RESEARCH STUDY

Best-Value Procurement in Design-Bid-Build Construction Projects: Empirical Analysis of Selection Outcomes

by
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Abstract

Best-value (BV) procurement is increasingly used in conventional design-bid-build (D-B-B) delivery, which raises questions regarding the influence of qualifications-based evaluation criteria when selecting construction contractors. The objectives of this study are to (1) examine the BV procurement outcomes that can be expected within D-B-B projects, (2) determine which evaluation criteria have the greatest dispersion amongst competing contractors, and (3) identify whether a relationship exists between cost and qualifications-based proposal submissions. A sample of 162 public institutional BV-procured D-B-B projects was collected that include evaluation results of 684 contractor proposals. Both descriptive and inferential statistics were utilized including the coefficient of variation and correlation analysis of evaluation criteria. The results show that BV-selected contractors contained substantial qualifications benefits in comparison to lowest and average bidder alternatives. Certain qualifications-based criteria, such as technical proposals, contractor interview scores, and safety proposals were found to have a greater dispersion among competing bidders than cost proposals. Contributions of this study to the body of knowledge include a sizable empirical data set of BV-procured D-B-B projects in the vertical sector and a unit of measure that considers dispersion among competing contractor proposals. To the current practice of the construction industry, project owners are recommended to consider BV for complex D-B-B projects and prioritize certain qualifications-based criteria that are well-suited for differentiating between competing contractor proposals.

Research Details

INTRODUCTION

Although the majority of construction services are still awarded using low-bid (LB) methods, the best-value (BV) procurement method is becoming increasingly common within the industry (AGC and NASFA 2008). BV procurement is defined as a method that concentrates on achieving the highest value by considering both cost and qualifications-based criteria in the selection process (El Wardani et al. 2006; MnDOT 2012). There are several trends in the construction industry that have led to the increased use of BV procurement. First, the expansion of alternative project delivery methods (APDMs) has established more wide-spread familiarity with non-low bid procurement methods within the construction industry (McKeon 2016; Schleifer et al. 2014). APDMs such as design-build (D-B), construction manager/general contractor (CMGC or CMAR), and integrated project delivery (IPD) are commonly procured using BV or qualifications-based selection (QBS) rather than LB (Molenaar et al. 2010; AGC 2009). Second, the implementation of BV has recently expanded into D-B-B projects as an effective strategy to improve

project outcomes and enhance consistent project performance (Tran et al. 2016). BV procurement of contractors within D-B-B projects is a departure from conventional cost-based procurement methods, where the lowest bidding contractor is typically selected so long as their bid is deemed to be responsible and responsive to the owner's requirements. When using LB procurement methods, project owners inherently presume that construction performance will be approximately equivalent regardless of which contractor is selected (Schleifer 2017). Additionally, cost is the only meaningful criterion that separates competing bidders under LB procurement. Professional associations in the construction industry, including the Associated General Contractors of America (AGC 2009; AGC 2017), the Design-Build Institute of America (DBIA 2012), the American Institute of Architects (Sandquist 2007), the Construction Management Association of America (McKeon 2016), and the National Association of State Facilities Administrators (AGC and NASFA 2008), however, have argued that contractors' performance should not be treated like a commodity. In fact, the contractors' performance varies upon their past performance, key personnel, project approaches, and related experience (AGC 2017). Yu and Wang (2012) emphasized that BV procurement, which combines cost and qualifications, may represent the most advantageous procurement method for the owner.

The current body of knowledge lacks extensive and quantitative data sets of BV procurement applied within the D-B-B delivery system. To address this gap, and provide owners with a more complete understanding of how BV procurement may be utilized in D-B-B projects, the main objectives of this study include:

- Analyzing empirical data on the bid costs, schedule proposals, and owner evaluations scores of all qualifications-based criteria for each competing bidder collected from 162 BV-procured D-B-B projects;
- Investigating if BV procurement outcomes differ from traditional LB procurement, and if so, to understand the extent to which owners gain benefits in the form of greater qualifications among selected contractors;
- Evaluating the dispersion among competing contractor proposals for common evaluation criteria. In turn, these results aim to identify evaluation criteria that achieve the largest differential between competing contractors; and
- Determining whether a relationship exists between contractor bid costs and the evaluation scores received on their qualifications proposals, which will shed light on whether the selection of a more qualified contractor comes at a greater bid cost to the owner.

The following sections summarize the literature review, present research methodology, and discuss the key findings in detail.

LITERATURE REVIEW

A number of studies have discussed different procurement processes used in the construction industry. The typical procurement procedures are LB, QBS, and BV.

Low-Bid Procurement in Construction

LB traditionally provides several benefits to construction owners. The first benefit is in terms of short-term monetary savings since the owner is guaranteed to achieve the lowest cost option at the time of bidding. The second benefit relates to simplicity of the procurement selection process (Yu and Wang 2012). In

highway construction projects, LB is often supported by federal, state, and municipal legislation due to the transparency it fosters in the evaluation process as the lowest bidder is readily discernable (Gransberg and Ellicott 1996, Tran et al. 2016).

Despite its advantages and widespread use, LB procurement has several drawbacks. For example, LB excludes quality considerations during the evaluation process, such as a contractor's technical proposal, past performance, and other qualifications-based criteria (Ahmed et al. 2012). Researchers (e.g., El Wardani et al. 2006; Richey 2012) have also found that LB has been linked to inconsistent performance during the construction phase. Through analyzing 70 vertical construction projects, El Wardani et al. (2006) found that LB-procured projects suffered 9 percent and 5.6 percent greater cost and schedule growth, respective, when compared with similar projects procured via BV methods. Richey (2012) recognized a new library project in Palo Alto, California that accrued $1.7 million in change orders and one year delay. The LB-selected contractor was awarded with an initial bid that was $8 million below the estimated cost of $32 million. In this project, a dispute arose when the owner alleged the contractor had bid as low as possible and then submitted an unreasonable number of requests for information and change orders. Conversely, the contractor argued that the design and specifications were not explicitly defined, which caused a substantial cost growth and delays (Richey 2012). Such disputes are not uncommon in traditional LB systems (Sandquist 2007).

Qualifications-Based Selection in Construction

QBS is defined as a procurement system which completely concentrates on the evaluation of qualifications-based criteria and does not include consideration of cost proposals. The use of QBS in the construction sector is rare and generally confined to APDM projects. Previous research has indicated that owners tend to favor non-cost criteria over time when they become more experienced in using APDMs (Gransberg and Shane 2015). Traditionally, architecture and engineering (A/E) services in the United States have been procured via QBS methods. The Books Act requires all federal agencies to utilize QBS for A/E procurements and many states have adopted "mini-Brooks" policies that emulate the federal legislation (DBIA 2012; McKeon 2016). A fundamental premise behind the use of QBS in A/E is that the procurement process occurs when the project's design is not yet complete (or has even been started); therefore, the lack of scope definition makes it difficult for A/E firms to provide accurate pricing without more detailed discussion of the owner's project needs and priorities (Chinowski and Kingsley 2009). Furthermore, the A/E industry is widely perceived as a professional service where a firm's past performance, qualifications, and technical proposal are critical to achieving successful design outcomes (Christodolou et al. 2004).

Best-Value Procurement in Construction

BV procurement theoretically achieves a balance between LB and QBS methodologies by considering both cost and qualifications criteria. Previous research has demonstrated various benefits of applying BV procurement within the construction industry compared with the traditional LB system. For example, Perrenoud et al. (2017) found that contractors who received more favorable qualifications-based evaluation scores tended to achieve better performance in the areas of project quality, professionalism, risk communication, and overall customer satisfaction. BV has also been shown to achieve a reduction in cost growth, schedule growth, disputes, and claims (Abdelrahman et al. 2008).

Researchers have found that BV procurement brings benefits to both construction owners and contractors. For example, Gransberg and Shane (2015) identified BV as a procurement method which can achieve greater consistency in long-term project performance. Abdelrahman et al. (2008) indicated that BV has been found to achieve positive project performance due to its emphasis on value-added services and qualifications-based criteria. Ahmed et al. (2012) emphasized the need of BV in the contractor selection for highway projects rather than the conventional LB due to the ability to consider the contractor's responsibility for maintenance across the project's operational lifespan. According to Sullivan and Guo (2009), BV procurement can benefit contractors by providing improved cash-flow and increased profitability because it can lead to a more performance-based project environment.

It is important to note that many professional organizations in the design and construction industry support the use of BV for procuring construction services and have lobbied for its continued growth. The American Institute of Architects (AIA) stated the potential of qualifications-based evaluation criteria in providing better contractor selection outcomes in terms of cost savings and value engineering (Sandquist 2007). The Construction Management Association of America (CMAA) has promoted the use of qualifications-based criteria as an essential part for procuring construction management services which potentially increases project performance (McKeon 2016). A joint publication between the Associated General Contractors of America (AGC) and the National Association of State Facilities Administrators (NASFA) advocated for and defined recommended best practices for owners to utilize BV procurement in construction (AGC and NASFA 2008). Additionally, both the Design-Build Institute of America (DBIA) and AGC identified qualifications-based criteria as important factors to achieve lower final project costs regardless of project delivery method (DBIA 2012; AGC 2009).

Best-Value Procurement within D-B-B Projects

Although LB is still the predominant methodology for procuring contractors within D-B-B projects, BV is becoming increasingly common. For example, in CMAA's (2012) publication, *An Owner's Guide to Project Delivery Methods*, BV is noted as a "common" procurement method for D-B-B projects even though LB was still recognized has the "most common" procurement method. Historically, the United States public sector has mainly used BV procurement for APDMs such as D-B and CMGC, yet there is a trend towards expanding BV usage within D-B-B projects. For example, legislation recently allowed the University of California to consider additional values when selecting contractors, which leads to 13 percent of all contracts (totaling $1.2 billion) utilizing the BV construction authority from the period of 2012 to 2015 (UCOP 2018). Based on this momentum, a bill was passed (SB762) which established a pilot program to allow several California-based counties to use BV procurement for construction services (SB762 2015). Other agencies have also moved towards BV procurement in D-B-B projects. The Minnesota Department of Transportation published a BV procurement manual that directly discusses how BV can be used within D-B-B (MnDOT 2012). Other departments of transportation (DOTs), including Michigan, New York State, and Oregon DOTS, have recently begun to test BV procurement within D-B-B, (Tran et al. 2016). This trend in the public sector procurement is expected to continue its growth, typically due to owner perceptions that BV enables selection of more highly qualified contractors who have the ability to deliver successful project performance outcomes.

Current Studies of Best-Value in Design-Bid-Build Projects

Research on BV implementation in D-B-B projects is limited. As one of the first studies to focus exclusively on BV within D-B-B projects, Tran et al. (2016) conducted case studies of BV application to highway construction projects from Michigan, New York State, and Oregon Departments of Transportation (DOTs). A major conclusion from these case studies was the recommendation that using BV in D-B-B projects has the potential to increase project success and reduce project risk factors.

The majority of current BV procurement research within construction has been limited to the context of APDMs (e.g., D-B and CMGC projects) rather than traditional D-B-B. As cited by Yu and Wang (2012), BV has the potential to be more advantageous to owners in selecting qualified contractors compared with LB-procured D-B projects. In comparison with other procurement methods, such as LB, sole source, and QBS in D-B projects, BV can substantially reduce schedule growth (El Wardani et al. 2006). Additionally, Yu et al. (2013) proposed an index to support owners in choosing to utilize BV procurement methods within APDMs rather than the traditional LB approach. Gransberg and Shane (2015) demonstrated lessons learned about using BV in CMGC projects and recommended that owners should consider BV in the selection of construction services. Recently, Alleman et al. (2017) concluded that BV procurement in CMGC might pose potential risks and require more negotiating work. They suggested that BV should be used in D-B-B projects, which have higher levels of designs at the time of bidding.

RESEARCH QUESTIONS

Previous research has found that there is increased potential for project success and a reduction of project risk factors when public owners have used BV procurement in D-B-B projects (Tran et al. 2016). Based on this evidence, owners may be interested in further studies related to how BV procurement procedures can be implemented within their operations. This leads to the development of the following research questions for this study:

Research Question 1: What are the selection outcomes within D-B-B construction projects procured via BV?

In BV-procured projects, initial contracted values of selected contractors by definition may be higher than those of LB-procured projects; in addition, the most beneficial bidders should be distinctive from other bidders in terms of qualifications (Yu and Wang 2012). This research question aims to investigate selection outcomes of BV-procured D-B-B projects with descriptive statistics associated with evaluation criteria's ranking and differential in evaluation scores compared with other competing bidders. This information is beneficial to owner organizations in that it will identify how often BV will be selected coincident with the lowest bidder, the best qualified bidder, and combinations thereof.

Research Question 2: Which evaluation criteria explicitly differentiate among competing bidders?

A common perception in the construction industry is that the owner should focus on primarily on cost when selecting contractors in D-B-B projects. The underlying assumption is that any selected contractor will deliver a comparable scope; therefore, minimal differences are expected to exist between competing bidders in terms of non-cost criteria such as quality, schedule, and qualifications (Ahmed et al. 2012; Gransberg and Shane 2015; Schleifer 2017). Yet in BV procurement, multiple qualifications-based criteria will be evaluated. This research question investigates the extent to which differential exists among competing bidders (measured in terms of the coefficient of variation between associated evaluation

scores) in a variety of common qualifications-based criteria in addition to cost and schedule proposals. To address this research question, the authors established the following research hypothesis: the coefficient of variation of evaluation scores among competing bidders has a statistically significant difference for separate evaluation criteria (e.g., technical proposals, past performance, contractor interview scores, schedule proposals, and cost proposals).

Research Question 3: At the time of bid submission, what is the relationship between owner evaluations of qualifications-based criteria and corresponding contractor bid costs?

A common perception in the construction industry is that companies and project teams who possess greater qualifications will generally correspond with higher costs or fees (Yu et al. 2013). The intent of this research question is to determine whether this perception is accurate within D-B-B procurement scenarios. The data sample consisted of projects procured via a two-envelop BV system where owner evaluation scores are unbiased by cost proposals, which is an apt scenario to investigate this research question. The research hypothesis associated with this research question is that greater evaluation scores for qualifications-based evaluation criteria correspond with greater bid costs.

METHODOLOGY

The research methodology included four steps: (1) literature review; (2) data collection; (3) data analysis; and (4) findings and discussion. Figure 1 graphically illustrates these four steps. Step 1 involves a comprehensive literature review of the current procurement practices using in the construction industry and the need for additional empirical analysis of BV procurement in D-B-B projects. Step 2 includes data collection of 162 BV-procured D-B-B projects, consisting of Request for Proposal (RFP), evaluation matrices/scores, and bidding costs. Step 3 performs descriptive analysis to identify selection outcomes of BV-procured D-B-B projects and inferential statistics analysis to investigate the coefficient of variation among evaluation scores for competing bidders as well as the relationship between contractor bid costs and their respective evaluation scores on qualifications-based criteria. Step 4 discusses key findings. The following sections present data collection and data analysis in detail.

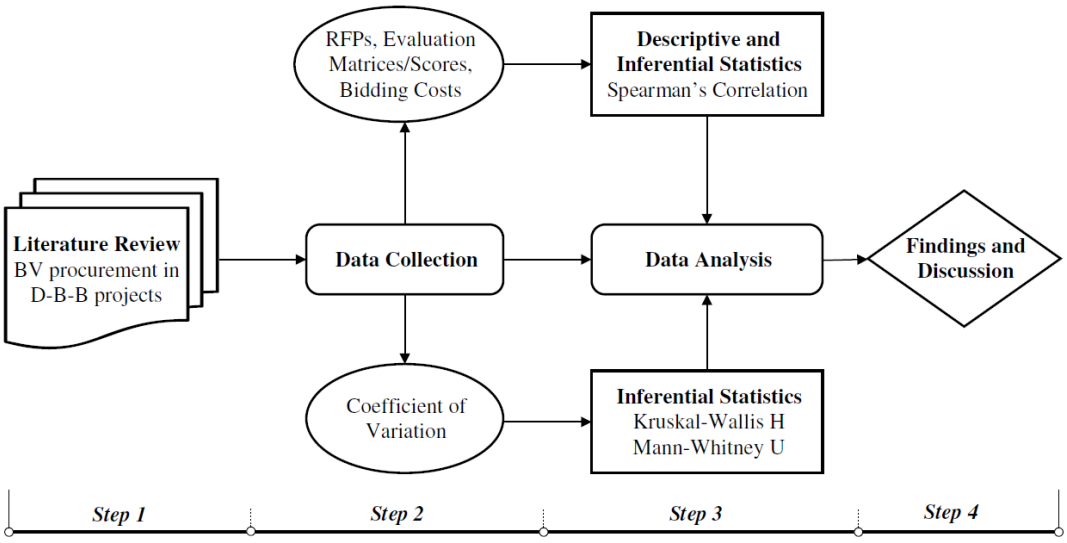

Fig. 1. Research methodology.

Data Collection

Initially, more than 177 BV-procured D-B-B construction projects were collected, including projects from both the horizontal and vertical sectors. Project records were collected for analysis rather than utilizing a survey methodology. The following project records were collected for each project included within the dataset: the project RFP, the owner's evaluation matrix and associated evaluation scores of all competing contractors, and bid costs from all competing contractors. The final dataset was limited to projects in the North American vertical sector. All projects were procured by public owners in the institutional sector, including state, city, and municipal government agencies as well as elementary, secondary, and post-secondary school systems. The final dataset consisted of 162 projects that met the above criteria.

Within the data sample, the projects were filtered to ensure similar construction scopes, facility types, and BV procurement procedures. All projects were vertical construction within institutional facilities. The scopes were largely consistent in terms of the functional use of the buildings, which mainly consisted of classrooms, laboratories, and office spaces. The majority of projects were renovations, and, upon inspection, no substantial difference was found between the procurement procedures nor contractor proposal responses for new construction and renovation projects, likely due to the similarity in owner organizations, facilities, and construction scopes. Furthermore, all projects in the data sample utilized virtually identical BV procurement procedures, including virtually identical evaluation criteria, similar weighting schemes, and consistent evaluation scoring procedures within the owners' RFPs.

The BV procurement processes within the data sample considered similar evaluation criteria centered on both qualifications (technical proposal, past performance, contractor interview scores, and safety) and non-qualifications (cost and schedule) items. Table 1 shows descriptive statistics related to the evaluation weights for each individual evaluation criteria as established within the owner's RFP document.

Table 1. Descriptive statistics for evaluation criteria weights

Criterion	*n*	Range (%)	Minimum (%)	Maximum (%)	Mean (%)	Median (%)	Standard deviation
Cost	162	40.0	10.0	50.0	25.7	25.0	6.5
Technical proposal	162	38.0	10.0	48.0	32.8	35.0	6.9
Past performance	158	42.0	3.0	45.0	14.8	15.0	8.7
Contractor interview	100	30.0	10.0	40.0	27.9	30.0	5.4
Schedule	106	18.0	2.0	20.0	8.5	7.0	4.5
Safety	43	29.0	1.0	30.0	9.4	10.0	4.1

It is noted that the evaluation weights shown are normalized to a one-hundred percent scale to show the relative importance the owners placed on each evaluation criteria. For example, the cost criterion examined from 162 projects was found to have a median of 25 percent of the total evaluation weight, whereas the remaining 75 percent of the weight was distributed in the schedule and other qualifications-based criteria. The evaluation criteria were analyzed in isolation to understand the ranking of selected contractors, differential in evaluation scores between selected contractors and their competitors, coefficient of variation in evaluation scores among competing bidders, and relationships between bidding costs and qualifications-based criteria evaluations.

The owner's evaluation matrix from each project in the data sample (N=162) was reviewed. Each project's evaluation matrix contained the owner evaluation committee's scoring results for every contractor proposal submitted (a total of 684 separate contractor proposals, which gives an average of 4.2 proposals

per project). The owner evaluation committees provided a separate evaluation score for each qualifications-based criteria on a 0 to 100 percent evaluation scale. The evaluation matrices also included the numerical dollar values of the bid costs each contractor submitted as well as the proposed schedule duration of the construction phase. Table 2 summarizes the project information including the cost, schedule, and bids.

Table 2. Summary of project information

Category	Sum
Total number of projects (n)	162
Total awarded cost	$315,255,527
Mean awarded cost	$1,946,022
Standard deviation of awarded cost	$6,324,127
Maximum awarded cost	$65,605,923
Minimum awarded cost	$22,500
Total awarded schedule (days)	11,293
Mean awarded schedule (days)	116
Standard deviation of awarded schedules (days)	82
Maximum awarded schedule (days)	511
Minimum awarded schedule (days)	19
Total number of bids	684
Mean bid per project	4
Maximum bid per project	12
Minimum bid per project	1

Descriptive Statistics and Ranking Analysis of BV Procurement Selection Outcomes

To address the first research question, two areas of investigation were conducted to understand the selection outcomes of BV-procured D-B-B projects. First, the ranking of selected contractors in terms of both cost and qualifications-based criteria was analyzed. This information is of interest to owners because, by definition, a BV procurement process has the potential to result in the selection of a contractor who is neither the lowest bid nor the best qualified. Owners are therefore interested to understand the characteristics of selected contractors to understand whether BV achieves an appropriate balance between cost and qualifications criteria.

To establish the selection criteria rankings, the selected contractor's ranking within the cost criteria was determined by identifying the lowest bid within each project as the top-ranked cost proposal, and then ranking all other proposals in order from least to most expensive. From a qualifications-based perspective, contractors within each project were also ranked according from the greatest to least total evaluation scores received (technical proposals, past performance, contractor interviews, and safety).

The second area of investigation for BV selection outcomes focused on the differential in proposal scores received by the selected contractors in comparison with the lowest and average bidders for each project. First, the average rank and evaluation scores of selected contractors were determined. Second, the average evaluation scores for the lowest bid and the average bid, which is the average of the bid costs, were calculated. The percent differential between the low bid and average values was then calculated in relation to the selected contractors to determine whether owners were achieving substantial improvements in qualifications-based criteria.

Coefficient of Variation among Competing Bidders for Each Evaluation Criteria

To address the second research question and its associated hypothesis, the coefficient of variation (CV) of each evaluation criterion was calculated and analyzed. CV is a statistical indicator of dispersion of variables, known as relative standard deviation, and is reported as a percentage. CV is calculated by the ratio of the standard deviation to the mean and only valid with the ratio scale data (Abdi 2010; Hopp and Spearman 2008; Poshdar et al. 2014). A key feature of CV is to represent the magnitude of variability in relation to the mean (Hopp and Spearman 2008). In this study, CV values were calculated for each evaluation criteria (cost, schedule, technical proposals, past performance, contractor interviews, and safety) as a measure of dispersion among competing bidders. The resulting CV data was then analyzed to determine whether the separate evaluation criteria achieved varying levels of dispersion. In this manner, evaluation criteria that achieved higher values for CV can be considered to achieve greater dispersion (or differentiation) between competing bidders.

Although CV is primarily used with descriptive statistics, it has been utilized with statistical inferences, such as testing hypotheses and estimating parameters, in many scientific fields (Curto and Pinto 2009; Forkman and Verrill 2008; Forkman 2009; Kelley 2007; Tian 2005). Using inferential statistics for CVs is usually conducted under the normality assumption (Amiri 2016). Yet Miller (1991) affirmed that the use of non-parametric tests with distribution-free data in CV inferential testing can be statistically applicable and conclusive. Fung and Tsang (1998) mentioned Kruskal-Wallis H test in testing the equality of CVs despite the fact that this test is not truly powerful in determining the “exact” critical values in hypothesis testing.

Normality investigation was conducted with both Shapiro-Wilk test and Kolmogorov-Smirnov test in order to select appropriate statistical testing methods for the CVs. Observing p-values less than 0.05, the data were not normally distributed, and there was a rejection of using analysis of variance and relevant parametric testing methods. The Kruskal-Wallis H test was then selected, for it is a nonparametric test used to investigate whether there are statistical significance in differences between medians of two or more groups of independent variables. The Mann-Whitney U test was used as a post-hoc test for pairwise comparisons. Because of the differences in the distribution shape of the independent groups, the mean-rank differences was used for analysis instead of the medians in the post-hoc test.

Spearman’s Correlation Coefficient between Evaluation Scores for Each Criteria

To address the third research question and its associated hypothesis, the relationship was examined between each contractor’s proposed bid cost, proposed construction schedule duration, and their evaluation scores for each qualifications-based criteria. The data were not normally distributed with two normality tests (Shapiro-Wilk and Kolmogorov-Smirnov) and required an alternative of the Pearson’s correlation, which is the parametric testing method for continuous variables. A Spearman product moment correlation was performed for each bivariate pairing of evaluation criteria to determine whether associations existed between six evaluation criteria used within these BV-procured projects. The results of these analyses are discussed in detail below.

RESULTS AND DISCUSSION

This section summarizes the results associated with the key findings from the analysis to respond to the research questions: (1) Selection outcomes of BV-procured D-B-B projects; (2) Coefficient of variation among competing bidders; and (3) Relationship between qualifications-based evaluation criteria and bid costs.

Frequency of Lowest Bidding Cost and Best Qualifications Selections

BV selection outcomes within D-B-B projects appear to achieve a reasonable balance between LB and QBS procurement methods. As shown in Table 3, BV procurement resulted in the selection of the best-qualified contractors in approximately half of all cases (54.4%). Table 3 also shows that BV resulted in selection of the lowest-bid contractors in slightly less than half of cases (42.1%). One can observe from Table 3 that 67 percent of selected contractors (67% = 24.0% + 14.0% + 16.4% + 12.9%) were ranked among the top two bidders in both cost and qualifications criteria. Similarly, 88.3 percent of selected contractors were ranked among the top three bidders in cost and qualifications categories.

Table 3. Cost–qualifications ranking for selected contractors ($n = 162$)

	Qualifications				
Cost	1st (%)	2nd (%)	3rd (%)	≥4th (%)	Total (%)
1st	24.0	14.0	2.9	1.2	42.1
2nd	16.4	12.9	2.9	1.8	33.9
3rd	9.9	3.5	1.8	1.1	16.4
≥4th	4.1	2.4	0.6	0.5	7.6
Total	54.4	32.8	8.2	4.6	100.0

Note: Qualifications = technical proposal + past performance + contractor interview + safety proposal.

These findings imply that traditional LB procurement infrequently results in selection of the best-qualified contractor for the owner's specific project, as the lowest-bid contractor was also found to be the best-qualified contractor in less than a quarter of all cases (24%). Based on this finding, traditional LB procurement may reasonably be expected to select the non-best-qualified contractor in more than 75 percent of cases. One implication of this finding is that LB procurement methods may be less well-equipped for projects with greater risk, complexity, or unusual project constraints. In such projects, owners may prefer to seek a contractor with the greatest available expertise, experience, and technical skill sets, yet LB procurement may rarely select the best-qualified contractor among the pool of competing bidders. This result is in line with previous studies that have highlighted the importance of selecting the best-qualified contractor for complex projects (Molenaar et al. 2010; Yu and Wang 2012). On the other hand, it is noted that the ideal outcome of selecting both a contractor that was the highest qualified with the lowest bid cost occurred in nearly one-quarter of procurements.

Based on these findings, public owners are recommended to consider BV procurement for complex projects within the context of the traditional D-B-B delivery system. The inclusion of qualifications-based criteria, in addition to price, can better ensure that the owner secures a partnership with a contractor who is highly qualified to address the project's specific scope complexities. To achieve clarity in the evaluation of qualifications-based criteria, public owners are recommended to prioritize criteria that facilitate the greatest differentiation among competing contractor proposals. This study found that contractor technical proposals, contractor interviews, and safety proposals all resulted in relatively high dispersion

among competing bidder evaluation scores, which implies that these criteria are well-suited for evaluating the most qualified contractors during the proposal evaluation stage of a D-B-B project.

Frequency of Selection Rankings related to Technical Proposals, Contractor Interviews, and Bid Cost

An additional analysis was conducted to specifically identify selected contractor rankings in the areas of technical proposals, contractor interviews, and bid costs. As shown in Table 4, the selected contractor had the top-ranked technical qualifications in nearly 70 percent of BV procurements.

Table 4. Cost–technical proposal ranking for selected contractors ($n = 162$)

	Technical proposal				
Cost	1st (%)	2nd (%)	3rd (%)	≥4th (%)	Total (%)
1st	30.1	7.2	2.4	1.2	41.0
2nd	22.3	6.6	1.8	1.8	32.5
3rd	11.5	3.6	1.2	0.6	16.9
≥4th	5.4	0.6	1.2	2.4	9.6
Total	69.3	18.1	6.6	6.0	100.0

Table 4 shows that although the top-ranked technically qualified contractor was also the lowest bidder in 30 percent of cases. The top-ranked contractor was also among the two lowest bidders in more than half of cases and among the top three lowest bidders in nearly 64 percent of cases. This result indicates that technically qualified contractors were also the lowest bidder with more than 50 percent of the time in the BV environment.

Table 5 shows the rankings of selected contractors in terms of cost proposals and contractor interview evaluation scores. Selected contractors received the top-ranked contractor interview score in 73 percent of cases and were also the lowest bidder in 32 percent of cases.

Table 5. Cost–contractor interview ranking for selected contractors ($n = 162$)

	Contractor interview				
Cost	1st (%)	2nd (%)	3rd (%)	≥4th (%)	Total (%)
1st	32.0	7.2	1.0	0.0	40.2
2nd	26.8	2.1	3.1	0.0	32.0
3rd	7.2	4.1	3.1	0.0	14.4
≥4th	7.2	0.0	0.0	6.2	13.4
Total	73.2	13.4	7.2	6.2	100.0

It is noted that when the top-ranked contractor interview was selected, the contractor was among the top two lowest bid costs in nearly 60 percent of cases and top three lowest bid costs in more than two-thirds of cases (Table 5).

In BV-procured D-B-B projects, the selected contractor often achieves the highest score in both technical proposals and contractor interview. Table 6 shows that, in nearly 75 percent of cases, the D-B-B project owner selected a contractor with either the best technical proposal or the best contractor interview presentation. In addition, selected contractors ranked in top two of both contractor interviews and technical proposals in 88 percent of cases, which indicates that BV-selected contractors in D-B-B projects commonly demonstrate strong qualifications in both their written proposals and project team interviews.

Table 6. Contractor interview–technical proposal ranking for selected contractors ($n = 162$)

Contractor interview	Technical proposal				
	1st (%)	2nd (%)	3rd (%)	≥4th (%)	Total (%)
1st	59.8	13.1	2.2	2.2	77.2
2nd	9.8	5.4	0.0	0.0	15.2
3rd	4.4	1.1	1.1	1.1	7.6
≥4th	0.0	0.0	0.0	0.0	0.0
Total	73.9	19.6	3.3	3.3	100.0

Differential in Evaluation Scores between Selected, Lowest, and Average Bidders

In comparison with LB procurement, BV achieves substantial benefits associated with contractor qualifications and schedule proposals. As shown in Table 7, BV-selected contractors achieved greater evaluation scores in all of the qualifications-based criteria when compared to the lowest-bid contractors. For example, there were substantial increases in the quality of technical proposals and contractor interviews with a 21.2 and 15.1 percent differential, respectively.

Table 7. Differential between selected contractors and competing proposals

Evaluation criteria	Selected contractor average score (%)	Average bidder average score (%)	Lowest bidder average score (%)	Differential from average bidder (%)	Differential from lowest bidder (%)
Cost	—	—	—	−2.2	+6.8
Technical proposal	73.2	62.0	60.5	+18.2	+21.1
Past performance	94.4	92.2	92.5	+2.4	+2.1
Contractor interview	80.3	70.8	69.8	+13.4	+15.1
Schedule	—	—	—	−7.4	−6.8
Safety	63.9	62.3	61.8	+2.6	+3.3

One can observe from Table 7 that marginal improvements were also observed in BV-selected contractors' safety proposals (3.3% greater) and past performance (2.4% greater). BV-selected contractors also proposed shorter construction schedule durations on average (6.4% faster than the lowest-bid contractors).

Although BV procurement resulted in the selection of higher bid costs than traditional LB procurement, BV-selected contractors still represented lower costs than the average bidder. BV-selected contractors submitted bid costs that were 6.9 percent more expensive than the lowest-bid contractors. Yet in the broader context, BV-selected contractors were still 2.4 percent less expensive than the average bid cost. Table 7 shows that BV-selected contractors had substantial benefits compared with the average bidder in several qualifications-based criteria, such as technical proposals (17.9%), contractor interviews (14.2%), and schedule proposals (7.5%). Marginal gains compared with the average bidder were found in safety proposals (2.6%) and past performance (2.4%).

Coefficient of Variation among Competing Bidders for Each Evaluation Criterion

Table 8 summarizes descriptive statistics results of CV among competing bidders for each evaluation criteria.

Table 8. COV descriptive statistics

Statistic	Cost (%)	Technical proposal (%)	Past performance (%)	Contractor interview (%)	Schedule (%)	Safety (%)
Mean (%)	12.6	27.3	8.9	24.8	26.0	22.1
Median (%)	10.0	21.0	4.0	21.0	23.0	19.0
Lower bound of 95% confidence interval for mean (%)	11.1	23.3	6.3	20.6	21.7	16.3
Upper bound of 95% confidence interval for mean (%)	14.0	29.6	10.9	28.2	30.0	27.5
Standard deviation (%)	9.4	20.0	14.5	18.4	21.4	18.2
N (%)	158	158	152	92	103	43
Unit of measure	$	0–100%	0–100%	0–100%	Days	0–100%

The CV values for each evaluation criteria represent a measure of dispersion among competing contractor proposals, where larger CV values may be interpreted to correspond with an evaluation criteria that results in greater differentiation in evaluation scores between competing bidders. In the context of inferential statistics, results of the Kruskal-Wallis H test revealed a statistically significant difference (χ^2 = 167.1, p = .000) among the CV values for the six separate evaluation criteria, including technical proposals, past performance, contractor interviews, schedule proposals, and cost proposals. The results lead to the acceptance of the research hypothesis, affirming that the CV of evaluation scores among competing bidders has a statistically significant difference for separate evaluation criteria.

Post-hoc analysis was conducted via the Mann-Whitney U test to determine which pairs of evaluation criteria had statistically significant differences in CV values. Assessment of pairwise results provided in Table 9 identified three groupings of evaluation criteria with statistically significantly different CV values. The first group contained four evaluation criteria which had the largest CV values, including technical proposals ($\bar{x}$ = 27.3%, Med=21.0%), schedule ($\bar{x}$ = 26.0%, Med=23.0%), contractor interviews ($\bar{x}$=24.8%, Med=21.0%), and safety ($\bar{x}$=22.1%, Med=19.0%). The second group consisted solely of cost proposals, which had moderate CV values ($\bar{x}$ =12.6%, Med=10.0%) that were statistically significantly different than all other evaluation criteria. The third group had the lowest values of CV and consisted solely of past performance ($\bar{x}$=8.9%, Med=4.0%).

Table 9. Mann-Whitney U test for COV pairwise comparisons

Base evaluation criteria	Comparison evaluation criteria	Mean rank difference	Mann-Whitney U	*z*-score	*p*-value (2-tailed)
Cost	Technical proposal	−78.46	6,283.00	−7.63	0.00[a]
	Past performance	72.13	6,420.00	−7.08	0.00[a]
	Contractor interview	−52.49	4,216.00	−5.54	0.00[a]
	Schedule	−51.39	4,932.50	−5.38	0.00[a]
	Safety	−33.61	2,261.00	−3.36	0.00[a]
Technical proposal	Past performance	103.67	3,976.50	−10.18	0.00[a]
	Contractor interview	5.68	6,938.00	−0.60	0.55
	Schedule	5.36	7,802.50	−0.56	0.57
	Safety	14.50	2,907.00	−1.45	0.15
Past performance	Contractor interview	−69.58	3,004.50	−7.46	0.00[a]
	Schedule	−76.51	3,130.50	−8.13	0.00[a]
	Safety	−55.42	1,410.50	−5.69	0.00[a]
Contractor interview	Schedule	−1.00	4,689.50	−0.12	0.90
	Safety	6.04	1,801.00	−0.84	0.40
Schedule	Safety	6.87	2,006.00	−0.90	0.37

[a]Statistical significance at the 0.05 level (2-tailed).

The CV results lead to several discussion points. First, this study found relatively higher CV values for technical proposals, contractor interviews, and safety proposals as compared with cost proposals. These results therefore indicate that substantial dispersion exists in the level of qualifications between competing contractors, even in D-B-B projects where contractors are proposing on a largely static scope represented by a complete set of contract documents. These results support the AGC's (2017) position that contractors are not a commodity; rather, construction can be considered as a professional service where procurement processes emphasize the evaluation of qualifications-based criteria.

A second discussion point is that there is relatively low dispersion among the bid costs of competing contractors within D-B-B projects. Analysis of all contractor bids revealed the CV between competing bids to be fairly low in comparison to other evaluation criteria on a per project basis ($\bar{x}$ = 12.6%, Med=10.0%). Owners can therefore anticipate competing contractor bids to be fairly consistent within the context of D-B-B projects. This is likely explained by the fact that contractors are bidding upon a 100-percent complete set of contract documents, which means that the project scope is fully defined and contractor estimates are based upon nearly identical project parameters, material quantities, and specifications. This finding further supports Yu et al.'s (2013) call for the appropriate use of multi-criteria BV procurement for construction services rather than single-criteria methods such as LB procurement.

Relationship between Qualifications-Based Evaluation Criteria and Bid Costs

In BV-procured D-B-B projects, the level of qualifications a contractor brings to a project was found to have no direct association with their bid cost. All contractor bids from the data sample were normalized against the low bid alternative and the average bid on a per project basis. As shown in Table 10, neither measure of contractor bid cost was found to have a statistically significant correlation with the qualifications-based criteria of technical proposals, contractor interviews, nor safety proposals. Contractor bid cost compared with the lowest bid alternative did have a statistically significant and inversely proportional correlation with past performance; however, the correlation coefficient (r_s= –0.109) was so weak that it represented no association of practical significance to the industry (Zou et al. 2003). Therefore, the research hypothesis that greater evaluation scores for qualifications-based evaluation criteria correspond with greater bid costs was rejected.

Table 10. Spearman's correlation of all evaluation criteria versus lowest bid and average bid

Code	Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	Cost versus lowest bid	1	—	—	—	—	—	—
(2)	Cost versus average bid	0.797[a]	1	—	—	—	—	—
(3)	Technical proposal	–0.057	0.013	1	—	—	—	—
(4)	Past performance	–0.109[a]	–0.057	0.034	1	—	—	—
(5)	Contractor interview	–0.091	–0.030	0.131[b]	0.169[a]	1	—	—
(6)	Schedule	–0.030	0.026	–0.125[a]	–0.007	0.209[b]	1	—
(7)	Safety	0.053	0.035	0.024	–0.019	0.050	–0.054	1

[a]Significant at the 0.01 level (2-tailed).
[b]Significant at the 0.05 level (2-tailed).

When owners determine that a contractor has demonstrated greater qualifications than their competitors, this study found no evidence that the contractor's corresponding bid cost would be higher than competing bids. This result was somewhat surprising since conventional wisdom holds that firms with greater qualifications may command higher fees (Yu et al. 2013). A potential explanation is that

qualified contractors may be leverage their experience and technical expertise to execute the construction phase more efficiently than their competitors, which can lead to overall cost savings and in turn result in competitive bid costs. This is supported by the fact that 67 percent of BV-selected contractors ranked among the top two bidders in both cost and qualifications criteria and 88.3 percent of were ranked among the top three. In this manner, the results of this study clearly indicate the ability of BV procurement to provide construction owners with a selection outcome that balances cost and qualifications-based criteria.

CONCLUSION, CONTRIBUTIONS, AND LIMITATIONS

Along with the growth of BV procurement across the construction industry, construction owners have gradually viewed BV as an appropriate option for D-B-B projects. Yet few owners have direct experience in applying BV procurement within the context of the D-B-B delivery system. To bridge this gap, this research aimed to build upon the existing literature, which lacks extensive empirical datasets on this increasingly relevant topic, and explore the implementation of BV procurement in D-B-B projects. Toward this end, the authors quantitatively analyzed each project's RFP and evaluation matrix, which included all bidding and evaluation scoring data for every participating contractor's BV proposal (N=684), via both descriptive and inferential statistics.

This study found that BV procurement achieves a balance between LB and QBS procurement methods in that BV resulted in selection of the best qualified contractor in more than half of cases and the lowest bid contractor in slightly less than half of cases. BV-selected contractors ranked as the top qualified and lowest cost bidder in nearly a quarter of the time, ranked in the top two of qualifications and cost in 67 percent of the time, and top three in 88 percent of the times. BV-selected contractors also had substantially greater qualifications when compared with lowest bidder and average bidder alternatives. Owner evaluation scores for qualifications-based criteria were found to have statistically significant greater CV values than cost proposals, indicating that a range of contractor qualifications is readily discernable in D-B-B procurement scenarios. Finally, no statistically significant relationship was found between owner evaluation scores of contractor qualifications-based proposals and corresponding bid costs. This suggests that more qualified contractors do not necessarily come at a premium, perhaps due to their ability to deliver the construction phase more efficiently.

Research Contributions

The current body of knowledge lacks extensive and quantitative data sets of BV procurement applied within D-B-B delivery system. This study takes a first step in addressing this gap by compiling empirical data from 162 D-B-B projects procured via BV. As a contribution to the current BV literature in construction, which is mainly focused on the horizontal sector, this study assembled a dataset comprised entirely of vertical construction projects. The unit of measurement within this paper also contributes an analysis of the evaluation scores determined by the owner evaluation committee for each bidder (both selected and unselected) within the data set. Previous studies have more commonly focused on owner weighting of evaluation criteria rather than the evaluation scores themselves, and rarely included data from all competing bidders.

This study also provides several contributions to industry practitioners within both owner and contractor organizations. First, the empirical results demonstrate that BV procurement achieves a reasonable balance between LB and QBS methods and that LB-procured projects will rarely select the best qualified

contractor. This finding may serve as motivation for owners to increasingly consider BV as an appropriate procurement option for D-B-B projects in situations where it would be beneficial to hire a contractor with impressive qualifications. Furthermore, the results refute the perception that greater qualifications will be correlated with higher bid costs, meaning that owners do not have to pay a substantial premium to partner with more highly qualified contractors. Finally, analysis of competing contractor proposals found larger dispersion among qualifications-based criteria than in cost proposals, which supports the viewpoint of numerous design and construction professional organizations that advocate construction as a professional service rather than a commodity. This information is also beneficial for construction contractors to strategize their proposal development efforts when participating in a BV procurement; that is, a contractor has greater opportunities to differentiate themselves from competing contractors in their qualifications-based proposal submissions than in their bid cost.

Limitations and Recommendations for Future Research

A limitation of this study was that project closeout data (in terms of final cost and schedule growth) was not available in the dataset. Although the scope of this paper was focused on the bidding stage, future studies are recommended to collect final cost and schedule performance data for BV-procured D-B-B projects. This additional data on cost and schedule growth would enable researchers to more clearly identify project performance implications of BV procurement.

Another limitation of this study was that the dataset was restricted to vertical construction projects in the public institutional sectors. The current body of knowledge would benefit from future studies that compile data from other areas of the vertical sector, including private construction owners and projects in the commercial, healthcare, and residential sectors. Similar empirical datasets could also be collected from the horizontal, manufacturing, and power generation sectors of the construction industry.

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