Relative Importance of Subcontractor Selection Criteria: Evidence from Singapore

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Abstract: Subcontractors carry out a large portion of the work done in construction projects. Thus, selecting the right subcontractor essentially contributes to the project’s success. We designed a choice-based conjoint experiment to examine the relative importance of four criteria in the subcontractor selection process of main contractors from Singapore: price, technical know-how, quality, and cooperation. Although main contractors adopt a multicriteria selection process and perceive all four criteria to be important for their choice decision, the actual choice situation reveals that price is still by far the most important selection criterion, followed by quality, cooperation, and technical know-how. Main contractors are not willing to compromise on price but accept a lower performance of a known subcontractor on the remaining criteria.

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Introduction

Nowadays, main contractors are more involved in site organization and management tasks (Humphreys et al. 2003) and rely on subcontractors for up to 90% of the total value of construction projects to carry out the actual work (Hinze and Tracey 1994). Subcontracting is advantageous for main contractors since they can keep their companies trim and nimble and can tap on subcontractors’ specialization (Arditi and Chotibhongs 2005). Although the success of a project does not depend wholly on judicious subcontractor selection, choosing the right subcontractors is important because many defaults in the past have been due to subcontractors accepting jobs they are incapable of undertaking and good subcontractors being given inappropriate contracts (Okoroh and Torrance 1999; Kumaraswamy and Matthews 2000). Several sophisticated methods have already been proposed for the selection of main contractors and subcontractors, such as multicriteria decision making, multiattribute analysis, multiattribute utility theory, multiple regression, cluster analysis, bespoke approaches, fuzzy set theory, and multivariate discriminant analysis (Hatush and Skitmore 1997; Albino and Garavelli 1998; Holt 1998; Mahdi et al. 2002). It is argued that improved selection processes are also required down the supply chain to the subcontractors and suppliers in order to ensure that clients’ needs are satisfied and projects can be successfully completed (Loh and Ofori 2000). However, there is scarce evidence whether multicriteria underlie the selection of subcontractors and if so, to what extent different criteria account for the choice decision. Our research specifically examines the relative importance of several criteria in the subcontractor selection process of main contractors from Singapore. Knowing the criteria from which main contractors derive the highest utility will allow subcontractors to pursue appropriate tender strategies and acquire capabilities to increase their chance of being awarded contracts.

It is important to note that we are not primarily interested in the perceived importance of selection criteria. Our focus is rather on the trade-offs we expect main contractors to make among the levels of various criteria when actually choosing subcontractors. Our main assumption is that subcontractors hardly ever perform superiorly on all criteria for a particular project, and that main contractors have to balance the criteria with each other. For instance, a main contractor may rate tender price and know-how as highly important for the selection decision but the subcontractor with the lowest offer may have only little experience in similar work compared to competitors. The main contractor has to decide either to compromise on price or know-how when choosing a subcontractor for this particular project or to negotiate on price to obtain the most favorable offer. At which trade-off level main contractors are willing to accept a subcontractor is the main concern of our research. Given the trade-off assumption, asking solely for the perceived importance of selection criteria would involve the risk of measuring intentions instead of actual practices (Verma and Pullman 1998).

Selection Criteria

The selection criteria we investigated were: price, technical know-how, quality, and cooperation. This section reviews the literature on these four criteria.

Price

According to the economic Theory of the Firm (Coase 1937; Machlup 1946), the contractors’ objective is to maximize their...
profit. A corollary of this theory is that given a level of output, firms minimize costs. Firms that do not come close to maximizing their profits and minimizing their costs are not likely to survive. Main contractors need to win tenders so that they have a chance to maintain the viability of their businesses (Dulaimi and Hong 2002). Based on the contractors’ need to minimize cost and maximize profit, they are likely to select subcontractors who submit the lowest price. Profit maximization is the closest approximation to the average behavior in the construction industry (Hillebrandt 1985). Indeed, tender price has been the dominating decision basis in subcontracting choices for decades and is still shown to be a significant criterion (Greenwood 2001).

**Technical Know-How**

Subcontractors are hired to perform specific tasks on a project and, consequently, need to possess certain technical know-how to undertake the demanded work (Kumaraswamy and Matthews 2000; Arditi and Chotibhorngs 2005). Technical know-how comprises knowledge of technical information about objects and concepts required to do the job, and knowledge of processes and judgmental criteria required for efficient or correct action on the job (Hunter 1983). According to Gushgari et al. (1997), technical knowledge is an understanding of complex elements required to effectively complete tasks associated with a given profession. As such, it enables the development of technical competence (Peters 1981) and technical expertise (Russell et al. 1990; Shah and Murphy 1995) and, consequently, the use of correct working methods to competently handle machines and equipment. Thus, indicators of a subcontractor’s know-how are the applied working methods, materials, machines, and tools evaluated on the basis of past projects.

**Quality**

Besides having the technical knowledge to accomplish desired tasks, the provided work quality is a critical antecedent to the overall project performance (Loh and Ofori 2000; Arditi and Chotibhorngs 2005). Quality is the extent to which subcontractors actually deliver products or services that meet project requirements. Admittedly, technical know-how can contribute to the quality of the final product, but there are other factors determining whether the final product delivered by the subcontractor meets project requirements (e.g., working environment, quality planning and control, and attitude of employees).

Quality may comprise four aspects: technical quality, functional quality, workmanship quality, and architectural quality (Pain and Bennett 1988). Technical quality is a measure of the quality of the building at the technical level, that is, the quality of materials, components, fittings, and finishes. Functional quality is the extent to which the building meets the objectives for which it was intended. Workmanship quality is a measure of the standard of workmanship in the completed building. Architectural quality is a measure of the quality of the building in architectural and aesthetic terms.

Quality is usually evaluated based on past experience with the subcontractor or on the basis of reputation based on opinions and experiences of other firms. Main contractors are more likely to award contracts to subcontractors that demonstrate superior technical and workmanship quality and show good site management and supervision ability (Dulaimi and Hong 2002) to ensure good product quality. Admittedly, good past performance is not a guarantee for future performance. However, past behavior and/or past performance is the best predictor of future behavior and performance (Hogan, et al. 1996) based on the Consistency Principle (Epstein 1979). Studies have shown that past job performance is a valid predictor of future job performance (Hunter and Hunter 1984).

**Cooperation**

In the construction industry, there are underlying difficult relationships and lack of communication among various parties (Higgin and Jessop 1965; Faulkner and Day 1986). Since subcontracted services have to be performed through relationships established between main contractors and subcontractors, cooperation or the extent to which subcontractors fulfill agreements and proactively solve and prevent problems is seen to be highly relevant for the operational efficiency of construction projects (Humphreys et al. 2003). This includes individuals who exhibit courtesy and altruism, do not make complaints, are helpful, and cooperate with co-workers and customers (Borman and Motowidlo 1993). Main contractors will be more willing to select subcontractors that show a positive attitude, commitment, and quick response to their needs (Dulaimi and Hong 2002). Like quality criterion, cooperation can be evaluated on the basis of the contractor’s own experience with particular subcontractors, or on the basis of reputation in terms of opinions and experiences of other firms.

**Research Design**

As stated above, our main assumption is that main contractors have to make trade-offs while choosing subcontractors. We are interested in the relative importance the four criteria price, technical know-how, quality and cooperation possess in these trade-off decisions. That is, main contractors derive their preference for a particular subcontractor from the conjoint evaluation of the subcontractor’s performance on the four criteria. We conducted a discrete choice experiment to elicit the relative importance of the four criteria in forming this preference.

Choice experiments have been frequently applied in marketing studies to determine consumer preferences (Ewing and Sarigöllü 2000; Dhar and Wertenbroch 2000) and have also been employed in many other disciplines such as transportation, tourism, and health research (e.g., Delleart et al. 1995; Sapede and Girod 2002; Dickson et al. 2004). Typically, in a choice experiment respondents are requested to choose the alternative that best reflects their preferences among a set of alternatives (e.g., products). The researcher controls the characteristics of the alternatives (e.g., product price) by delineating choice sets according to the design procedures of statistical experiments and hence can assume the choices of respondents to be dependent on the alternatives’ characteristics.

In our experiment the alternatives to be chosen are subcontractors who are characterized by their performance on the four criteria. In order to determine whether the criteria play a vital role in subcontractor choice, we first asked the respondents to rank the importance of each criterion on a scale from 1 to 5 (very important) to 5 (very unimportant). The actual choice task requested the main contractors to choose between four subcontractors—three subcontractors typified as known to the main contractor and one subcontractor with whom the main contractor had not had any working relationship before. The three known subcontractors were differently described by the four criteria with two levels each (Table 1).

A combination of three differently performing known subcon-
tractors represented a choice set. To each choice set we added the unknown subcontractor as fourth alternative but with fixed, superior performance criteria. Our assumption was that respondents prefer known subcontractors in the first place, as they can rely on their own experience while evaluating them. Thus, the choice task not only aimed at revealing the relative importance of selection criteria but also asked for the trade-off level at which main contractors switch from a known to an unknown subcontractor. Figure 1 depicts a sample choice set with the four alternatives.

The total number of choice sets that can be presented to the respondents is obtained by combining the two levels of the four criteria with each other and by combining the three known subcontractors with each other. That would result in \((2^4)^3 = 4,096\) choice sets. Obviously, such a full factorial design would not be viable. For most choice experiments a fractional factorial design is needed that reduces length and difficulty of the choice task without sacrificing too much of the statistical quality (Louviere 1988). Several design procedures were proposed to obtain practicable designs that would allow main effects and/or two-way interaction effects to be estimated. We applied the method that Street et al. (2005) suggested for choice sets with three alternatives and binary attributes. Based on an orthogonal main effects plan for the first alternative, we systematically changed the levels in a way that one level appears twice and the other level appears once in a choice set. Following this design procedure, our experimental design resulted in eight choice sets each with three subcontractors labeled as known and differing in their performance criteria and one unknown subcontractor as fourth alternative with fixed superior performance criteria. Our assumption was that respondents preferred known subcontractors in the first place, as they can rely on their own experience while evaluating them. Thus, the choice task not only aimed at revealing the relative importance of selection criteria but also asked for the trade-off level at which main contractors switch from a known to an unknown subcontractor. Figure 1 depicts a sample choice set with the four alternatives.

The final questionnaire consisted of two parts. The first part required respondents to provide information about themselves, their firms, and their perception on the importance of the four criteria. The second part involved the actual choice task. It presented the eight different choice sets to each of the respondents who had to choose between variations of three known subcontractors and one unknown subcontractor as fixed alternative. These choice sets differed among each other but each respondent received the same eight choice sets. In Fig. 1 an example of one choice set is represented. Explanatory notes were provided to define selection criteria and provide guidance on answering the choice questions.

The population frame comprised all the 2,000 odd registered construction firms in Singapore. The sample selection was based on stratified sampling. All the registered building contractors were divided into seven grades, based on their bidding capacity, which was determined by, inter alia, their paid up capital. All the firms in the largest four grades (A1, A2, B1, and B2) were selected for study \((n = 221)\) because they are likely to be appointed as main contractors who would then employ subcontractors to carry out work.

A pilot study was conducted with three randomly selected experienced building contractors. The contractors confirmed that the four criteria are valid measures and that the choice sets represent realistic decision situations. They requested definitions of the criteria and the relative importance of each criterion. Based on the feedback, more explanatory notes were provided for the choice questions, and a five-point Likert scale was given to rate the importance level of each criterion. The finalized questionnaire was then distributed by post to the selected samples in 2006. The questionnaire was self-administered, which precluded verification of responses.

### Data Analysis

To analyze the choices main contractors made among the four subcontractors in the eight choice sets, we used the multinomial logit (MNL) model. The MNL model is the basic model for discrete choice experiments and its advantage lies in the simplicity of estimation. Its disadvantage is that it is unable to analyze the behavior for each respondent but this is not needed for the purpose of our study. The model can be expressed as follows (Louviere et al. 2000):

\[
P_{iq} = \frac{\exp(V_{iq})}{\sum_{j=1}^{J} \exp(V_{jq})} \quad (1)
\]

\[
V_{iq} = \sum_{k=1}^{K} \beta_{ik} X_{ikq} \quad (2)
\]

where \(P_{iq}\) = probability of subcontractor \(i\) to be selected from the \(q\)th choice set with \(J\) possible alternatives; \(V_{iq}\) represents the lin-

### Table 1. Description of Selection Criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Level 1</th>
<th>Level 2</th>
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</thead>
<tbody>
<tr>
<td>Price: offered for the work and compared to competitors and based on the tender</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Technical know-how: in terms of applied working methods, materials, machines, and tools and based on reference past projects</td>
<td>Superior</td>
<td>Sufficient</td>
</tr>
<tr>
<td>Quality: in terms of the extent to which products/services delivered meet project requirements and based on past experience/reputation</td>
<td>Superior</td>
<td>Sufficient</td>
</tr>
<tr>
<td>Cooperation: in terms of extent to which agreements are fulfilled and problems are proactively solved and prevented and based on past experience/reputation</td>
<td>Superior</td>
<td>Sufficient</td>
</tr>
</tbody>
</table>

### Fig. 1. Sample choice set
ear additive utility or attractiveness of subcontractor \( i \) in choice set; \( qX_{ik} = \text{value or level of criterion } k \) of subcontractor \( i \) in choice set \( q \); \( \beta_k \) depicts the effect of criterion \( k \) on the utility of subcontractor \( i \); and \( K \) = total number of attributes or in our case criteria. Since the known subcontractors in our choice experiment disclose no further information to the respondent besides their performance criteria, we considered the utility parameters of the four criteria and thus the choice probability to be same for all three subcontractors. In other words, we only calculated the utility of one known subcontractor compared to the attractiveness of one unknown subcontractor.

We used effect coding as the coding scheme for estimating the parameters of the model (Louviere 1988). By using \(-1\) and \(+1\), the model estimates equal the contribution of each criterion to the utility of the subcontractor without confounding with the constant term or base alternative. If the level of technical know-how, quality, and cooperation was superior, it was coded \(+1\). The level was coded \(-1\) if the criteria were characterized as being sufficient. The high price level was coded \(-1\) and for the low price level we used \(+1\). For analyzing the data and determining the parameters of the model we used maximum likelihood estimation. This calculation process is iterative and will repeat itself until it obtains the single value of a parameter which maximizes the likelihood function. In other words, when the single value of a parameter is found, the observed sample data would be most likely to occur.

Results

Descriptive Statistics

Of the 221 questionnaires sent out, 38 were returned with varying degrees of completeness. While \( n = 38 \) may appear to be low, it represents 17% of the population frame \( (N = 221) \). The non-response rate is adequate, given Singapore's small construction industry. The results should be read accordingly and their restricted generalization beyond the context of Singapore should be kept in mind.

The characteristics of the respondents and their firms are shown in Table 2. The majority of respondents are middle to top management, indicating that the results reflect the views of senior people who regularly make decisions about subcontractor selection. Their firms are medium sized in terms of number of staff and annual sales. The majority of them undertake complex residential and commercial projects.

Perceived Importance of Selection Criteria

Table 3 presents the importance of the four selection criteria as perceived by main contractors ranging from 1 (very important) to 5 (very unimportant). The results show that main contractors consider all four criteria to be important for the selection of subcontractors. Price is regarded to be the most important followed by technical know-how, quality and cooperation. However, the large standard deviations suggest no statistically significant differences between the four means. Indeed, analysis of variance among the four criteria results in \( F = 0.925 \) and \( p = 0.430 \).

Relative Importance of Selection Criteria

Table 4 shows the parameter estimates for the main effects of the MNL model. With 38 respondents and 8 choice sets offered, theoretically, there should be 304 observations (each choice made
represents one observation, 8 choices per respondent × 38 respondents = 304). However, there are only 296 observations because of missing data. Among the 296 observations, eight observations were not used for analysis because they were inconsistent with the other responses. After these were excluded, 288 (296 − 8 = 288) observations were used for detailed data analysis.

To determine how well the estimated model reproduces the observed choices, we compared the log-likelihood of the model LL(β) with the log-likelihood of a base model LL(0) in which no coefficients are estimated (Table 5). The log-likelihood ratio test shows that the estimated model is statistically significant at the 5% level and thus better represents the data. Similar to the proportion of explained variance in linear modeling, the pseudo-$R^2$ gives an indication to which extent the model explains variation in the choices observed. Our model shows a pseudo-$R^2$ of 0.30 which according to Hensher et al. (2005) represents a decent model fit.

Standard errors and $p$ values are also reported in Table 4. All parameters are statistically significant at the 1% level. Since we used standardized coding for the levels of the four selection criteria, the estimated parameters represent the relative importance of the criteria for subcontractor choice. A positive parameter suggests a positive relationship between the criterion and a subcontractor’s utility. For instance, if a subcontractor performs with superior quality, the overall utility for that subcontractor increases. Likewise, the negative sign of the price parameter indicates that the overall utility of a subcontractor will increase if the offered price decreases. Our results show that price is by far the most important criterion, accounting for almost 50% of the preference forming of main contractors. This is followed by quality and cooperation. The least important selection criterion is technical know-how. What attracts attention is the relatively large and significant constant term which has a negative sign and, thus, a negative effect on subcontractor’s utility. This constant reflects the utility associated with the unknown subcontractor, whom we used as fixed comparator. In other words, the respondents attribute a positive utility to an unknown subcontractor performing superiorly with regard to all four criteria, and the overall utility of the known subcontractors is relative to this base alternative.

**Discussion**

Given the assumption that subcontractors are not superior with regard to all performance criteria for a particular project, main contractors have to balance these criteria when choosing a subcontractor. We investigated the relative importance of the four criteria: price, technical know-how, quality, and cooperation. When we asked about the importance of the four criteria on average, the main contractors perceived all criteria as critical for subcontractor selection. At the first glance, the results suggest a balanced weight of the criteria in the selection process. However, the standard deviations indicate a greatly dispersed importance rating which diminishes the stability of this conclusion. Indeed, in an actual choice situation, the criteria importance in preference forming changes considerably while the robustness of the findings improves. Although all four criteria still have an effect on the utility of a subcontractor, the preference forming and thus the selection decision is largely dominated by price. That may be due to three reasons.

First, subcontractors who offered low bid prices help main contractors sustain their business and ensure that the cash flow is positive. Profit margins are determined largely by bid price more than by other influencing factors. As the construction industry has a low entry barrier, profit margins are often small due to fierce competition. The lower the subcontractor’s bid price, the higher the potential profit margin will be for the main contractor, assuming that the project progresses smoothly without major impediments.

Second, there is an increasing availability of construction systems and products that meet minimum specifications in response to the dominance of lowest bids in the construction industry. With more systems available to meet demands, competition among subcontractors would be stronger, leading to dominance of lowest bid price as they compete to win limited projects. Thus, the main contractor would be more influenced by the bid price since the quality of the end-product would be largely comparable due to similar systems and products offered by different subcontractors.

Third, main contractors could have viewed price as the most important subcontractor selection criterion because it is an objective and measurable variable. Other factors like quality and cooperation level are more difficult to quantify. Main contractors may feel more certain of their profit margins once they have “locked in” the subcontractor prices.

Although quality is the second most important criterion, its contribution to preference forming is far less than price. Quality usually comes with a higher price and in small to medium-sized works, minimum quality with a small budget is often strived for instead of setting a large budget to achieve high quality. Moreover, the aforementioned construction systems and products may ensure certain quality standards, and particular technical quality aspects become less relevant for the selection decision. However, it can be argued that subcontractors’ workmanship will form a large portion of main contractors’ quality perception, since construction materials and components need to be assembled in a proper way to achieve the required building performance. That quality is more important than cooperation and technical know-how may be due to the contractual obligations of main contractors to deliver work on time and to a specified quality level. Subcontractors vicariously help main contractors to fulfill their contracts by providing products and services that meet project specifications which main contractors are ultimately responsible for. On the other hand, subcontractors who produce poor quality may cause complaints to be lodged with irreparable damage to the main contractors’ reputation.

Although they are the least important criteria, cooperation and technical know-how still contribute to the attractiveness of a subcontractor. An explanation for the level of their importance can be found if both criteria are regarded as means to facilitate the attainment of the main contractors’ contractual obligations (e.g., timely completion and quality). Over 50% of the main contractors in our study perceive their projects to be complex. Inherent to complex projects are unforeseen events and imperfect information which may lead to disturbances and contradictions during project
implementation. Cooperative subcontractors are desirable because they would help to identify and manage risks of complex projects in a timely manner to alleviate potential problems which may translate into losses for the main contractor. Subcontractors with technical know-how are beneficial as they anticipate and solve these problems during the project. That does involve more than the identification and usage of appropriate working methods and technical equipment. It also covers the adjustment of these alternatives to the specific circumstances of the project. While cooperation refers to the willingness to prevent and deal with problematic incidents stemming from the complexity of a project, technical know-how represents the capability to find adequate solutions for the problems in a timely, quality-effective, and cost-efficient manner. A reason for the lower importance of both criteria compared to quality may lie in the existence of other factors (e.g. the usage of standardized systems, products, and procedures) which are not related to the selection decision but also safeguard main contractors’ obligations.

Some managerial implications result from our findings. First of all, subcontractors need to focus on preparing tenders with most favorable prices. A low price is a necessity for being selected. However, a low price alone cannot guarantee to become the preferred subcontractor. Our results show that the utility of a subcontractor increases with superior quality, cooperation, and technical know-how. Compared to an unknown subcontractor performing superiorly on all criteria, known subcontractors will attain a positive utility when they are able to combine a low price with a superior level of two of the other three criteria. Put differently, main contractors are willing to compromise on one of the three criteria in order to choose a subcontractor they have already worked with. For main contractors, past experience is a more reliable source for evaluating the performance of a subcontractor. In particular, quality and cooperation are linked to the main contractors’ preference for known subcontractors. These criteria can only be accurately evaluated on the basis of previous experiences, which provide more detailed and accurate information than the reputation of an unknown subcontractor. Of the three criteria, quality of products and services delivered is the criterion main contractors are least willing to compromise on. Hence, subcontractors can achieve the greatest additional impact on choice probability if they ensure that quality standards meet project specifications and improve workmanship quality to properly assemble construction systems. Showing cooperative behavior and gaining technical know-how are then possible measures to indicate the willingness and capability to fulfill the main contractor’s contractual obligations, to alleviate potential problems and to solve critical events most effectively and efficiently.

Conclusion

This research investigated the relative importance of criteria used by main contractors to select subcontractors. Our starting point was the assumption that main contractors have to make trade-offs among the levels of different selection criteria while choosing subcontractors. Although main contractors seem to perceive price, quality, cooperation, and technical know-how as similarly important for the selection of subcontractors, our choice experiment shows that price is still the predominant basis for the choice decision. Main contractors are not willing to compromise on price when choosing a subcontractor. Someone may argue this finding is not new but our research reveals a more detailed picture of subcontractor selection. Notwithstanding being the most important criteria a favorable price is not sufficient for being selected. The choice decision of main contractors does not solely depend on the tender price. The attractiveness and thus the choice probability will increase with a superior quality, cooperative behavior, and technical know-how. Particularly known subcontractors can take advantage of their previous relationships with main contractors. With a superior quality, main contractors are willing to accept a lower performance on cooperation and technical know-how of known subcontractors.

Based on our research it can be argued that main contractors adopt a multiriteria selection but which is not balanced. That raises the questions when and how a more balanced selection decision contributes to project performance. It is recommended that future research explores the influence of situational factors on the importance of selection criteria. For instance, project complexity might have an effect on the importance of cooperation and for highly specialized services, technical know-how may play a more prominent role in decision making. In addition, the research findings may be limited and even inapplicable to countries outside Singapore. It would therefore also be worthwhile to replicate the study in other countries where project risks and work culture are different from Singapore. An additional aspect for further research would be how subcontractors perceive the importance of choice criteria and how their view matches the decisions of main contractors.

Notation

The following symbols are used in this paper:

\[ K \] = total number of attributes; 
\[ P_{iq} \] = probability of alternative \( i \) to be selected from the \( q \)th choice set with \( J \) possible alternatives; 
\[ V_{iq} \] = utility of alternative \( i \) in choice set \( q \); 
\[ X_{ikq} \] = value of attribute \( k \) of alternative \( i \) in choice set \( q \); and 
\[ \beta_{ik} \] = effect of attribute \( k \) on the utility of alternative \( i \).

References


