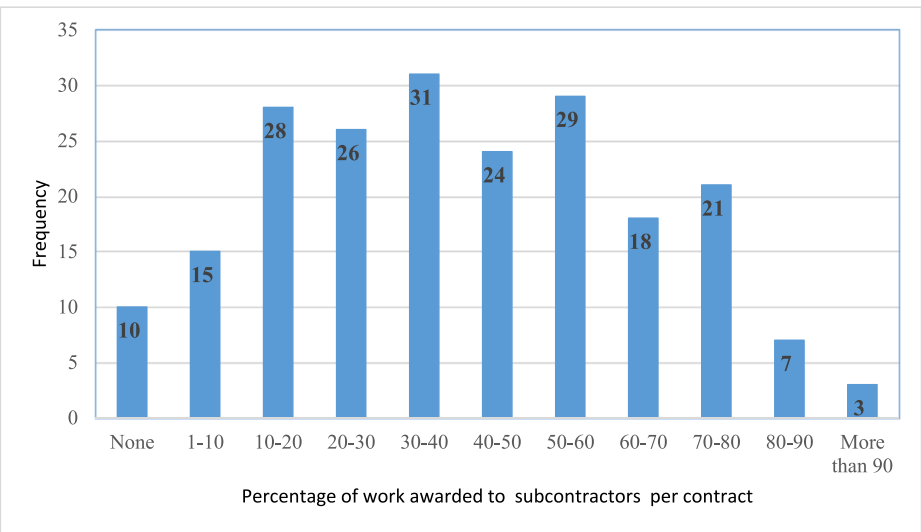

Fig. 2. Percentage of construction work subcontracted by the prime contractors.

Table 4
Reliability statistics.

Cronbach's Alpha	Part 1	Value	0.771
		N of Items	13[a]
	Part 2	Value	0.748
		N of Items	13[b]
	Total N of Items		26
Correlation Between Forms			0.670
Spearman-Brown Coefficient	Equal Length		0.803
	Unequal Length		0.803
Guttman Split-Half Coefficient			0.803

[a] The items are: Tender price and quotations of subcontractor, Financial capacity/stability of subcontractor, Adequacy, qualification and experience of subcontractor's management staff, Adequacy, qualification and experience of subcontractor's skilled labour, Schedule of payment to suppliers, Sufficiency of subcontractor's plant and equipment, Health and safety records, Previous performance of subcontractor, Current workload of subcontractor and capability to support new project, Location of the subcontractor, Have appropriate insurance covers, Referencing and recommendations, ISO's certification of subcontractor.

[b] The items are: Knowledge and compliance to government regulations, Nationality of subcontractors, Commitment to sustainability requirements, Expected completion date, Ability to initiate value engineering change proposal, Willingness to tender, Reputation of subcontractor, Subcontractor's ability to formulate and implement site waste management plan, History of claims, arbitrations and contractual disputes in the executed projects, Past working experience with the subcontractor, Personal relationship, Training facilities for labour, Construction method used by the subcontractor.

(Table 4). The Guttman test measures the internal consistency and reliability of the criteria. In Guttman, it is assumed that the two halves of the test should produce similar true scores and error variance. A value of more than 0.60 for both the correction and the Guttman coefficient is recommended. The validity test was based on construct validity. Construct validity may be assessed through discriminant and convergent validity. The data revealed that most of the correlation results ranged between 0.20 and 0.80. A correlation of more than 0.80 implies collinearity between the criteria, whereas a correlation of less than 0.2 implies that the criteria are not related. Further, a one-sample *t*-test was conducted to examine the measurement of the population with respect to each of the criteria (Table 5). The null hypothesis was that the criteria are not used to select subcontractors (H0: U=U0) and the research hypothesis was that the criteria are used to select subcontractors (Hr: U > U0). The statistical significance of each of the criteria (Hr: U >

Table 5
Results of *t*-test and Standard Error Mean.

Criteria	Test Value = 3.5					
	T	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference		Std. Error Mean
				Lower	Upper	
Tender price and quotations of subcontractor	8.822	0.000	0.495	0.385	0.606	0.056
Financial capacity/stability of subcontractor	11.375	0.000	0.594	0.491	0.697	0.052
Adequacy, qualification and experience of subcontractor's management staff	0.081	0.935	0.005	−0.110	0.119	0.058
Adequacy, qualification and experience of subcontractor's skilled labour	5.132	0.000	0.274	0.168	0.379	0.053
Schedule of payment to suppliers	−2.138	0.034	−0.118	−0.227	−0.009	0.055
Sufficiency of subcontractor's plant and equipment	4.183	0.000	0.250	0.132	0.368	0.060
Health and safety records	9.872	0.000	0.566	0.453	0.679	0.057
Previous performance of subcontractor	9.614	0.000	0.566	0.450	0.682	0.059
Current workload of subcontractor and capability to support new project	6.030	0.000	0.344	0.232	0.457	0.057
Location of the subcontractor	−7.264	0.000	−0.425	−0.540	−0.309	0.058
Have appropriate insurance covers	−2.627	0.009	−0.170	−0.297	−0.042	0.065
Referencing and recommendations	3.003	0.003	0.184	0.063	0.305	0.061
ISO's certification of subcontractor	−1.844	0.067	−0.123	−0.254	0.008	0.066
Knowledge and compliance to government regulations	6.100	0.000	0.354	0.239	0.468	0.058
Nationality of subcontractors	−2.442	0.015	−0.175	−0.315	−0.034	0.071
Commitment to sustainability requirements	2.091	0.038	0.123	0.007	0.238	0.059
Expected completion date	13.139	0.000	0.712	0.605	0.819	0.054
Ability to initiate value engineering change proposal	0.597	0.551	0.038	−0.087	0.162	0.063
Willingness to tender	−0.315	0.753	−0.019	−0.137	0.099	0.060
Reputation of subcontractor	8.097	0.000	0.481	0.364	0.598	0.059
Subcontractor's ability to formulate and implement site waste management plan	4.411	0.000	0.259	0.143	0.375	0.059
History of claims, arbitrations and contractual disputes in the executed projects	1.356	0.177	0.085	−0.039	0.208	0.063
Past working experience with the subcontractor	8.699	0.000	0.495	0.383	0.608	0.057
Personal relationship	−6.680	0.000	−0.453	−0.586	−0.319	0.068
Training facilities for labour	−3.775	0.000	−0.212	−0.323	−0.101	0.056
Construction method used by the subcontractor	3.748	0.000	0.193	0.092	0.295	0.052

U0) showed that all the criteria were statistically significant. However, the results of 'adequacy, qualification, and experience of the subcontractor's management staff', 'ability to initiate value engineering change proposal', 'willingness to tender', and 'history of claims, arbitrations, and contractual disputes in the executed projects" show discrepancies in the measurement of the respondents about the criteria. However, the small standard errors suggested that the measurements of the respondents were indicative of the measurements of the population with respect to each of the criteria. The results of the KMO (0.808) and Bartlett's test ($\chi 2$ (378) = 1567.206, $p < 0.050$) implied that the respondents were drawn from the same population and that the criteria could be used for a specific aim.

The descriptive statistics on the prioritization of the criteria are contained in Table 6. The AII for all the criteria was 73.40 and the average standard deviation was 17.23. Contextualising the relationship between the mean and standard deviation to these findings implied that at least 95% of the respondents measured that the criteria are very important to prime contractors for selecting subcontractors. Specifically, less than 9% of the respondents affirmed that the criteria were least or less important to the selection of subcontractors by the prime contractors. However, 34% measured that the criteria are important and about 60% of the respondents measured that the criteria are very or extremely important. In the context of the distribution of the AII in the section research methodology section, the criteria can be grouped into two categories. Four of the criteria are extremely important while the remaining 22 criteria are very important in making decision on the selection of competent and suitable subcontractors by the prime contractors for a project.

4.3. Results of the factor analysis on the selection criteria

Because the ratio of respondents to a criterion is 8:1, the data are suitable for factor analysis. Similarly, the number of criteria per component is at least two. The Principal Component Analysis and Varimax rotation strategy were used. Kaiser's normalisation technique was used to normalise the row of the factor patterns. The categorisation was computed based on the correlation among the variables. Kaiser's MSA (measure of sampling adequacy) for the criteria, which explains how small the overall partial correlations were compared to the original correlations, was approximately 0.8604. The factor analysis returned a statistical determination of 0.001. This is adequate. The threshold is 0.000001 [22,32]. If the value is less than 0.000001, it is an indication of multicollinearity. However,

Table 6
Descriptive statistics of the importance of the selection criteria.

Factor	Least important	Less important	Important	Very important	Extremely important	Importance Index	Std. Deviation
Expected completion date	1	4	30	91	86	84.25	15.79
Financial capacity/stability of subcontractor	0	3	43	97	69	81.89	15.22
Health and safety records	0	6	49	82	75	81.32	16.70
Previous performance of subcontractor	1	4	53	76	78	81.32	17.15
Tender price and quotations of subcontractor	1	5	50	94	62	79.91	16.35
Past working experience with the subcontractor	1	3	58	84	66	79.91	16.58
Reputation of subcontractor	0	9	54	81	68	79.62	17.30
Knowledge and compliment on government regulations	1	11	54	98	48	77.08	16.89
Current workload of subcontractor and capability to support new project	1	6	68	87	50	76.89	16.63
Adequacy, qualification and experience of subcontractor's skilled labour	0	7	72	95	38	75.47	15.52
Subcontractor's ability to formulate and implement site waste management plan	1	10	73	83	45	75.19	17.13
Sufficiency of subcontractor's plant and equipment	1	15	62	92	42	75.00	17.40
Construction method used by the subcontractor	0	6	94	91	31	73.87	15.02
Referencing and recommendations	0	18	74	77	43	73.68	17.84
Commitment to sustainability requirements	4	10	78	90	30	72.45	17.08
History of claims, arbitrations and contractual disputes in the executed projects	5	15	75	85	32	71.70	18.24
Ability to initiate value engineering change proposal	3	17	92	63	37	70.75	18.41
Adequacy, qualification and experience of subcontractor's management staff	0	22	88	75	27	70.09	16.92
Willingness to tender	2	24	80	82	24	69.62	17.47
Schedule of payment to suppliers	1	22	102	69	18	67.64	16.06
ISO's certification of subcontractor	3	39	71	73	26	67.55	19.36
Have appropriate insurance covers	5	27	101	51	28	66.60	18.82
Nationality of subcontractors	8	34	84	53	33	66.51	20.81
Training facilities for labour	2	33	89	78	10	65.75	16.38
Location of the subcontractor	3	47	106	43	13	61.51	17.02
Personal relationship	11	50	84	52	15	60.94	19.74

Table 7
Total variance explained.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.852	22.508	22.508	5.852	22.508	22.508	2.644	10.169	10.169
2	1.966	7.562	30.070	1.966	7.562	30.070	2.301	8.852	19.020
3	1.624	6.244	36.314	1.624	6.244	36.314	2.024	7.786	26.806
4	1.515	5.826	42.140	1.515	5.826	42.140	1.993	7.664	34.470
5	1.416	5.446	47.585	1.416	5.446	47.585	1.953	7.512	41.983
6	1.214	4.669	52.254	1.214	4.669	52.254	1.914	7.362	49.345
7	1.069	4.111	56.365	1.069	4.111	56.365	1.825	7.020	56.365
8	1.026	3.946	60.311						
9	.988	3.801	64.112						
10	.891	3.425	67.537						
11	.812	3.122	70.659						
12	.783	3.012	73.671						
13	.720	2.771	76.442						
14	.710	2.730	79.172						
15	.623	2.395	81.567						
16	.607	2.334	83.900						
17	.524	2.015	85.915						
18	.518	1.993	87.908						
19	.497	1.912	89.820						
20	.464	1.784	91.604						
21	.442	1.700	93.304						
22	.418	1.609	94.913						
23	.388	1.492	96.405						
24	.351	1.350	97.756						
25	.324	1.245	99.001						
26	.260	.999	100.000						

the results of the KMO (0.802) and Bartlett's test ($x2$ (325) = 1446.135, p = 0.000) also implied that the respondents have similar experiences with respect to the criteria. The results clustered the 26 criteria into 7 components for meaningful decision-making (Table 7). This was also evidenced in Fig. 3, as the function, flattened out essentially after the seventh component. There are no cross-loadings, as a component has 2 or more criteria. Table 8 contains the distribution of the prequalification criteria for each of the components. The 7 components explained 56% of the total variance. Data are adequate if the total variance explained exceeds 50% and each of the eigenvalues exceeds 1. However, research recommends a 60% threshold for the variance explained. However, it is argued that for confirmatory analysis, more than 60% is required, and 50% is adequate for exploratory factor analysis. Multiple studies have reported a total variance of less than 60% [29,38,63]; and [75]. Another reason why 50% is adequate is the homogeneity of a dataset, because homogeneity in data lowers the variance and factor loadings. The eigenvalue is the quality score of a component, and only

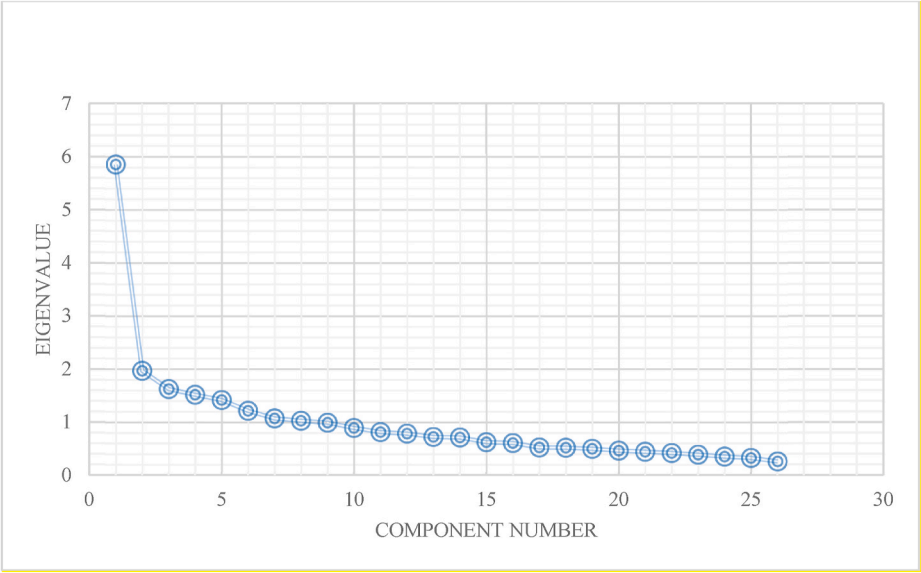

Fig. 3. Rotated component matrix.

Table 8
Rotated Factor Pattern for the selection criteria.

	Component (Y)						
	Labour ($X_{1)}$	Standards ($X_{2)}$	Performance (X_3)	Strategy (X_4)	Location (X_5)	Price (X_6)	Policy (X_7)
Current workload of subcontractor and capability to support new project	0.620						
Adequacy, qualification and experience of subcontractor's skilled labour	0.616						
Subcontractor's ability to formulate and implement site waste management plan	0.590						
Adequacy, qualification and experience of subcontractor's management staff	0.583						
Sufficiency of subcontractor's plant and equipment	0.547						
Have appropriate insurance covers	0.448						
Personal relationship		0.714					
Ability to initiate value engineering change proposal		0.709					
ISO's certification of subcontractor		0.590					
Willingness to tender		0.532					
Reputation of subcontractor			0.711				
Past working experience with the subcontractor			0.625				
Previous performance of subcontractor			0.518				
Construction method used by the subcontractor				0.741			
History of claims, arbitrations and contractual disputes in the executed projects				0.705			
Training facilities for labour				0.485			
Schedule of payment to suppliers				0.456			
Location of the subcontractor					0.764		
Nationality of subcontractors					0.730		
Referencing and recommendations					0.546		
Tender price and quotations of subcontractor						0.746	
Financial capacity/stability of subcontractor						0.721	
Knowledge and compliance to government regulations							0.670
Expected completion date							0.597
Commitment to sustainability requirements							0.597
Health and safety records							0.511
Eigenvalue	5.852	1.966	1.624	1.515	1.416	1.214	1.069
Variance explained (%)	22.508	7.562	6.244	5.826	5.446	4.669	4.111
Internal consistency	0.567	0.636	0.618	0.597	0.680	0.733	0.594
MSA for second order factor analysis	0.782 $\chi 2$ (15) = 253.76	0.737, $\chi 2$ (6) = 124.34	0.584, $\chi 2$ (3) = 64.565	0.722, $\chi 2$ (6) = 1070.87	0.579, $\chi 2$ (3) = 72.77	0.500, $\chi 2$ (1) = 45.71	0.663, $\chi 2$ (6) = 60.44
***p* for second order factor analysis**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Variance explained for second order factor analysis (%)	61.04	51.45	54.16	49.41	55.45	72.14	42.65
Cronbach's alpha for second order factor analysis	0.729	0.682	0.567	0.655	0.585	0.613	0.546

components with high Eigenvalues are likely to represent a real underlying factor. Please insert Tables 7 and 8 and Fig. 3 here.

5. Discussion of findings

Subcontractors are crucial to the performance of the construction sector. Hence, careful selection of subcontractors is critical to the successful completion of a project. Prime contractors use multiple criteria to select suitable subcontractors because it is a multidimensional problem. In a multidimensional problem, constructs or variables contribute different weights in decision making. The criteria that were used by G 7 contractors for selecting subcontractors are presented and discussed in the following sections. The first

part focused on the analytical discussion to achieve the first objective, and the second part dealt with the clustering of the criteria to achieve the second objective of the research.

5.1. Discussing the taxonomy of the selection criteria

Because of space constraints, only the first 10 criteria are briefly discussed. The completion date is the most important criterion that the prime contractor uses to pre-qualify subcontractors for a project. In fact, more than 80% of the respondents measured this criterion as very important or extremely important. Similar research elsewhere revealed that completion time is one of the most important factors for the contractor's selection [27]. This is not surprising since project costs increase as projects are delayed [61]. While previous research has investigated critical success factors in the performance of the construction industry [86], little is known if the financial stability of the contractors has a significant impact on the success of the project performance. A result of a survey shows that the debt profiles of the Malaysian construction contractors are high and that the need to service the debt is very significant (Wan Mahmood and Zakaria, 2007). Research has shown that disruption in payment to the contractors is a major factor causing a delay in project delivery [8]. Therefore, it is not surprising that the financial capacity of subcontractors is the second criterion that is used to select subcontractors. Subcontractors with high financial capacity will be entertained by flexibility in payment terms and conditions. Disruption in payment to subcontractors would lead to project delays and disputes and litigation, especially if the subcontractors have cash flow problems. But subcontractors with a strong financial base may proceed with work if there is strong evidence that the prime contractors will settle the outstanding debts in due course. In fact, subcontracting involves providing credit facilities to prime contractors and clients.

There is a high degree of poor safety and health practises in the Malaysian construction sector. Therefore, it is not surprising that the health and safety record is found to be the third primary criterion for the selection of subcontractors. Recent research found a great divide between prime contractor/subcontractor safety management and enforcement [74]. It is important that the safety credentials of the subcontractors are considered because the prime contractors would transfer the safety management of the site to the subcontractors during the site operations [74]. The fourth criterion is the previous performance of the subcontractors. Securing new projects depends very much on the background and reputation of subcontractors. Before the prime contractor selects a subcontractor for a project, the prime contractor will often examine the performance of their previous or current subcontractors. Subcontractors with a strong track record of performance on previous or ongoing projects will be given a high rating or recommendation (Horm et al., 2005). Tender price is often the basic determinant of tender selection. Research indicates that price is the dominant criterion in New Zealand's public projects [77] and this is the case in many countries. The prime contractors will typically select subcontractors with lower prices to maximise their profits. If the subcontractors' quotations are high enough to affect the prime contractor's profit, it is very likely that the subcontractors will not be selected. However, research shows that selecting subcontractors based on price does not add value to projects. In Australia [49], found that selecting subcontractors based on tender price increases post-award supervision and performance monitoring costs. This would eventually increase the cost of construction and lead to a loss of profits and client dissatisfaction.

This research found that past working experience of a subcontractor with a prime contractor is very important. This is similar to finding elsewhere [57]. Besides completing a project on time and within budget, how disputes and discrepancies are resolved is strategic to prime contractor organisations. In addition, prime contractors will not select subcontractors that do not comply with the contract terms and conditions of the previous project. Many subcontractors often violate government regulations to save costs and increase profit. However, this may lead to penalties and claims. Therefore, it is expected that knowledge of and compliance with government regulations by the subcontractors will be very important. Ignorance of government policy will result in fines and sometimes suspension of work. Familiarity with the regulatory frameworks (e.g., standards, codes, regulations, legislation, etc.) is very important, especially if it involves international parties [85]. The prevailing workload of a subcontractor and their capability to support a new project are very important. Even if the subcontractors are qualified to tender, their prevailing workloads will affect their ability to support new projects efficiently. For instance, commitment to a project may mean a lack of labour for a new project, especially with inadequate training facilities. Also, plants and equipment may not be available for the next project. As part of the pre-qualification process, prime contractors often demand that the subcontractors submit a list of their main skilled labour. Therefore, it is expected that the adequacy of qualified and experienced subcontractor's skilled labour is considerably significant. In fact, none of the respondents measured the criterion as the least important. This is insightful because there is a high shortage of skilled labour in the construction sector. The availability and skills of construction workers are very critical to project completion. Especially in Malaysia, where more than 90% of the site labour is foreign immigrants. Therefore, any disruption in the supply of foreign labour could lead to project delays, poor quality, and cost overruns. The problem is made worse by the lack of adequate training facilities by the subcontracting companies.

5.2. Discussion of the results of factor analysis

This section addresses the second objective of the research. Clustering the selection criteria is very strategic for systemic decision-making. It enables problems to be solved from a multi-dimensional or systemic perspective rather than from an analytical approach. Despite their importance, however, the selection criteria have not been rigorously clustered [16,62]; and [55]. A few studies that categorised the criteria categorised the criteria subjectively [1,13] and iteratively. While [48] performed confirmatory analysis using SEM, many important criteria like financial capability [1,61], tender price [55], willingness to tender [55], proposed completion date [61], staff training facilities [61,62], waste management plan, the nationality of the subcontractor, and insurance coverage were not evaluated. Furthermore, the analysis was based on confirmatory analysis and the explanation provided for each of the criteria required more explanations. Beyond this, the previous studies focused on the entire construction industry. However, there is high variability in

the various segments of the construction industry. This research concentrates only on the building segment. Additionally, this research included a very large number of respondents as compared to previous similar research. The factor analysis conducted on the 26 selection criteria structured the criteria into seven components. A decision on the component's name can be made based on two methods. For instance, the component's name may depend on the component with the highest weightage under that component. Alternatively, the name may be derived based on the similarity amongst the factors that constitute a component. In this article, the second naming method was used because it is not biassed [69]. In other words, the similarity among the criteria is used to derive the name of a component, noting its difficulty. Furthermore, a second-order factor analysis that combined all the criteria under a component was computed for each of the components. Second-order factor analysis is required to further examine if the constructs in a component are indeed constituents of a component or if the component should be split into two or more [32,65]; and [22]. The discussion in this section is primarily exploratory due to the dearth of related research. Because of space, constraints, only an overview of the discussions is provided next.

5.2.1. Component 1: labour management

The first component has six criteria. However, the second-order factor analysis split the component into two components. The first sub-component is comprised of four selection criteria, which are the 'adequacy, qualification, and experience of subcontractor's skilled labour (0.782), the current workload of the subcontractor and the capability to support the new project (0.779), the sufficiency of the subcontractor's plant and equipment (0.757) and the adequacy, qualification, and experience of the subcontractor's management staff (0.629)'. The second sub-component is comprised of two criteria, which are: having appropriate insurance coverage (0.784) and the subcontractor's ability to formulate and implement a site waste management plan (0.779). The values in the parentheses are the factor loadings for the second-factor analysis. The subcontractor's workload and capability to support a new project are related to the sufficiency and availability of the skilled labour that the subcontractors can deploy to a new project. The prevailing current workload and capability to support projects may also have a negative relationship with the availability of plants and equipment for a new project. Most of the subcontractors have about 50 skilled laborers. However, for a big project, the subcontractor would need to engage and train new labour for the new project. Similarly, this would influence the subcontractor's ability to allocate plant and equipment to new projects. A sizeable number of subcontractors depend on the external market to hire plants and equipment for the new project. Most modern projects require complex mechanization. However, most subcontractors do not have the required plants and equipment to execute the projects they tender for, relying on companies that provide hiring services, but often, if demand is high, the hiring companies may not be able to meet the demand of the subcontractors. Delays in the supply of the plant and equipment on time could therefore affect the progress of the projects. Therefore, it is important for the main contractors to give preference to subcontractors that own their plants and equipment over those that depend on the hirer. It is not surprising to find that the ability of the subcontractor to provide insurance cover falls under this component. Banks or insurance companies will not provide insurance cover for construction companies that intend to tender projects that are far beyond their capability, especially if the subcontractor does not have adequate skilled labour, plant and equipment. Insurance companies will also need to make certain that the companies they choose to provide insurance cover have competent management staff. According to Ref. [43]; one of the main causes of waste on construction sites is the unavailability of a qualified subcontractor, on the basis of which lean management was used to reduce construction waste in Egypt. Although the relationship between the subcontractor's ability to formulate and implement site waste management and the appropriateness of the insurance cover for the subcontractors seems counter-intuitive. However, there is a relationship between some of the criteria and the implementation of the waste management plan. For instance, the subcontractors may not have the necessary plants and equipment to process waste. This can also be associated with the subcontractor's workload. Strategic waste management also requires skilled labour. That skilled labour may not be available for the next project if they are already preoccupied with the current workload. About 50% of the waste in Malaysia is generated by construction sector, and only about 10% of construction waste is recycled. Many contractors are now converting the waste to value through a careful waste management plan. Subcontractors that have the technology and skill to reduce or avoid waste on projects could submit fewer quotations. Therefore, it is expected that prime contractors will require the subcontractors to submit a plan on how they will manage the construction waste on the sites as part of the pre-qualification criteria.

5.2.2. Component 2: standard

This component has four criteria. Subcontractors may not be able or willing to tender if the project requires that the tenderer have experience in value management practice. In Malaysia, all public projects exceeding RM50 million must be value engineered, and it is highly encouraged for projects with a contract of less than RM50 million. Value management is perhaps the only technique with a dedicated unit in the Prime Minister's office. Therefore, it is not surprising that the ability of the subcontractors to initiate a value engineering change proposal is important. A value engineering change proposal is a form of value management practise that requires a contractor to initiate measures to reduce costs and time of projects. For the subcontractors to claim competency, it would be expected that some of the staff are certified members of the Malaysian Institute of Value Management or other similar institutes in other countries. Many contractors have an in-house standard for conducting value engineering, quality control and assurance, and tender submission. It is not difficult to explain that personal relationships with prime contractors will enhance the subcontractor's success in being selected if the subcontractor has experience in value engineering, is ISO certified, and is willing to tender for a project (see Ref. [34]. Willingness is a sign of motivation to participate in a task, and it can go a long way toward sustaining a commitment toward completing a task. The willingness of subcontractors to tender is a reflection of their capability to accomplish the work as required. While willingness is not the same as capability, it is important to note that the final list of the prequalified contractors includes only those that have the capability and are willing to tender for the project [64]. Some subcontractors only submit a tender, especially if

invited or based on a negotiated tender. Prime contractors will invite subcontractors that have worked for them on previous projects or are currently working for them that they know to have experience in value engineering change proposals and are ISO certified. ISO sets out the requirements for a quality management system and promotes efficiency in service delivery. Like ISO standards, value management standards seek to promote value-added services. ISO certification involves various aspects, including risk management, environmental management system, and risk management. ISO certified contractors were able to provide services to the client, according to research (Xiao and Proverbs, 2002 [48]; and [34]. However, research also shows that there are some problems holding the ISO certifications (Ofori and Gang, 2001; Zobel, 2007). A previous Malaysian study revealed that construction companies with ISO registration have high performance in terms of functionality, time and cost performance [9].

5.2.3. Component 3: performance

Although studies show that the reputation of a subcontractor is a major criterion for winning contracts [61], the relationship it has with other criteria has not been established. This research found that the past working experience of a subcontractor with a prime contractor is very important. Apart from the ability of subcontractors to perform their functions effectively, the process and behaviour in resolving disputes are very important in fostering the relationship. The construction sector is highly litigious. Poorly drafted or incomplete and unsubstantiated claims, as well as the failure to properly administer the contract, remain the major causes of disputes [11]. The average length of time to resolve a construction dispute is 15 months, and collaboration is suggested as a means to resolve the disputes [11]. Subcontractors that do not comply with the contract terms and conditions of a previous project will not be selected by the prime contractors. In fact, a second factor analysis finds a high positive correction among the criteria. Evidently, the reputation of the subcontractors depends on their past working experience with the subcontractor and their previous performance. Recent research in Egypt revealed that inefficient selection of the subcontractor and insufficient skill and defective workmanship of the subcontractor are some of the major causes of rework [9]. Therefore, it was expected that these three criteria would be attributes of the "performance" component. The reason for this is simple. Contractors will examine the list of their previous subcontractors and suppliers and invite those that have a good reputation. Branding is a very important indicator for winning a contract in the construction sector. Often, where there are no competent subcontractors in the list of subcontractors that have worked with the prime contractor, the prime contractor may seek help from their colleagues in other companies to recommend subcontractors for their work. In fact, many prime contractors will directly negotiate with reputable subcontractors for a new project. The correlation between past working experience with the subcontractor and the previous performance of subcontractors is positive.

5.2.4. Component 4: strategy

The construction method is one of the various strategies that contractors may use to increase productivity on construction sites. Therefore, it is not surprising that the method of construction is grouped along with the training facilities. A lot of training facilities maybe need to develop a suitable construction method. In fact, many contractors have specialized training facilities to train their labour on specialized or new construction techniques. Multiple studies show that a lack of training facilities is a major influencing factor for the performance of the construction sectors in many countries [16,61]. Lack of training facility has been cited as a major reason influencing the adoption of IBS and BIM in Malaysia. One of the major factors leading to claims in a construction contract is a delay in payment to the suppliers. Supply chain management is a strategic tool to ensure the successful completion of projects. However, the supply chain management might be hampered if the suppliers are not paid regularly. In Malaysia, the 'pay you when I received payment' that is rampant in the construction sector is negatively affecting the performance of the sector. Suppliers play active roles in guiding designers in material selection, prepare shop drawings, and produce systemized materials/components. Suppliers also provide credit facilities/loans to contractors/subcontractors. However, many projects have been suspended or delayed due to the inability of the contractors to pay suppliers regularly for the supplied materials in Malaysia. Therefore, it is important that the subcontractors are able to work with suppliers well (Mirawati et al., 2015 and [51] because one of the major causes of cost overrun of projects in Malaysia is the relationship that contractors have with the materials suppliers [2]. Many clients or prime contractors demand proof of payment for previous works to suppliers as part of prequalification criteria. It is expected that if suppliers have not received payment regularly, it would result in disputes. The situation may be worsened if the subcontractor does not use suitable construction methods. Construction claims and disputes may be resolved through arbitration or litigations. Subcontractors may face payment problem if the construction method that the subcontractors used are not familiar to the prime contractors especially, if there is a conflict to be resolved which may lead to disputes. However, if a dispute arises, it should be resolved amicably through any of the alternative resolution methods. While dispute is endemic in the construction sectors because of the number of parties and varying interests, it is preferable if parties can resolve the disputes without even approaching alternative methods of dispute resolution. However, for this to thrive trust must be established among parties.

5.2.5. Component 5: location

A second-order factor analysis that was conducted on the subcontractor's location, nationality of the subcontractors, and recommendation, the subcontractors combined the criteria into one component, location. The prime contractors prefer to select subcontractors that are close to the location of the work for a logistic reason. This is because operational costs like preliminary costs (i.e., accommodation and moving plant and equipment) would be reduced. Recent research in the US shows that project location is one of the major complex indicators, which affects project performance [37]. Availability and familiarity with competent subcontractors are usually problems facing prime contractors in a new geographical location. Foreign subcontractors may not have sufficient knowledge about the local market. The lack of such knowledge may affect their chance of being selected for the work. Because of the rate of indigenization of the Malaysian construction sector, most of the subcontractors that may be recommended are highly likely to be local subcontractors. Approximately, 99.86 of the construction business in Malaysia are owned by Malaysians in 2015 and only 52 of the

totals 40,558 are owned by foreigners (Department of Statistics, Malaysia (2017). There are 8 G7 foreign construction companies in Malaysia as at July 2021. Although data on the poor performance of the foreign subcontractors is not available, the tender price of foreign contractors is competitive as compared to local contractors. However, due to the construction culture, local contractors are often preferred. A recent finding in New Zealand [57] shows that one of the major selection criteria for inviting subcontractors to tender for projects is the location of the subcontractors relative to the location of the proposed project. Many subcontractors and suppliers win projects due to the recommendation and reference by colleagues, friends, or families. In Malaysia, many of the construction companies are connected to family business especially, among the Chinese community. Therefore, it is not surprising to find that recommendation and personal relationship with the main contractor have considerable influence on the selection of subcontractors. Recommendations from previous employers and financiers were also found to be a major pre-qualification in New Zealand [57]. Therefore, if there is no restriction for the contractors to tender for the work on account of their location and nationality and if they are recommended for a contract, they stand a better chance of being awarded the contract. However, even if the subcontractors received a high recommendation, they may not be selected if they are not Malaysian companies or and if they are far from the project site.

5.2.6. Component 6: pricing

The pricing component comprises the tender price and the subcontractor's financial capacity. Although, in theory, there is no conclusive evidence that both criteria are related. This study discovered a positive relationship between the two variables ($r = 0.443$, p.05). Construction projects are expensive enterprises. The undertaking of many construction projects necessarily involves the investment of large sums of money. The nature of construction organisations responsible for such construction is such that they hardly possess the required budget or capital of the magnitude capable of financing their proposed projects. Public and private clients and construction companies usually approach banks and financial organisations to borrow money to finance projects. Most developers and contractors acquire the fund through retained earnings, in which case bank interest will accrue (Ahuja and Walsh, 1983). A major factor influencing the quotation is the financial capability of the subcontracting organisation. The financial capacity of the subcontractors takes into account how much to charge for overhead and profit, considering the amount to pay on interest. It would be expected that subcontractors that do not depend on borrowed money would submit a lower bid because interest charges would not be included in the submitted tender price. But if the money were borrowed, the tender price would be higher because of the interest on the borrowed money. By implication, big or well-established subcontractors pay high overheads and submit quotations with a high-profit margin. This may be surprising, but it is the medium-sized or small companies that submit low prices because of lower overhead costs and the flexibility of their operational costs.

5.2.7. Component 7: policy

There are four related criteria that are grouped into this component. The criteria are related. This is also confirmed by the results of the second-order factor analysis. Health and safety have become explicit key performance indicators in the construction sector. Therefore, making a decision on the health and safety of construction workers is a very important part of sustainable construction management. Sustainable organisations must protect the safety, health, and welfare of their workers (Occupational Safety & Health Administration, 2020). While health and safety are not often considered to be similar to sustainability [70], there is a strategic linkage between the two [45]. In fact, sustainability and health & safety seek to achieve identical purposes. For instance, while sustainability seeks to preserve and conserve social, economic, and environmental resources, health and safety seek to protect and preserve the workers' wellbeing in an organisation. Organisations that prioritise the health and safety of workers will not misuse and deplete economic and environmental resources. Sustainability ensures that workers are protected against harm in workplaces [70] Center for Safety & Health Sustainability, 2020). A critical health and safety crisis in the construction sector is the spread of diseases [10,87] because construction activities are highly hazardous. Lack of adherence to regulations on health and safety and sustainability requirements or SOP could delay projects [88]. Many projects have been suspended because the contractors or developers violated SHASSIC (Safety and Health Assessment System in Construction) guidance, which extends the project completion date. Compliance with government regulations might delay the completion of the project due to the lengthy procedures involved. Compliance with government policies may tend to affect project progress and, in fact, increase project costs in the short run. For instance, recent research shows that compliance with COVID-19 could delay a project by up to 10% [88]. However, in the long run, the contractor could avoid fines for violating regulations. There are many regulations to ensure that construction sites should ensure sustainability and safety compliance. Many contractors have continued to violate these policies on the basis that compliance with the policy delays the progress of the project and reduces their profit.

Table 9
Model summary.[b].

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.258[a]	0.066	0.034	2.43998

[a] Predictors: (Constant), REGR factor score 7 for analysis 1, REGR factor score 6 for analysis 1, REGR factor score 5 for analysis 1, REGR factor score 4 for analysis 1, REGR factor score 3 for analysis 1, REGR factor score 2 for analysis 1, REGR factor score 1 for analysis 1.

[b] Dependent Variable: The percentage of a construction work awarded to subcontractors in previous projects.

Table 10
ANOVA[a].

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	86.483	7	12.355	2.075	0.048[b]
	Residual	1214.517	204	5.954		
	Total	1301.000	211			

[a] Dependent Variable: The percentage of a construction work awarded to subcontractors in previous projects.
[b] Predictors: (Constant), REGR factor score 7 for analysis 1, REGR factor score 6 for analysis 1, REGR factor score 5 for analysis 1, REGR factor score 4 for analysis 1, REGR factor score 3 for analysis 1, REGR factor score 2 for analysis 1, REGR factor score 1 for analysis 1.

Table 11
Coefficients.[a].

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.500	0.168		32.820	0.000
	Labour	−0.048	0.168	−0.020	−0.289	0.773
	Standards	−0.294	0.168	−0.118	−1.749	0.082
	Performance	0.386	0.168	0.155	2.295	0.023
	Strategy	0.152	0.168	0.061	0.906	0.366
	Location	−0.001	0.168	0.000	−0.007	0.994
	Price	0.270	0.168	0.109	1.606	0.110
	Policy	0.277	0.168	0.112	1.649	0.101

[a] Dependent Variable: The percentage of a construction work awarded to subcontractors in previous projects.

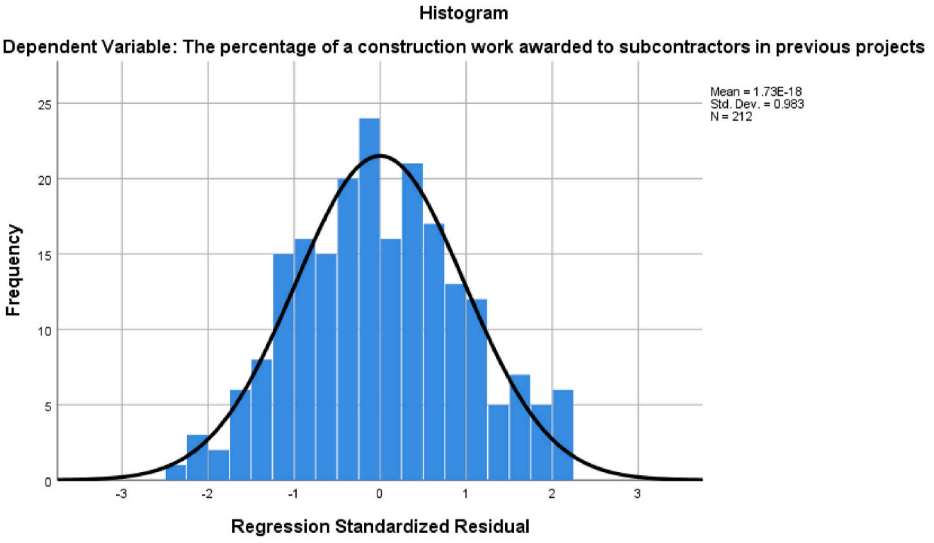

Fig. 4. Regression plot.

6. Overview of the application of the regression model

Based on the data in Table 7 a multiple linear regression analysis was computed using the percentage of the construction work awarded to subcontractors as the dependent variable. The results of the regression analysis are contained in Tables 9–11. Figs. 4 and 5 show that the data are near normal.

The regression results showed that the seven predictors explained approximately 26% of the variance ($R^2 = 0.258$, F (7,207) = 2.075, p.05). The overall model is significant. Performance was found to predict subcontractor selections moderately ($\beta = 0.386$, p = 0.023), but components may not have made significant contributions.

Size of projects awarded to subcontractors (Y) = 5.500 + 0.386 Performance +0 0.152 Strategy +0.270 Price +0.277 Policy - 0.048 Labour −0.294 Standards - 0.001 Location 2

In order for the main contractors to pre-qualify a suitable subcontractor, the equation can be used for this purpose. In practical terms, a subcontractor that obtains a high score will be considered as the most suitable for a project under consideration, whilst a subcontractor with a low score has a low possibility of being selected. In other words, a subcontractor that garnered a high score

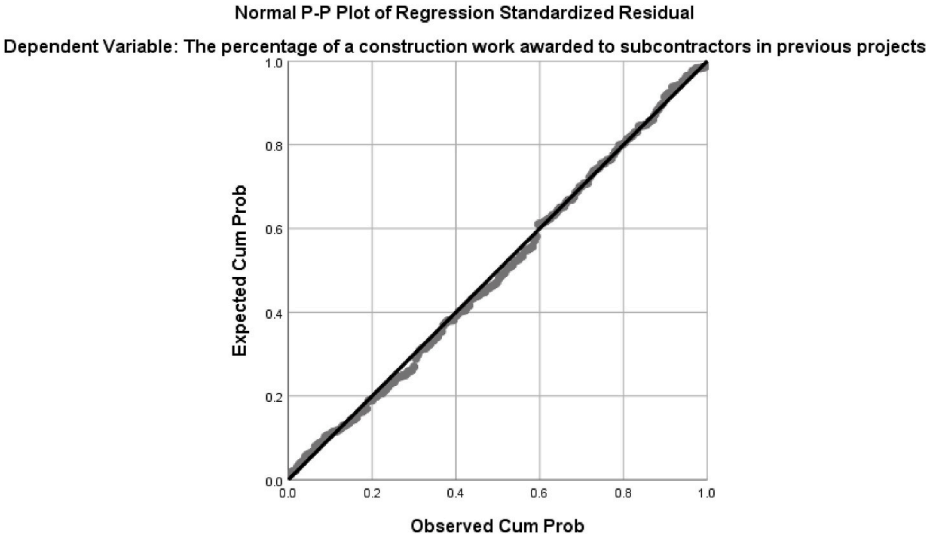

Fig. 5. P–P plot.

implies that the subcontracting organisation is highly rated on most of the criteria, while a subcontractor with a low score means that it does not meet the requirements of most of the criteria that the main contractor used as a benchmark. Based on this framework, the subcontractor that obtained a high score has appropriate human capital for the project.

The prequalification exercise can be conducted by an individual or by a team of experts/representatives in the main contractor organisation. The individual or team could rank each of the 7 components on a Likert scale. For instance, using a scale of 1–6 on their sites. Where 6 = extremely satisfied, 4 = very satisfied, 3 = satisfied, 2 = less satisfied, 1 = least satisfied, and 0 = not satisfied. The Y of the subcontractor will then be computed as a product of the evaluated Likert scale point and the percentage of variance explained as shown in the above equation. Subsequently, all the products will be summed up for the subcontractors. Finally, the subcontractor will be ranked in terms of the extent that they qualify for the project based on the components or the framework.

Example case.

- Assuming the score that a subcontractor (S_1) obtained on the 7 components is 5 each [$X_1 = 5$, $X_2 = 5$, $X_3 = 5$, $X_4 = 5$, $X_5 = 5$,X_6 5, $X_7 = 7$], the accumulated score will amount to 9.21
- Assuming the score for another subcontractor (S_2) is 4,3,4,3,4,5,5 respectively [$X_1 = 4$, $X_2 = 3$, $X_3 = 4$, $X_4 = 3$, $X_5 = 4$,X_6 5, $X_7 = 5$]. The accumulated score will amount to 9.157

Subcontractor S1 is therefore more suitable for the project. Although S2 performed relatively low in all the prequalification components, The personal relationship of the subcontractor with the prime and her competency in value engineering is low. It is probably likely that ISO certification is not specific to the project. It seems the subcontractor (S2) proposed an unsuitable construction method and lacks adequate training facilities for workers. The experience of the prime contractor and the subcontractors in resolving a dispute is not remarkable, and the subcontractors have a poor reputation based on the records of those that they worked for in the past. Due to these constraints, the subcontractor is not encouraged to tender for the project, but tendered because it has some advantage in offering a lower price and completing the project on time, as well as having a good health and safety management regime, being committed to sustainable construction practice, and being familiar with government regulations on construction projects.

7. Conclusion and limitations

The selection of suitable subcontractors is crucial for the performance of the project, the contractor's profit margin, and the clients' satisfaction. Our study responds to the lack of exemplar research on suitable selection criteria for building subcontractors in Malaysia. Without an effective evaluation framework, incompetent and unsuitable candidates may be selected. A comprehensive description of subcontractors' selection criteria-based on a survey of prime contractors has been presented. The findings of the factor analysis, though exploratory, provide insights into the relationships amongst the criteria. The main criteria are related to the availability of resources like labour, competency and materials; subcontractors' working experience; and the performance of the projects involved by subcontractors. Subcontractors' competency, and facilities are very pertinent criteria in the selection of subcontractors for projects. As will be expected, the location of a project and the tender price constitute major predictors of whether it will be selected or not. From the results, a framework based on the factor analysis technique that provides a general guide both to the prime contractors and subcontractors in their decision-making was presented. The prime contractors may use the findings as prequalification guidance for the selection of suitable subcontractors. For the subcontractors, the guidelines are very useful, because they will enable them to know the 'mindset' of the prime contractors and whether they should tender for work or not. The subcontractors will also use the framework strategically on aspects requiring development in their organisation. Previous research has assumed that these factors influence

projects linearly and individually. But the criteria interact with one another. Looking at the findings of this research from a practical point of view, the analysis and clustering of the criteria have several implications. The first major practical contribution of the present research is that it provides much needed empirical data on subcontracting practise in Malaysia. The data shows that it is very crucial to evaluate prequalification because more than 90% of construction contracts are executed by subcontractors. This information is important given that there is no comparative study in Malaysia. Defining the activities of subcontractors will assist policy-makers, prime contractors, consultants, and others in the selection of competent subcontractors. This will allow projects to be completed within budget, on time, and deliver high-quality buildings. A second important implication of our study derives from our findings on the uniqueness of the knowledge and information on the essence of the competency of the subcontractors. The findings imply that the availability of a competent subcontracting organisation is essential for the construction business. The findings point to a specific set of capabilities, resources, decision styles, strategies, and attitudes towards knowledge and evidence that may set apart the qualifications and credentials of subcontractors. While this research has provided insight into subcontracting in the Malaysian construction sector, it has some limitations. For instance, refurbishment work has a different set of requirements as compared to new projects. Refurbishment and maintenance have a lot of uncertainties, are complex, time constrained, and present less opportunity for mechanization. Although the number of respondents in this research is comparatively large, there may be a need to increase the response rate. The number of criteria may be increased in future research. In addition, a similar survey may be administered to the subcontractors to determine the extent to which they perceive the prime contractors' criteria to be the same. Future research may include more factors because the regression results suggest the 7 predictors are not good predictors. However, the results are indications of the features and predictors of the subcontractors' selection criteria.

Author statement

AbdulLateef Olanrewaju: Conceptualization, Methodology, Software, AbdulLateef Olanrewaju and Zhi Xun Bong: Data curation, Writing- Original draft preparation. AbdulLateef Olanrewaju and Zhi Xun Bong: Visualization, Investigation. AbdulLateef Olanrewaju: Software, Validation. AbdulLateef Olanrewaju and Christopher Preece: Writing- Reviewing and Editing, Establishment of pre-qualification criteria for the selection of subcontractors by the prime constructors for building projects.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] H. Abbasianjahromi, H. Rajaie, E. Shakeri, A framework for subcontractor selection in the construction industry, J. Civ. Eng. Manag. 19 (2) (2013) 158–168.
[2] H.S. Abdul-Rahman, R.I. Endut, N. Faisol, S. Paydar, The importance of collaboration in construction industry from contractors' perspectives, Procedia Soc. Behav. Sci. 129 (2014) 414–421.
[3] H. Abdul-Rahman, M.A. Berawi, A.R. Berawi, O. Mohamed, M. Othman, I.A. Yahya, Delay mitigation in the Malaysian construction industry, J. Construct. Eng. Manag. 132 (2006) 125, 2006.
[5] H. Adnan, M.N. Rahmat, N.F. Mazali, K. Jusoff, Risk Management Assessment for Partnering Projects in the Malaysian Construction Industry, in: Dynamic Positioning for Survival in Political Marketing Warfare Mugabe's Maneuverings Out of Crises in Zimbabwe, 2008, p. 76, 2008.
[6] A.H. Afolayan, B.A. Ojokoh, A.O. Adetunmbi, Performance analysis of fuzzy analytic hierarchy process multi-criteria decision support models for contractor selection, Scientific African 9 (2020), e00471.
[7] I. Aje, The impact of contractors' prequalification on construction project delivery in Nigeria, Eng. Construct. Architect. Manag. 19 (2) (2012) 159–172.
[8] W. Alaghbari, M.R.A. Kadir, A. Salim, Ernawati, The significant factors causing delay of building construction projects in Malaysia, Eng. Construct. Architect. Manag. 14 (2) (2007) 192–206.
[9] A.M. Al-Janabi, M.S. Abdel-Monem, K.M. El-Dash, Factors causing rework and their impact on projects' performance in Egypt, J. Civ. Eng. Manag. 26 (7) (2020) 666–689.
[10] A. Alsamawi, J. Murray, M. Lenzen, R.C. Reyes, Trade in occupational safety and health: tracing the embodied human and economic harm in labour along the global supply chain, J. Clean. Prod. 147 (2017) 187–196.
[11] Arcadis, Global Construction Disputes Report, 10th Anniversary Edition, 2020 (2020) Collaborating to achieve project excellence, www.arcadis.com.
[12] A. Ardeshiri, K. Willis, M. Ardeshiri, Exploring preference homogeneity and heterogeneity for proximity to urban public services, Cities 81 (2018) 190–202.
[13] G. Arslan, S. Kivrak, M.T. Birgonul, I. Dikmen, Improving sub-contractor selection process in construction projects: web-based sub-contractor evaluation system (WEBSES), Autom. ConStruct. 17 (4) (2008) 480–488.
[14] A.K. Birjandi, F. Akhyani, R. Sheikh, S.S. Sana, Evaluation and selecting the contractor in bidding with incomplete information using MCGDM method, Soft Comput. 23 (20) (2019) 10569–10585.
[15] BuildInfo, Contractors urged to employ model terms for subcontract work contracts, CIBD Malaysia 9 (12) (2010) 1–10.
[16] R.M. Choudhry, J.W. Hinze, M. Arshad, H.F. Gabriel, Subcontracting practices in the construction industry of Pakistan, J. Construct. Eng. Manag. 138 (12) (2012) 1353–1359.
[17] X. Chen, Y. Ding, C.A. Cory, Y. Hu, K.J. Wu, X. Feng, A Decision Support Model for Subcontractor Selection Using a Hybrid Approach of QFD and AHP-Improved Grey Correlation Analysis, Construction and Architectural Management, Engineering, 2020.
[18] CIDB, Country Report Malaysia. 22nd Asia Construct Conference Seoul, Korea, 25 – 27 October 2017, 2017. Accessed on. (Accessed 31 December 2019).
[19] CIDB, Model Terms of Construction Contract between Contractor and Subcontractor for Subcontract Work, 2007, ISBN 983 2724 45 7 (Third print May 2007 (Revised)), www.cidb.gov.my.
[20] CIDB, Construction Industry Review and Prospect 2016/2017, 2018, ISBN 978-967-0997-18-6. www.cidb.gov.my.
[21] CIDB, QLASSIC Report 2016, 2018. www.qlassic.cidb.gov.my.
[22] L. Cohen, L. Manion, K. Morrison, Research Methods in Education, Routledge, New York, 2017.
[23] Construction 2025, Industrial Strategy: Government and Industry in Partnership, 2013. Available at, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210099/bis-13-955-construction-2025-industrial-strategy.pdf.
[24] H. Doloi, Analysis of pre-qualification criteria in contractor selection and their impacts on project success, J. Constr. Manag. Econ. 27 (12) (2009) 1245–1263.
[25] A.Z. Dulung, L.S. Pheng, Factors influencing the selection of subcontractors in refurbishment works, Architect. Sci. Rev. 48 (1) (2005) 93–103.
[26] J. Egan, Rethinking Construction, Department of the Environment Transport and Regions, HMSO, London, 1998.

[27] S.M. El-Sayegh, M. Basamji, A. Haj Ahmad, N. Zarif, Key contractor selection criteria for green construction projects in the UAE, Int. J. Constr. Manag. (2019) 1–11.
[28] A. Enshassi, F. Arain, B. Tayeh, Major causes of problems between contractors and subcontractors in the Gaza Strip, J. Financ. Manag. Property Construct. 17 (1) (2012) 92–112.
[29] S. Folkman, R.S. Lazarus, R.J. Gruen, A. DeLongis, Appraisal, coping, health status, and psychological symptoms, J. Pers. Soc. Psychol. 50 (3) (1986) 571.
[30] A. Hartmann, J. Caerteling, Subcontractor procurement in construction: the interplay of price and trust, Supply Chain Manag.: Int. J. 15 (5) (2010) 354–362.
[31] O. Hosny, K. Nassar, Y. Esmail, Prequalification of Egyptian Construction Contractors Using fuzzy-AHP Models, Construction and Architectural Management, Engineering, 2013.
[32] P.R. Hinton, Statistics Explained, Routledge, 2014.
[33] E. Jazayeri, H. Liu, G.B. Dadi, Assessing and evaluating subcontractor management safety policies, Construct. Res. Congr. 2018 (2018) 251–261.
[34] I. Joseph, A. Mwasha, The effects of ISO certification on organization workmanship performance, Qual. Manag. J. 19 (1) (2012) 53–67.
[35] M.R. Kadir, W.P. Lee, M.S. Jaafar, S.M. Sapuan, A.A.A. Ali, Factors affecting construction labour productivity for Malaysian residential projects, Struct. Surv. 23 (2005) 42–54, 2005.
[37] S. Kermanshachi, E. Safapour, Identification and quantification of project complexity from perspective of primary stakeholders in US construction projects, J. Civ. Eng. Manag. 25 (4) (2019) 380–398.
[38] B.S.K. Kim, D.R. Atkinson, P.H. Yang, The Asian Values Scale: development, factor analysis, validation, and reliability, J. Counsel. Psychol. 46 (3) (1999) 342–352.
[39] S. Koçak, A. Kazaz, S. Ulubeyli, Subcontractor selection with additive ratio assessment method, J. Construct. Eng. Manag. Innov. 1 (1) (2018) 18–32.
[40] P.O. Kukoyi, I.C. Osuizugbo, H.S. Yohanna, U.E. Edike, I.E. Ohiseghame, Pre-qualification of selecting construction project contractors using health and safety criteria, J. Eng. Proj. Prod. Manag. 11 (1) (2020) 30–36.
[41] M.M. Kumaraswamy, J.D. Matthews, Improved subcontractor selection employing partnering principles, J. Manag. Eng. 16 (3) (2000) 47–57.
[42] A. Idrus, M. Sodangi, M.A. Amran, Decision criteria for selecting prime contractors in Malaysia, Res. J. Appl. Sci. Eng. Technol. 3 (12) (2011) 1358–1365.
[43] U.H. Issa, M. Alqurashi, A model for evaluating causes of wastes and lean implementation in construction projects, J. Civ. Eng. Manag. 26 (4) (2020) 331–342.
[44] N.X. Mashwama, I. Musonda, An Investigation on the Impact of Subcontracting System on the Eventual Quality of Construction Facilities in Swaziland-an Exploratory Study, 2014.
[45] L. Moretti, V.A.D.A. Mandrone, A. D'Andrea, S. Caro, Evaluation of the environmental and human health impact of road construction activities, J. Clean. Prod. 172 (2018) 1004–1013.
[46] F. Ismail, A. Hashim, R. Ismail, M. Majid, The operationalisation of safety culture for the Malaysian construction organisations, Int. J. Bus. Manag. 4 (2009) P226.
[47] M. Latham, Constructing the Team, HMSO, London, 1994.
[48] Y. Lew, S. Hassim, R. Muniandy, T.L. Hua, Structural equation modelling for subcontracting practice: Malaysia chapter, Eng. Construct. Architect. Manag. 25 (7) (2018) 835–860.
[49] H. Lingard, D. Oswald, T. Le, Embedding occupational health and safety in the procurement and management of infrastructure projects: institutional logics at play in the context of new public management, Construct. Manag. Econ. 37 (10) (2019) 567–583.
[50] W.H. Loh, G. Ofori, Effect of registration on performance of construction subcontractors in Singapore, Eng. Construct. Architect. Manag. 7 (1) (2000) 29–40.
[51] A. Lozano-Torro, T. Garcia-Segura, L. Montalban-Domingo, E. Pellicer, Competitive advantages and barriers in international construction: an origin-host market approach, J. Civ. Eng. Manag. 26 (5) (2020) 475–489.
[52] I. Richter, R.S. Mitchell, Handbook of Construction Law and Claims, Reston Publishing Company, 1982.
[53] P. Manu, N. Ankrah, D. Proverbs, S. Suresh, Mitigating the health and safety influence of subcontracting in construction: the approach of prime contractors, Int. J. Proj. Manag. 31 (7) (2013) 1017–1026.
[55] M.M. Marzouk, A.A. El Kherbawy, M. Khalifa, Factors influencing sub-contractors' selection in construction projects, HBRC J. 9 (2) (2013) 150–158.
[56] N.X. Mashwama, I. Musonda, An investigation on the impact of subcontracting system on the eventual quality of construction facilities in Swaziland-an exploratory study, in: F.A. Emuze, C.A. Aigbavboa (Eds.), Conference proceedings: TG59 "People in construction" Conference, 6-8 April 2014, Port Elizabeth, South Africa, 2014, pp. 191–200.
[57] J. Mbachu, Conceptual framework for the assessment of subcontractors' eligibility and performance in the construction industry, Construct. Manag. Econ. 26 (5) (2008) 471–484.
[58] J. Mbachu, Sources of contractor's payment risks and cash flow problems in the New Zealand construction industry: project team's perceptions of the risks and mitigation measures, Construct. Manag. Econ. 29 (10) (2011) 1027–1041.
[59] A.S.M. Misbah, V. Disaratna, P. Ganeshu, F.S. Nazeer, Analysis of Survival Factors of Subcontractors in Economic Recession, in: Y.G. Sandanayake, S. Gunatilake, A. Waidyasekara (Eds.), Proceedings of the 8th World Construction Symposium, Colombo, Sri Lanka, 8-10 November 2019, 2019, pp. 66–76, https://doi.org/10.31705/WCS.2019.7. Available at, https://2019.ciobwcs.com/papers.
[60] Zydrune Morkunaite, Valentinas Podvezko, Edmundas Kazimieras Zavadskas, Romualdas Bausys, Contractor selection for renovation of cultural heritage buildings by PROMETHEE method, Arch. Civ. Mech. Eng. 19 (2019) 1056–1071.
[61] S.T. Ng, Z. Tang, Labour-intensive construction sub-contractors: their critical success factors, Int. J. Proj. Manag. 28 (7) (2010) 732–740.
[62] C.Y. Ng, Problems Associated with Nominated Subcontractors in Malaysian Construction Industry, Universiti Teknologi Malaysia, 2006.
[63] R.A. Peterson, A meta-analysis of variance accounted for and factor loadings in exploratory factor analysis, Market. Lett. 11 (3) (2000) 261–275.
[64] R. Pettinger, Construction Marketing: Strategies for Success, Macmillan International Higher Education, 1998.
[65] A.K. Pituch, J. Stevens, Applied Multivariate Statistics for the Social Sciences: Analyses with SAS and IBM 's SPSS, sixth ed., Routledge, New York, 2016.
[68] O.J. Olaniran, The effects of cost-based contractor selection on construction project performance, J. Financ. Manag. Property Construct. 20 (3) (2015) 235–251.
[69] A.L. Olanrewaju, A. Idrus, A.L. Olanrewaju, A. Idrus, What is determining affordable housing shortages in the Greater Kuala Lumpur, Malaysia? Property Manag. 38 (1) (2020) 52–81. Emerald.
[70] OSHA (The U.S. Department of labor and the U.S Occupational safety and health Administration 2015), Sustain. Workplace: New Approach Adv. Worker Saf. Health. https://www.osha.gov/sites/default/files/OSHA_sustainability_paper.pdf. www.osha.gov/sustainability.
[71] M. Sambasivan, Y.W. Soon, Causes and effects of delays in Malaysian construction industry, Int. J. Proj. Manag. 25 (2007) 517–526.
[72] U. Sekaran, R. Bougie, Research Methods for Business: A Skill Building Approach, John Wiley & Sons, 2016.
[73] Z. Shehu, I.R. Endut, A. Akintoye, Factors contributing to project time and hence cost overrun in the Malaysian construction industry, J. Financ. Manag. Property Construct. 19 (1) (2014) 55–75.
[74] F. Sherratt, P. Farrell, R. Noble, UK construction site safety: discourses of enforcement and engagement, Construct. Manag. Econ. 31 (6) (2013) 623–635.
[75] A.B. Smith, Y. Oluboyede, R. West, J. Hewison, A.O. House, The factor structure of the GHQ-12: the interaction between item phrasing, variance and levels of distress, Qual. Life Res. 22 (1) (2013) 145–152.
[76] P. Sohoni, K.N. Jha, Evaluating the factors for shore selection in multi-storey building construction, Int. J. Constr. Manag. (2020) 1–10.
[77] M. Soltanifar, A Framework to Improve the Performance of Public Tender Evaluation Procedures in New Zealand (Doctoral Dissertation, Auckland University of Technology, 2020.
[78] N.U.I. Soomro, A.H. Memon, N.A. Memon, K.R. Memon, Contractor's selection criteria in construction works in Pakistan, Eng. Technol. Appl. Sci. Res. 10 (2) (2020) 5520–5523.
[79] A. Supardi, H. Adnan, F.M. Mohammad, Sub-Contractors' Readiness on the Malaysian Security of Payment Legislation in Construction Industry, International Conference on Construction and Project Management, Chengdu, China, 2010, pp. 248–252, 16 – 18 November 2010.
[80] G. Winch, The growth of self-employment in British construction, Construct. Manag. Econ. 16 (5) (1998) 531–542.

[81] A. Wolstenholme, S.A. Austin, M. Bairstow, A. Blumenthal, J. Lorimer, S. McGuckin, W. Guthrie, Never Waste a Good Crisis: a Review of Progress since Rethinking Construction and Thoughts for Our Future, 2009.
[82] C.H.J. Wu, The impact of customer-to-customer interaction and customer homogeneity on customer satisfaction in tourism service—the service encounter prospective, Tourism Manag. 28 (6) (2007) 1518–1528.
[83] B. Üsdiken, Z. Sözen, H. Enbiyaoglu, Strategies and boundaries: subcontracting in construction, Strat. Manag. J. 9 (1988) 633–637.
[84] S. Ulubeyli, A. Kazaz, Fuzzy multi-criteria decision-making model for subcontractor selection in international construction projects, Technol. Econ. Dev. Econ. 22 (2) (2016) 210–234.
[85] W.P. Utama, A.P. Chan, R. Gao, H. Zahoor, Making international expansion decision for construction enterprises with multiple criteria: a literature review approach, Int. J. Constr. Manag. 18 (3) (2018) 221–231.
[86] Y.C. Yong, N.E. Mustaffa, Critical success factors for Malaysian construction projects: an empirical assessment, Construct. Manag. Econ. 31 (9) (2013) 959–978.
[87] X. Zhang, S.R. Mohandes, Occupational Health and Safety in green building construction projects: a holistic Z-numbers-based risk management framework, J. Clean. Prod. 275 (2020), 122788.
[88] A. Olanrewaju, A. AbdulAziz, C.N. Preece, K. Shobowale, Evaluation of measures to prevent the spread of COVID-19 on the construction sites, Clean. Eng. Technol. 5 (2021), 100277, https://doi.org/10.1016/j.clet.2021.100277.