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Jasper Mbachu

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Conceptual framework for the assessment of subcontractors' eligibility and performance in the construction industry

JASPER MBACHU*

Massey University, New Zealand

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Subcontractors handle a major portion—about 85%—of all construction projects in the building industry. The ability of the main contractor and consultants to deliver the project within time, quality and cost targets depends largely on the performance of the subcontractors. Selection of subcontractors on the basis of overall ability to perform is therefore crucial to successful project delivery. The key criteria for assessing subcontractors' eligibility for tender invitation and award, and subsequent performance at the construction stage, were investigated. Using the descriptive survey method, 243 contractors and 307 subcontractors registered with the Gauteng Master Builders Association of South Africa were surveyed. The multi-attribute technique was used to analyse the data. Results showed that quality record is the most influential criterion for selecting high performing subcontractors at the pre-qualification stage, and for assessing their performance at the construction stage. Tender price exerts the most significant influence in the subcontract award. A framework was developed for use by main contractors and consultants in the assessment of the suitability and performance of subcontractors. Application of the framework to a case study demonstrated its merit as a tool for ensuring that only high performing subcontractors are selected for subcontract jobs.

Keywords: Performance evaluation, pre-qualification, selection, subcontracting, tendering.

Introduction

Hoban and Francis (2003) see the subcontractor as a specialist hired by the main contractor to perform specific tasks on a project as part of the overall contract. Hinze and Tracy (1994), and Hoban and Francis (2003) identify three main categories of subcontractors in the construction industry: trade contractors—those that specialize on specific trades such as painting and brickwork; specialist subcontractors—those that undertake specialist services, especially building or engineering services such as electrical, plumbing and HVA; and the labour-only subcontractors—i.e. skilled tradesmen that provide labour-only services, while the main contractor provides the materials and attendance. From a contractual point of view, subcontractors could be categorized as domestic—those that the contractor has the free will to hire to perform specific tasks; and the nominated subcontractor who, as the name implies, is nominated by the client or client agent to undertake specified aspects of the main contract. All subcontractors are required to enter into contractual relation with, or be employed by, the main contractor.

Subcontracting constitutes a major portion of all construction projects in the building industry. For instance, Hinze and Tracy (1994) observe that about 80–90% of Australian building projects are subcontracted out. The ability of the main contractor and consultants to deliver the project within time, quality and cost targets depends largely on the performance of the subcontractors. Reasons for subcontracting include: expected high quality of works, since subcontractors are seen as 'specialists' in their own fields; the main contractor's margin and costs are known from the commencement of the contract through the subcontractors' quotations; the main contractor passes on the risks and responsibilities of redeployment, hiring and firing of subcontracting workers on to the subcontractors; cash flow problems and the challenge of financing

*E-mail: j.i.mbachu@massey.ac.nz

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the project are all eased by the use of subcontractors. The main contractor's overheads commitment in the form of supervision, office staff, accommodation, etc., can be reduced significantly, when working with reliable subcontractors; should for one reason or another performance failure occur, the cost distribution can in many cases minimize the risk element to the main contractor.

Risks of subcontracting

In spite of its benefits, subcontracting presents some inherent risks. For instance, Karim *et al.* (2006) and Thomas *et al.* (2002) report that quality remains a critical issue in subcontracting, with the cost of quality rectification problems being as high as 12% of the total project cost.

In the traditional procurement arrangement option, the contractor enters into contractual arrangements with the subcontractors, and is responsible for coordinating and controlling their works to ensure that the project is delivered to time, cost and quality targets. Cooke and Williams (1998) argue that more risk is placed upon the main contractor in managing subcontractors, especially where the value of the subcontractors' works is significant in relation to the main contractor's work. Thus, where a large portion of the work is subcontracted out, the contractor may not be in control of the quality of work and progress except by efficient management. In this context, the main contractor's performance and reputation may depend on the performance of the subcontractors. Cooke and Williams (1998) opine that by subcontracting a large portion of work to subcontractors, the main contractor virtually becomes a 'construction manager'. If the contractor does not have sufficient construction management skills, the control and coordination of the subcontractors and their works become problematic, and could result in unsatisfactory project outcomes. Al-Sobiei *et al.* (2005) link the risk of contractor default in Saudi Arabia to the capability of the contractor to execute the work, which ultimately depends on the performance of the subcontractors used. Selection of high performing subcontractors through a methodical approach could therefore be a way of reducing subcontracting risks.

It should be noted that the use of a performance bond as a subcontract risk mitigating measure is a ruse. This is because bond companies are notoriously reluctant to meet commitments in the event of failure of bonded subcontractor to perform. Bond companies tend to link the bonded subcontractor's performance failure to the actions or inactions of the main contractor's team. The bond security should be useful only in the context that the surety's willingness or readiness to provide bond cover to a particular subcontractor could be an indication of the low risk profile of the subcontractor, in so far as the bond premium is pitched at the normal level.

Subcontractor selection process

Subcontractor selection is largely on the basis of lowest tender (CSIR, 2002b). This is because the traditional procurement system, which is used in most cases, is based on contract works that are, in theory, fully specified, thus making lowest price the only award criterion (Cauwelaert, 1999). In a few other cases, subcontracts were awarded on the basis of economically most advantageous tender, given that a selection based on lowest tender could cause immense additional costs in the long run due to inherent characteristics such as deficient quality of work and the attendant cost of rework, additional cost of supervision, preponderance of claims, disputes and adversarial relations, and in worst cases, abandonment of work or bankruptcy.

Several approaches exist for subcontract tender evaluation on the basis of tender price. Most of these approaches involve the computation of arithmetic means that measure the deviation of a particular tender from an average of all tender prices submitted, with additional consideration given to the constituent elements of the tender price, and how the items or elemental rates compare with the estimates of the owner's consultants.

However, by neglecting the key criteria underpinning performance, main contractors could, and in fact do, select subcontractors who lacked the necessary competencies and dispositions to perform. Perhaps this explains the prevailing inability to meet key project objectives, which has resulted in high rates of client dissatisfaction not only in the South African context but also in the global construction industry (Bowen *et al.*, 1997; Liu and Walker, 1998; Green and Lenard, 1999; Mbachu and Nkado, 2006).

Optimal selection of subcontractors on the basis of overall ability to perform, rather than on tender price alone, is crucial to successful project delivery. Having a well-defined and holistic framework for selection provides a clear baseline for benchmarking performance and ensures that the right sets of subcontractors are selected to do the job.

Subcontractor selection criteria for public and private jobs in South Africa

Most construction professionals believe that the South African construction industry suffers from unfair

tendering practices (Bowen *et al.*, 2007). However, laid-down tendering procedures are followed in both the public and private sectors.

In the public sector, selection of subcontractors for public works not exceeding R2 million follows a 'targeted procurement' policy (Watermeyer, 2000), which largely excludes competition based on price and competency. The strategic procurement system in place is underpinned by the Preferential Procurement Policy Framework Act (Act 5 of 2000) (DPW, 2004a). The Act ensures that preference is given to the selection of subcontractors who fall under historically disadvantaged individuals (HDI), women, disabled persons, and small, medium and micro-enterprises (SMMEs). This is aimed at redressing the injustices of the apartheid regime. Operationally, public works subcontractor selection is based primarily on total points scored from equity ownership and price. Other points of lesser significance which are used, perhaps where ties exist in the selection process include the length of time the company has been in existence, nature of the principal business activities, and the number of permanent staff employed by the tenderer.

In the private sector, subcontractor selection is open to general competitive processes, but must meet the provisions of the Equality and Prevention of Unfair Discrimination Act, No.4 of 2000, the Employment Equity Act, No.55 of 1998, and the Gender Equality Act, No.39 of 1996. This means that the ideals of the public works tendering processes should be followed in all cases. Ideally, within the bounds of the regulations, main contractors usually keep a list of subcontractors they have worked with in the past. The criteria for retention in the list often include proven competence, integrity, reliability, good relationship and trust. This practice concurs with the recommendations of Cooke and Williams (1998) that main contractors should review their lists of subcontractors periodically so as to exclude those whose performance has been unsatisfactory and to allow the introduction of new subcontractors.

The regulatory framework for subcontractor selection in South Africa is justified for socio-political imperatives, including the prevention of unfair discrimination, employment equity and gender equality. However, selection based on merit should also be considered, as this provides the platform for development of competitive skills and growth of the subcontractors who belong to the disadvantaged groups and who are targeted to be protected. In addition, it could improve the viability and global competitiveness of the South African construction industry. This is because, if selection is based on socio-political reasons alone, there will be little incentive for the SMMEs to learn, develop, innovate and grow.

There is therefore a need for a holistic framework for the assessment of subcontractors' eligibility for tender invitation and award, and for their subsequent performance at the construction stage in the South African construction industry.

It should be noted that, whether in the public or private sector, the key aim of subcontractor selection should be to ensure that only those subcontractors who have what it takes to contribute to the efficient and effective delivery of the project objectives are selected. This requires well-defined selection criteria. Where the main contractor has the freedom to use whatever approach he or she deems fit, several criteria have been established to guide the selection of subcontractors. For instance, Cooke and Williams (1998) list criteria for subcontractor selection: previous experience with the subcontractor; subcontractor's ability to manage resources and liaise with the main contractor's staff (including good relationship management); financial capacity; expertise; reputation; current commitment/workload; acceptability of the subcontractor to the building owner; competitiveness of the subcontractor's tender price and item rates; contractual risks taken by the main contractor on the subcontract trade; quality of work; and trade and bank references.

Okoroh and Torrance (1999) identify further criteria for subcontractor selection in the refurbishment projects: financial strength; previous experience; ability to submit a bona fide bid; labour resources; management capability; current and anticipated workload; quality of workmanship; transportation/project location; safety records/working practices; reliability and trustworthiness. Maturana *et al.* (2007) recommend performance in relation to lean principles and partnering practices as the basis for onsite subcontractor evaluation and selection.

Further subcontractor selection criteria could draw from Gruneberg *et al.*'s (2007) performance-based contracting, whereby the extent to which the completed section or entire building or structure performs in the operation phase could count significantly to subcontractor's quality records, and therefore play a critical role at the pre-qualification or pre-contract selection stages. However, linking in-use performance of the completed structure to the quality of work of a subcontractor may require time-consuming and costly forensic investigations, the results of which could be contentious.

Several other criteria exist in the literature for subcontractor selection. However, it is not helpful to merely identify and list these criteria without any form of qualification as to their relative levels of influence in the selection process. The aim of this study is to contribute to filling this gap. In doing this, the key questions posed were: (1) What are the priority criteria

for selecting high performing subcontractors at the pre-contract stages, and for evaluating their performance at the construction stage? (2) Can a framework be developed, using the identified criteria, for the assessment of the eligibility and performance of subcontractors in the construction industry?

Research objectives

The objectives of the study were: (1) To identify and prioritize the criteria for assessing the eligibility of subcontractors for tender invitation at the pre-qualification stage, and for the award of subcontracts at the pre-contract stage; and subsequently for measuring their performance at construction stage. (2) To develop a framework for the assessment of the suitability and performance of subcontractors in the construction industry.

Scope and limitations

Given that subcontractor selection in the public sector is primarily underpinned by socio-cultural and political agenda, the scope of this study is limited to the private sector, which operates largely on the dynamics of market and economic forces and within the bounds of the prevailing regulatory framework. Also the scope is more applicable to the domestic subcontractors over whom the main contractor has more powers to choose or not to choose, and less applicable to the specialist subcontractors nominated by the employer or employer's agents.

Method

The descriptive survey method was used to survey 243 contractors and 307 subcontractors registered with the Gauteng Master Builders Association (GMBA) of South Africa. The data gathering involved two stages: qualitative and quantitative data gathering stages. At the qualitative data gathering stage, a convenience sample of five main contractors and five subcontractors were interviewed with a view to generating the constructs for the design of the questionnaire. During this stage, the interviewees were asked to suggest key criteria for subcontractor assessment during each of the three stages: pre-qualification for tender invitation at the screening stage, tender award at the pre-contract stage, and performance at construction stage. The recurring constructs generated at the interview stage were incorporated into semi-structured questionnaires, which were pre-tested by a convenience sample of three contractors and three subcontractors that did not participate at the interviews. The questionnaires were improved for clarity and appeal using the inputs from the pre-tests and were subsequently administered by fax to the rest of the respondents in the sampling frames that did not participate in the interview and pre-test sessions.

At the questionnaire survey stage, respondents were asked to rate the levels of importance or influence of the identified criteria in the assessment and distinguishing of the subcontractors to meet the objectives at each of the three stages. A five-point Likert rating scale was provided for rating the attributes or criteria in the subset for each stage (1 being, 'not influential' or 'not important'; 5 being 'very influential' or 'very important').

Methods of data analyses

Multi-attribute analysis was used in the analysis of the quantitative data. This drew from the multi-attribute utility approaches of Chang and Ive (2002), and was deemed appropriate by Mbachu and Nkado (2006) and Mbachu and Nkado (2007) for the nature of the research data and questions. The analysis involved the computation of the following parameters:

Mean rating (MR)

This was computed as the sum of the product of each rating point (P) and the corresponding percentage response to it ($R_{\%}$), out of the total number of responses (TR) involved in the rating of the particular variable, i.e.:

$$\mathrm{MR} = \sum_{i=1}^{5} (P_i \times R_i\%) \tag{1}$$

where: P_i=rating point i ($1 \leq i \leq 5$); $R_i\%$=percentage response to rating point i. The mean rating analysis focused on evaluating respondents' collective rating of a variable on the rating scale used.

Relativity index (RI)

This was used to compare the MR (i.e. mean rating) values obtained in Equation 1 for the variables in a given subset. It was computed as a unit of the sum of MRs in a subset of variables:

$$RI_i = \frac{MR_i}{\sum_{i=1}^{N} MR_i} \tag{2}$$

The relativity index could stand for the relative influence index or the relative importance index (RII)

of a given attribute in a subset. The RII was used to rank-order the attributes in a given subset, with the attribute having the highest RII value being the most influential or the most important in the subset.

Framework for assessing subcontractor's eligibility and performance

The second objective of this study was to develop a framework for the assessment of the qualification and performance of subcontractors in the construction industry. The study assumed two stages in the assessment of the subcontractor's eligibility for tender invitation and subcontract award, i.e. pre-qualification and pre-contract stages. This drew from the recommendations contained in the Chartered Institute of Building Code of Estimating Practice (CIOB, 1983).

Framework for the assessment of the subcontractor's eligibility at the pre-qualification and pre-contract stages was developed from the analysed list of the influential criteria at each stage. The key components of the assessment model are:

(1) RI_i (the relativity index): This indicates the relative influence or relative weight of the i^{th} criterion in the subset (see Equation 2).

(2) APR_i (average performance rating): Average of the Tender Evaluation Committee members' ratings for a subcontractor's performance in meeting the i^{th} criterion in the subset (i.e. for the five-point Likert rating scale used, $1 \leq APR_i \leq 5$).

(3) PS_i (performance score) achieved by a subcontractor in meeting the i^{th} criterion. PS_i was computed as follows:

$$PSi = RIi \times APR \tag{3}$$

(4) PER (pre-qualification eligibility rating): This is the performance score achieved by a subcontractor. PER was computed as follows:

$$PER = \sum_{i=1}^{N} PSi \tag{4}$$

(For the five-point rating scale used, $1 \leq PER \leq 5$)

The PER value computed for each subcontractor at the pre-qualification stage can be used to determine the level of a subcontractor's qualification and ranking among the subcontractors to be selected; it therefore provides the basis for shortlisting subcontractors to be invited to tender. For this purpose, the PER value could be fitted into any one of the five bands of the transformed Likert continuum:

PER	Subcontractor's level of qualification
<1.51	Not qualified
1.51–2.49	Somewhat qualified
2.50–3.49	Averagely qualified
3.50–4.49	Highly qualified
>4.49	Very highly qualified

Having passed the pre-qualification/screening stage, subcontractors invited to tender and who submit bona fide bids could be assessed at this stage with a view to selecting those who qualify to be awarded the subcontract. The frameworks for pre-contract selection of subcontractors and for measuring the performance of the subcontractors follow the same process for pre-qualification above. The generic models for these assessments are formulated as follows:

(1) Pre-qualification/screening stage: The generic model for this stage is as follows:

$$\sum_{i=1}^{N} RI_i \times APR_i = \sum_{i=1}^{N} PS_i = PER \tag{5}$$
$$(1 \leq PER \leq 5)$$

Implications of the PER value are as follows:

- A subcontractor meets the minimum pre-qualification requirements if his or her PER score is equal to or greater than 2.5, which is the threshold of the 'averagely qualified' rating band in the pre-qualification rating continuum.
- In the list of qualified subcontractors, the most qualified is the one with the highest PER score.
- The required number of subcontractors to be shortlisted and subsequently invited to submit tender could be selected on the basis of their PER value rankings.

(2) Selection for subcontract tender award: The generic model for this purpose is similar to the pre-qualification/screening model of Equation 5, but modified as follows:

$$\sum_{i=1}^{N} RI_i \times APR_i = \sum_{i=1}^{N} PS_i = QRSA \tag{6}$$
$$(1 \leq QRSA \leq 5)$$

where QRSA= qualification rating for subcontract award.Implications of the QRSA value are as follows:

- A subcontractor meets the minimum requirements for the award of the subcontract if his or her QRSA score is equal to or greater than 2.5, which is the threshold of the 'averagely

qualified' band in the eligibility rating continuum for the subcontract award.
- In the list of eligible subcontractors, the most qualified is the one with the highest QRSA score.
- The required number of subcontractors to be awarded the subcontract could be selected on the basis of their QRSA value rankings.

(3) Construction stage performance assessment: The generic model for this purpose is similar to the pre-qualification/screening model of Equation 5, but modified as follows:

$$\sum_{i=1}^{N} RI_i \times APR_i = \sum_{i=1}^{N} PS_i = PR \quad (7)$$
$$(1 \leq PR \leq 5)$$

where PR= performance rating achieved by the subcontractor at the construction stage. Implications of the PR value are as follows:

- A subcontractor meets the minimum performance expectations if his or her PR score is equal to or greater than 2.5—the threshold for the 'average performance' rating in the five-band Likert rating continuum.
- In the list of subcontractors that meet the threshold performance expectations, the best performing is the one with the highest PR score.
- Retention or future selection of subcontractors could be on the basis of their PR scores in the current job.

Process flowchart for subcontractor qualification and performance assessment

The above frameworks for the assessment of the subcontractors' eligibility for tender invitation and award, and subsequent performance at the construction stage are incorporated into a process flowchart in Figure 1. The chart could be used as a tool for subcontractor selection and management in the construction industry.

Case study

The developed theoretical framework for the assessment of a subcontractor's eligibility and performance was applied in a case study scenario to demonstrate its practical application. The setting was a medium sized construction company in the Gauteng Province which had three commercial/office projects at different stages of development. The selected subcontract trade was waterproofing. No reason was behind the selection other than convenience. Six waterproofing firms were screened at the pre-qualification stage with a view to selecting those who would meet the pre-qualification criteria, and who would subsequently be invited to tender. The company's subcontract Tender Evaluation Committee (TEC) based their criteria for each stage on the generic list of influential criteria established in the study, with possible modifications to suit the peculiar needs of the projects.

Results

Survey responses

Out of the 550 questionnaires administered, only 75 were returned by the cut-off date set for the receipt of responses. Forty responses were found usable. This implied a very low 7.3% effective response rate. This poor response implied that the views of the majority of the respondents were not represented and could limit the extent to which the findings could be generalized across the population of subcontractors and main contractors. However, the random sampling of respondents from the target sampling frames ensured that all respondents had equal opportunity of being sampled; this approach has the potential for eliminating or minimizing bias inherent in a limited number of samples (Leedy and Ormrod, 2004).

Analyses of the respondents' demographic profiles showed that 60% were subcontractors, while 40% were main contractors. The subcontractors comprised specialist (60%), trade (35%) and labour-only subcontractors (5%). The majority (55%) of the subcontractors indicated having worked in more than one subcontractor category. For the main contractors, 20% operated as multinational, 50% as national/provincial and 30% as city-wide contractors. The views expressed were therefore predominantly those of specialist subcontractors; the findings should be interpreted in this context.

Overall, the survey responses were from key individuals in their respective firms who had long experience of the construction industry (average of 15 years). The high profiles of the respondents meant that quality inputs were received, which could enhance the reliability and validity of the conclusions drawn from the findings.

Criteria for assessing subcontractors' eligibility and performance

The first objective of the study was to identify and prioritize the criteria for the assessment of the eligibility

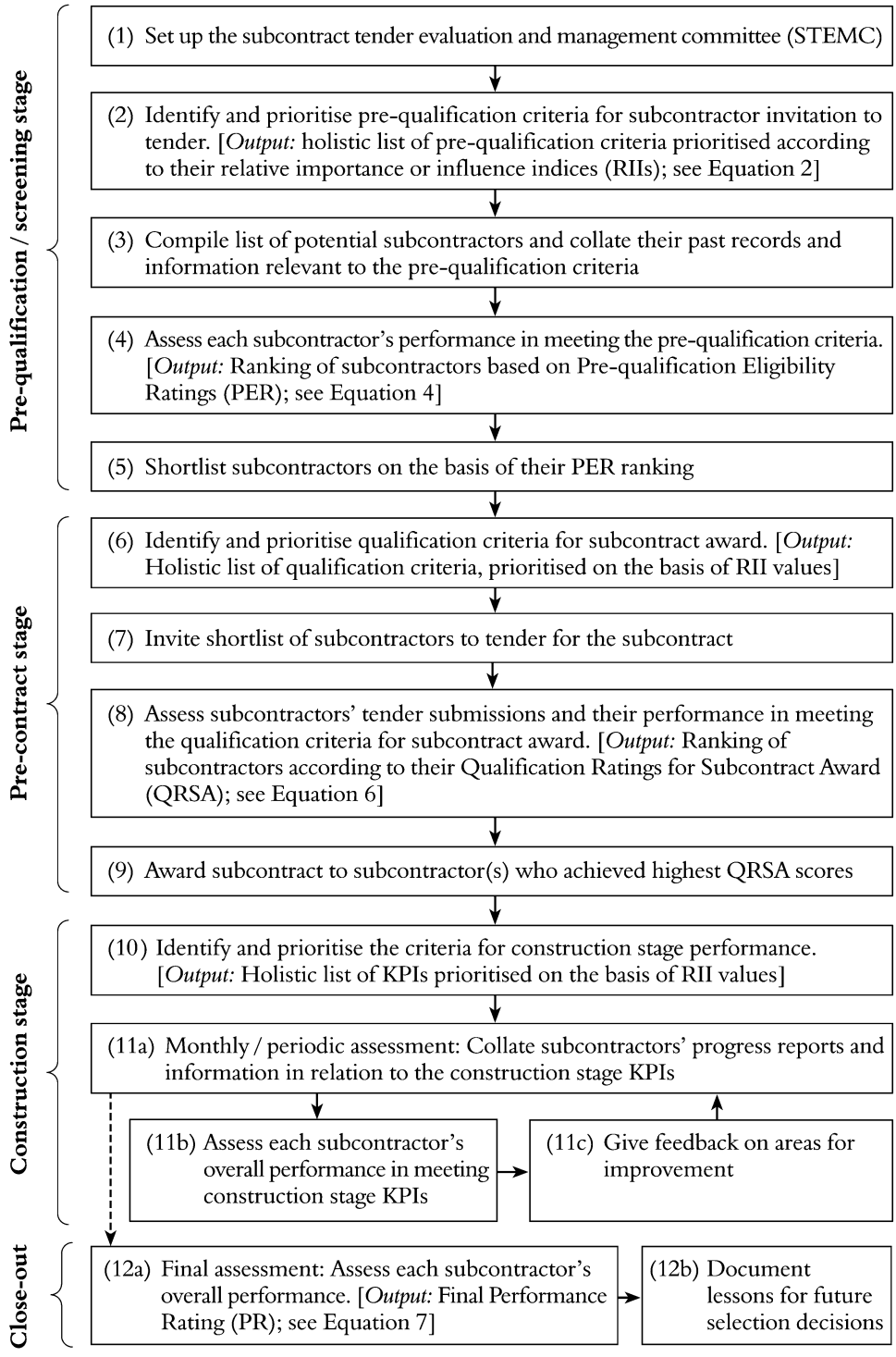

Figure 1 Process flowchart for subcontract selection and management in the construction industry

of subcontractors for tender invitation and award, and for measuring their performance at construction stage. As mentioned in the Method section, the criteria were identified as constructs during the qualitative data gathering stage via unstructured interviews. At the questionnaire survey stage, respondents were asked to rate the levels of importance or influence of the identified criteria in the assessment and distinguishing of the subcontractors to meet the objectives at each of the three stages. The analysis and findings in relation to

the key criteria for each stage assessment are presented and discussed in the following sections.

Criteria for subcontractor pre-qualification for tender invitation

The criteria for ensuring that only high performing subcontractors are shortlisted for invitation to tender are analysed and presented in Table 1. The mean ratings (MRs) and the relative influence indices (RII) (see Equations 1 and 2) were used to analyse the relative levels of influence of the identified criteria in the pre-qualification selection, with a view to segregating the influential and non-influential criteria. The most influential in this set is quality of work, which includes ability to comply with design specifications and to minimize rework. Perhaps the reported problem of poor quality of workmanship among the contractors in the South African construction industry could be responsible for the high emphasis on quality. For instance, the Council for Scientific and Industrial Research (CSIR, 2002b) reports that the trend of clients accepting lowest cost tenders is encouraging a situation where quality assurance procedures and site supervision are inadequate, resulting in a further overall decline in quality.

Criteria for subcontractor qualification for tender award

Having met the pre-qualification criteria, a subcontractor should be shortlisted and eligible for invitation to tender. The influential criteria for assessing the suitability of the subcontractor for the award of the subcontract are analysed and presented in Table 2. The analyses were similar to the analysis for pre-qualification for tender invitation as described before. Results showed that the level of the competitiveness of the subcontractor is the deciding subset of factors for selection and award of the subcontract. This

Table 1 Subcontractors' pre-qualification criteria

		Contractors' general requirements from subcontractors	Level of influence in the selection process					TR	MR	RI
			VI	I	SI	LI	NI			
			5	4	3	2	1			
			%	%	%	%	%			
Influential criteria: MR > 2.5	1	Quality of work; ability to comply with specifications; minimal rework	71	19	10	0	0	39	4.6	0.16
	2	Productivity records, leadership qualities and ability to manage own workforce	35	55	10	0	0	40	4.3	0.15
	3	Technical and managerial competence and experience in the job at hand; size/annual turnover; strength of workforce	40	45	5	5	5	40	4.1	0.15
	4	Reputation and attitude; past records of working relationship with current contractor and/or reference from previous employers and financiers	18	25	45	8	5	40	3.4	0.12
	5	Health and safety records	21	26	26	16	11	38	3.3	0.12
	6	Financial capacity; ability to provide own attendance needs; possession of special tools and equipment that could reduce main contractor's P&G costs	13	20	38	25	5	40	3.1	0.11
	7	Current workload and commitment, and ability to mobilize on site when needed	15	18	18	33	18	40	2.8	0.1
	8	Location of the subcontractor and knowledge of the project environment: local labour laws, site conditions, material supplies, etc.	5	16	22	49	8	37	2.6	0.09
Not influential								Σ	28.2	1.0
	9	Competitiveness: networking ability/level of connections in the industry	5	13	25	35	23	40	2.4	0.07
	10	Compliance with statutory regulations: Black Economic Empowerment, Gender Equality, Workman's Compensation Act, tax regulations, etc.	0	18	23	21	39	39	2.2	0.06
	11	Experience with the present contract form, terms and conditions	5	8	11	45	32	38	2.1	0.06

Notes: Levels of influence: VI= very influential; I= influential; SI= somewhat influential; LI= less influential; NI= not influential. TR= total responses; MR= mean rating (see Equation 1); RI= relativity index (see Equation 2).

Table 2 Subcontractors' pre-contract qualification criteria

		Contractors' general requirements from subcontractors	Level of influence in the selection process					TR	MR	RI
			VI	I	SI	LI	NI			
			5	4	3	2	1			
			%	%	%	%	%			
Influential criteria: MR $\geq$ 2.5	1	Competitiveness of the tender price and the constituent elements; ability to submit bona fide tenders with minimal tagged items; reasonable discounts	55	25	10	5	5	40	4.2	0.17
	2	Evidence of adequate resources/capacity (financial records, possession of necessary equipment, skilled workforce and managerial competency)	40	45	10	5	0	40	4.2	0.17
	3	Reference from previous employers and financiers	35	49	10	0	5	40	4.1	0.16
	4	Provision of necessary bonds or specific insurance requirements	30	30	30	10	0	40	3.8	0.15
	5	Efficient programming of subcontract work and proper fit with main contractor's master programme for efficient coordination purpose; proper risk analysis and method statements	15	25	35	15	10	40	3.2	0.13
	6	Well-articulated health and safety plan	16	11	47	16	11	38	3.1	0.12
	7	Readiness to mobilize on site	5	11	57	21	6	37	2.9	0.11
								Σ	25.4	1.00

Notes: Levels of influence: VI= very influential; I= influential; SI= somewhat influential; LI= less influential; NI= not influential. TR= total responses; MR= mean rating (see Equation 1); RI= relativity index (see Equation 2).

includes the competitiveness of the subcontractor's tender price and item rates, and ability to submit bona fide tenders with minimal tagged items. The finding aligns with the general tendency to award main contracts and subcontracts on the basis of lowest tender (CSIR, 2002b).

However, in the context in which respondents rated the variables, the competitive rates and bid do not necessarily imply lowest tender, but quotations which are adjudged reasonable and competitive as an outcome of a typical checking procedure when comparing subcontractors' quotations, including consideration of the following (Cooke and Williams, 1998, p. 240):

> Does the work described in the quotation comply with the specification? Have all the items been priced, and if not, are they included in other rates? Are unit rates consistent throughout the quotation? Has it been ascertained that the quotation does not form a counter-offer, and that the subcontractor has accepted the terms and conditions of enquiry.

Criteria for assessing subcontractors' construction stage performance

Table 3 presents the important criteria for assessing the performance of a subcontractor during the construction stage. Analysis of the respondents' ratings as described before shows that consistency of the quality of the subcontract work with the quality level required of the main contract work was perceived to be the most important criterion for assessing the subcontractor's performance at this stage. Contextually, quality of work includes compliance with the specifications for materials and methods, and zero or minimal defects or rework. The next criterion in importance is the rate of productivity of the subcontractor. This should be expected since the rate of productivity will naturally ensure on-time delivery if the quality of work is right. Furthermore, the finding shows that quality was consistently perceived as the most influential criterion underlying subcontractor selection and performance. Perhaps this underscores the need for the construction excellence model (SACEM) and quality assessment system (CONQUAS) developed by the Council for Scientific and Industrial Research (CSIR, 2002a) to improve the quality performance of contractors in the South African construction industry.

Framework for assessing subcontractor's eligibility and performance

The component models for the assessment of the subcontractors' eligibility for tender invitation and

award at the pre-qualification and pre-contract stages, and for subsequent measurement of their performance at the construction stage were developed in the Method section. Respectively, these comprise the pre-qualification/eligibility rating (PER) (i.e. Equation 5), the qualification rating for subcontract award (QRSA) (Equation 6), and the construction stage performance rating (PR) (Equation 7). A flowchart (Figure 1), which incorporates the stage-assessment models was developed as a tool for subcontract selection and performance management.

Practical application of the framework for assessing subcontractor's eligibility and performance

Real life application of the conceptual framework was undertaken in a case study scenario as described in the Method section. During the case study, a mini 'Tender Evaluation Committee' (TEC) comprising five members was set up to oversee the subcontract tender management. During one of its meetings, the committee had a brainstorming session to articulate and prioritize the influential criteria for the assessment of the eligibility of subcontractors for tender invitation and tender award, and their subsequent performance at the construction stage. The committee considered the lists of criteria established in this study for each stage as presented in Tables 1, 2 and 3. The committee had the option to modify the list as it deemed fit to meet the key needs of the building owner and the peculiarities of the project. Tables 4 to 6 show the criteria adopted for each of the three stages. These were slight modifications of the criteria identified in the study as presented in Tables 1 to 3. However, the methodology established in this study was followed in establishing the relative influence or relative importance indices (RI) of each adopted criterion.

Pre-qualification/screening stage

At the pre-qualification stage, six subcontractors who were specialists in waterproofing were screened with a view to selecting five that should be invited to submit tenders for the job. The screening process involved the TEC members rating the performance of each subcontractor on a five-point Likert scale, based on the collated information about each subcontractor that was considered relevant to the pre-qualification/screening stage assessment criteria for the job. The ratings by the five members of the TEC for each subcontractor's

Table 3 Subcontractors' construction stage performance criteria

		Contractors' requirements from subcontractors	Level of importance					TR	MR	RI
			VI	I	SI	LI	NI			
			5	4	3	2	1			
			%	%	%	%	%			
Important criteria: MR $\geq$ 2.5	1	Quality of work consistent with the quality level required of the main job; compliance with materials and method specifications; zero or minimal defects or rework	70	25	5	0	0	40	4.7	0.12
	2	High rate of productivity ensuring on-time delivery; efficient management and control of workforce	46	49	0	5	0	39	4.4	0.11
	3	Cost control and waste minimization	45	44	6	6	0	36	4.3	0.11
	4	Good working relations with main contractor's team; good tolerance, loyalty and zero or minimal adversarial relation	45	40	10	5	0	40	4.3	0.11
	5	Scope management: ability to manage changes without unnecessary claims	31	61	5	3	0	39	4.2	0.11
	6	Ability to manage the financial and contractual risks inherent in the subcontract	40	35	15	10	0	40	4.1	0.10
	7	Fair and minimal claims	30	50	10	10	0	40	4.0	0.10
	8	Onsite health and safety practice	31	35	16	10	8	38	3.7	0.09
	9	Compliance with contract terms and conditions, labour acts, building regulations, etc.	5	36	26	21	13	39	3.0	0.08
	10	Good communication network	10	20	45	5	20	40	3.0	0.07
								Σ	39.5	1.00

Notes: Levels of importance: VI= very important; I= important; SI= somewhat important; LI= of little importance; NI= not important. TR= total responses; MR= mean rating (see Equation 1); RI= relativity index (see Equation 2).

Table 4 Assessment of subcontractors' pre-qualification eligibility for tender invitation (subcontract: waterproofing)

Contractors' general requirements from subcontractors	Subcontractors' performance ratings and scores												
	RI_i	A		B		C		D		E		F	
		APR	PS	APR	PS	APR	PS	APR	PS	APR	PS	APR	PS
1 Track record of on-time completions	0.16	3	0.48	4	0.64	1	0.16	4	0.64	4	0.64	2	0.32
2 Reputation and attitude; past records of working relationship with current contractor and/or reference from previous employers and financiers	0.15	3	0.45	4	0.6	3	0.45	4	0.6	4	0.6	2	0.3
3 Performance/quality of work	0.15	2	0.3	4	0.6	4	0.6	4	0.6	4	0.6	1	0.15
4 Productivity records, leadership qualities and ability to manage own workforce	0.12	4	0.48	3	0.36	3	0.36	3	0.36	2	0.24	3	0.36
5 Health and safety records: compliance with safety standards	0.12	4	0.48	3	0.36	4	0.48	3	0.36	3	0.36	2	0.24
6 Financial capacity, ability to provide own attendance needs; possession of special tools and equipment that could reduce main contractor's P&G costs	0.11	2	0.22	2	0.22	2	0.22	4	0.44	2	0.22	2	0.22
7 Current workload and commitment, and ability to mobilize on site when needed	0.1	3	0.3	4	0.4	4	0.4	4	0.4	4	0.4	2	0.2
8 Location of the subcontractor and knowledge of the project environment: local labour laws, site conditions, material supplies, etc.	0.09	2	0.18	4	0.36	4	0.36	4	0.36	4	0.36	1	0.09
	1	Σ	2.89		3.54		3.03		3.76		3.42		1.88
Pre-qualification eligibility rating (PER):			2.89		3.54		3.03		3.76		3.42		1.88
Remarks:			AQ		HQ		AQ		HQ		AQ		SQ
Rank (1= most qualified)			5		2		4		1		3		6
Selected five:			✓		✓		✓		✓		✓		

Notes: RI_i= relativity index of criterion i (i.e. relative weight or importance of the i^{th} requirement; see Equation 2); APR= average of the performance ratings by the Tender Evaluation Committee members, ranging from 1 (i.e. very low) to 5 (i.e. very high); PS= performance score (i.e. RI × APR). Pre-qualification eligibility rating (PER) continuum: <1.51= NQ (not qualified); 1.51–2.49= SQ (somewhat qualified); 2.5–3.49= AQ (averagely qualified); 3.5–4.49= HQ (highly qualified); > 4.5= VQ (very highly qualified).

performance in meeting each of the pre-qualification assessment criteria were averaged to obtain the 'average performance rating' (APR) for each criterion/attribute (see Table 4). The performance score (PS) for each subcontractor in meeting each criterion was computed as the product of the APR and the relative influence index (RI) as given in Equation 3. Next, all the PSs for each subcontractor were summed up to obtain the pre-qualification eligibility rating (PER) as given in Equation 4. Finally, the PER values were ranked (1 being the most qualified); five were shortlisted on the basis of their PER ranks. Table 4 showed that the five best subcontractors selected in the order of their PER ranks were D, B, E, C and A. The sixth subcontractor (i.e. number F) was consequently screened out.

Pre-contract/tender award stage

After the close of tender, the five subcontractors who were invited and subsequently submitted their tenders were assessed for their eligibility for the award of the tender. The assessment process was similar to that of the pre-qualification/screening stage described above, but this time, the TEC members based their ratings of the performance of each subcontractor in meeting the criteria for contract award on the submitted tender and other bits of information about the subcontractors that were relevant to the assessment criteria. Table 5 shows the results of this assessment. At this stage, the summation of the PS values for each subcontractor yielded the qualification rating for subcontract award (QRSA), as given in Equation 6. In the table, the three subcontractors recommended for the subcontract awards were those with the highest QRSA values, namely, B, E and D.

However, the company's TEC went ahead to award the subcontract on the basis of the tender price and item rates (i.e. based only on competitiveness of the tender price—the first criterion in the subset). The subcontractors selected on this basis were B, C and A. Subcontractor B featured in both selection approaches.

Table 5 Assessment of subcontractors' eligibility for subcontract award (subcontract: waterproofing)

	Contractors' general requirements from subcontractors	RI_i	Subcontractors' performance ratings and scores									
			A		B		C		D		E	
			APR	PS	APR	PS	APR	PS	APR	PS	APR	PS
1	Competitiveness of the tender price and the constituent elements; ability to submit bona fide tenders with minimal tagged items; reasonable discounts	0.17	3	0.51	3	0.51	3	0.51	2	0.34	1	0.17
2	Surety bonds covering tender, performance and payment (i.e. providing construction performance and financial security in the event of performance or payment default)	0.17	2	0.34	4	0.68	3	0.51	2	0.34	4	0.68
3	Evidence of adequate resources/capacity (financial records, possession of necessary equipment, skilled workforce and managerial competency)	0.16	2	0.32	4	0.64	2	0.32	4	0.64	4	0.64
4	Teamwork/synergetic relationship	0.15	2	0.3	3	0.45	2	0.3	2	0.3	3	0.45
5	Reference from previous employers and financiers	0.13	2	0.26	5	0.65	2	0.26	4	0.52	3	0.39
6	Efficient programming of subcontract work and proper fit with main contractor's master programme for efficient coordination purpose; proper risk analysis and method statements	0.12	2	0.24	4	0.48	3	0.36	3	0.36	4	0.48
7	Readiness to mobilize on site	0.11	4	0.44	3	0.33	4	0.44	4	0.44	4	0.44
		1	Σ	2.41		3.74		2.7		2.94		3.25
	Qualification rating for subcontract award (QRSA):			2.41		3.74		2.7		2.94		3.25
	Remarks:			SQ		HQ		AQ		AQ		AQ
	Rank (1= most qualified)			5		1		4		3		2
	Recommended three based on QRSA rank:					✓				✓		✓
	Three selected based on tender price:			✓		✓		✓				

Notes: RI_i= Relativity index of criterion i (i.e. relative weight or importance of the i^{th} requirement; see Equation 2); APR= average of the performance ratings by the Tender Evaluation Committee members, ranging from 1 (i.e. very low) to 5 (i.e. very high); PS= performance score (i.e. RI × APR). QRSA continuum: <1.51=NQ (not qualified); 1.51–2.49=SQ (somewhat qualified); 2.5–3.49=AQ (averagely qualified); 3.5–4.49=HQ (highly qualified); > 4.5=VQ (very highly qualified).

Construction stage performance assessment

At the end of the subcontract, the performance of each of the three subcontractors was evaluated on the basis of how the subcontractor met the performance criteria set at this stage. Table 6 showed that the subcontractor, B, who achieved the highest QRSA ranking at the tender award stage (see Table 5) also achieved the highest performance rating (PR); while the other two subcontractors, i.e. A and C, achieved 'low' and 'average' performance ratings, respectively. On the basis of their poor QRSA rankings at the tender award stage as shown in Table 5, these two subcontractors should not have been awarded the subcontract in the first instance due to their inferior overall performance rankings. This finding pointed to a possible correlation between a subcontractor's pre-qualification ranking at the pre-contract stages, and his or her performance at the construction stage.

However, the above result is statistically unreliable, as several cases are needed for a valid and reliable conclusion. The result could be due to other mediating circumstances such as varying ergonomic conditions. More research is needed to explore the possibility of causal relations between construction stage performance and pre-contract qualification on the basis of a more holistic set of criteria other than tender price. But the result that one of the subcontractors who submitted lowest tenders ended up with lowest performance aligns with Latham's (1994) criticism of the practice of awarding tender on the basis of lowest price.

However, the application of this framework could help to ensure that only specialist subcontractors who had the overall competence and dispositions to perform are shortlisted for invitation to tender and subsequent tender award. This contrasts with the company's and industry norm of selecting subcontractors largely on the basis of price.

Conclusions

The priority criteria for the assessment of subcontractors' eligibility for tender invitation and award, and for their subsequent performance at the construction stage

Table 6 Assessment of subcontractors' performance at the construction stage

	Contractors' general requirements from subcontractors	RI_i	Subcontractors' performance ratings and scores									
			A		B		C		D		E	
			APR	PS	APR	PS	APR	PS	APR	PS	APR	PS
1	Quality of work; zero or minimal defects or rework	0.12	1	0.12	5	0.6	3	0.36	2	0.24	5	0.6
2	High rate of productivity ensuring on-time delivery; efficient management and control of workforce	0.11	3	0.33	5	0.55	3	0.33	2	0.22	4	0.44
3	Cost control and waste minimization	0.11	1	0.11	4	0.44	2	0.22	4	0.44	4	0.44
4	Good working relations with main contractor's team; good tolerance, loyalty and zero or minimal adversarial relation	0.11	1	0.11	4	0.44	2	0.22	2	0.22	3	0.33
5	Scope management: ability to manage changes without unnecessary claims	0.11	2	0.22	5	0.55	3	0.33	3	0.33	4	0.44
6	Ability to manage the financial and contractual risks inherent in the subcontract	0.10	2	0.2	4	0.4	4	0.4	4	0.4	5	0.5
7	Fair and minimal claims	0.10	2	0.2	5	0.5	5	0.5	5	0.5	6	0.6
8	Onsite health and safety practice	0.09	1	0.09	5	0.45	2	0.18	4	0.36	3	0.27
9	Compliance with contract terms and conditions, labour acts, building regulations, etc.	0.08	2	0.16	4	0.32	3	0.24	3	0.24	4	0.32
10	Good communication network	0.07	2	0.14	4	0.28	4	0.28	4	0.28	4	0.28
		1	Σ	1.68		4.53		3.06		3.23		4.22
	Performance rating (PR) achieved by each subcontractor:			1.68		4.53		3.06		3.23		4.22
	Remarks:			L		VH		A		A		H
	Rank (1=best performing)			5		1		4		3		2
	Best performing subcontractor:					✓						
	Subcontractors to be retained for future job:					✓		✓		✓		✓

Notes: RI_i=Relativity index of criterion i (i.e. relative weight or importance of the i^{th} requirement; see Equation 2); APR=average of the performance ratings by the Tender Evaluation Committee members, ranging from 1 (i.e. very low) to 5 (i.e. very high); PS=performance score (i.e. RI × APR) PR (performance rating) continuum: <1.51=VL (very low); 1.51–2.49=L (low); 2.5–3.49= A (average); 3.5–4.49=H (high); >4.5=VH (very high).

were investigated. On the basis of the analysed ratings of 40 subcontractors and main contractors registered with the Gauteng Master Builders Association, and the findings of a case study application of the developed framework, the following conclusions were reached:

(1) Quality of work was perceived as the most influential criterion for shortlisting a subcontractor for tender invitation. This included evidence of a subcontractor's ability to comply with specifications and to minimize rework.
(2) Competitiveness of item rates and overall tender sum, including the ability to submit bona fide tenders with minimal tagged items, were perceived to be the most influential criteria for the award of a subcontract.
(3) A subcontractor's quality of work that is consistent with the quality level required of the main job was perceived to be the most important criterion underlying performance at the construction stage.
(4) The concepts of pre-qualification eligibility rating (PER), qualification rating for subcontract award (QRSA), and performance rating (PR) could provide a holistic framework for the assessment of subcontractors' eligibility for tender invitation and award, and subsequent performance at the construction stage.

The use of the above concepts could ensure that subcontractors are selected not only on the basis of their tender prices, but on their overall ability to meet the priority requirements of the main contractor in the subcontract work. The application of the framework developed in the study pointed, though inconclusively, to a possible correlation between the level of qualification of a subcontractor for subcontract invitation and award, and the subcontractor's subsequent performance at the construction stage. More research is needed to explore possible correlations or causal relations between pre-contract qualification and construction stage performance. However, the findings of the case study suggest that the developed framework can be applied to

real life subcontractor selection and performance assessment process. The developed process flowchart is recommended for use by main contractors and consultants in assessment of subcontractors' eligibility for tender invitation and award, and for their subsequent performance at the construction stage. This provides a tool for subcontractor management, and to ensure that only subcontractors who have the ability to deliver are shortlisted and awarded the subcontract. In the construction industry, the practical value of the framework developed in the study is that it could contribute to eliminating or minimizing subcontracting risk, and could result in improved project delivery.

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