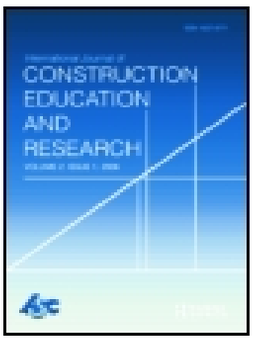

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An Empirical Study to Assist Owners in Selecting the Right Procurement Method for Design-Build Projects

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ABSTRACT

In design-build (DB), owners use procurement methods such as best value, qualification-based and sole source to offer a more objective approach when selecting design-builders. The aim of this study was to provide an empirical analysis that can assist the procurement method decision by examining how different project characteristics influence the procurement method selection and comparing DB project performance within the different procurement methods. The study statistically analyzed 160 DB projects completed between 2008 and 2019 worth over $14 billion. The results showed that best value is the most predominantly used procurement method and project characteristics such as project type, owner type, and contract method affect the selection of procurement methods significantly. Best value procurement is more likely to use lump sum contracts while qualification based is more likely to use GMP. Civil infrastructure projects and public owners tend to use best value more frequently while private owners use qualification based more often. In terms of performance comparison, projects with qualification-based procurement have better schedule performance while those with sole source have better cost performance. The findings provide practical considerations for owners in selecting the right procurement method for their projects, which can lead to improved delivery of DB projects.

KEYWORDS

Procurement method; design-build; best-value; qualification-based; sole source; performance; project characteristics

Introduction

For most of the twentieth century, construction projects were primarily completed under the design-bid-build (DBB) delivery method (Bilbo et al., 2015), which predominantly used the low-bid procurement method. While the low-bid procurement method has a long-standing legal precedence and has promoted open competition, it has also been recognized to have some major drawbacks (Scott et al., 2006). First, a system based strictly on the lowest price encourages contractors to implement cost-cutting measures instead of quality-enhancing measures, which makes it less likely that contracts will be awarded to the best performing contractors who will deliver the highest quality of projects (Scott et al., 2006). Second, there is the possibility of awarding a contract to a contractor that accidentally submits an unrealistically low-bid price. Often, such an occurrence works to the owner's and contractor's detriment by promoting disputes, increased costs, and schedule delays (Ioannou & Leu, 1993).

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Consequently, owners have shifted toward the use of other procurement methods with the proliferation of alternative project delivery methods (Scott et al., 2006) such as design-build (DB), construction manager at risk (CMR), and integrated project delivery (IPD). Each project delivery method has a few procurement options for selecting the winning contractor. According to Molenaar and Gransberg (2001), the three predominantly used procurement methods in DB projects are best value, qualification-based, and sole source. These procurement methods are intended to offer a more objective approach to evaluate a prospective contractor and allow the incorporation of different evaluation factors (El Wardani, 2004).

The selection of the appropriate procurement method for DB projects is an important decision for owners because it leads to the selection of the DB team. Obviously, the selection of an ill-qualified DB team can be particularly acute to project performance because the team can cause serious problems to both the design and construction of a project (El Wardani et al., 2006). In fact, a study conducted by Sanvido et al. (1992) found that among several factors, the selection of the right team that is effectively structured is essential to ensure a successful project delivery for different delivery systems. Moreover, since DB relies on contracting with a single entity to deliver the project, the procurement method used to select this entity should be comprehensive as much as possible to ensure successful performance of the project (El Wardani et al., 2006). However, the procurement method for a DB project is not only critical but can be more complex than for other delivery systems (Palaneeswaran & Kumaraswamy, 2000). This is because different factors can affect the choice of the procurement method in DB. For example, different contract methods such as lump sum and guaranteed maximum price (GMP) may also require different procurement methods so as to facilitate contractor evaluation (Chen et al., 2015). Additionally, each procurement method may have different implications on project performance and objectives. As such, the selection of a procurement method for DB projects must be given all the necessary considerations.

The aim of this study is to provide owners with a basis to decide how to select the best DB team by using the appropriate procurement method for their projects. The following objectives are outlined to achieve this aim: (1) to investigate whether project characteristics such as project type, owner type, and contract method influence the choice of procurement method; (2) to compare project outcomes in terms of cost and schedule performances between the different procurement methods for DB; and (3) to investigate whether there is an interaction between project characteristics and procurement methods regarding project cost and schedule performance. This research contributes to the current body of knowledge and facilitates further research by revealing the effect of associated project characteristics on the procurement method selection and providing empirical evidence on the cost and schedule performance of the procurement methods on DB projects. In general, the results of this study can assist owners in selecting the right procurement method for their projects, which can lead to improved delivery of DB projects.

Design-build procurement methods

Different procurement methods have been proposed for DB projects (El Wardani et al., 2006). However, this paper focuses on the predominantly used procurement methods as

derived from the data collected. This section provides an overview of the definition of procurement method and the different procurement methods used in this research.

"Procurement method" has been defined in many ways by different researchers. For example, according to El Wardani (2004), procurement method is the approach an owner follows to select a contractor to provide required services under a chosen project delivery system. Molenaar et al. (2010) also defined procurement method as the process of buying and obtaining the necessary property, design, contracts, labor, materials, and equipment to build a project. Similarly, Molenaar et al. (2009) defined procurement method as the process of selecting designers and constructors and purchasing the services and goods of those firms. From these definitions, the common characteristics of procurement method can be summarized as a process of selecting and hiring a team for the design and construction of a project.

In design-build (DB), the owner contracts with a single entity to provide both the design and construction services (Adamtey, 2019; Evbuomwan & Anumba, 2010). The owner therefore has one opportunity to select and hire both the architect and the contractor at the same time. This is critically important because the selection and hiring of an ill-qualified team will affect both the design and construction giving the owner no recourse to correct any errors in the design before construction like it could in DBB. However, the use of the appropriate procurement method can minimize this risk by ensuring the selection of the right DB team for the project (El Wardani et al., 2006). For this research, the DB procurement methods were limited to best value, qualification-based, and sole source based on the data collected. It is important to state that although low-bid procurement has been used in DB, it is deemed inappropriate for DB projects as owners need to provide detailed design information in requests for proposals (RFPs) and this will prevent innovative input from design-builders (Molenaar & Gransberg, 2001; Xia et al., 2013).

Best value selection

In this procurement method, the owner selects the design-builder by evaluating both technical and cost information in the submitted proposals (Beard et al., 2001). The cost aspect covers items such as the contractor's construction fee, overhead, and profit, while the qualification/technical proposal typically includes a combination of the following: past performance, schedule, safety, technical approach, experience of management personnel, and financial capacity (Alleman et al., 2017). Best value procurement begins with the owner establishing a selection criterion based on the specific qualitative and quantitative factors they desire. A weighting criterion is used to assign weights to each of the factors to be evaluated (El Wardani et al., 2006). Prospective DB teams submit their proposals based on these factors and criteria and the owner selects the package offering the best value based on the evaluation.

Best value procurement could be a one or two-step process. In the one-step process, the owner issues only an RFP and the design-builders submit proposals that are evaluated based on both technical and cost factors. It is common for negotiations to occur after the proposal submittal phase before the contract award. The two-step selection process occurs where the owner first issues request for qualifications (RFQ) and then follows by RFP. Through the RFQ, the owner typically pre-qualifies a short list of design-builders who demonstrate the necessary experience, reputation, financial resources, and other qualifications to complete

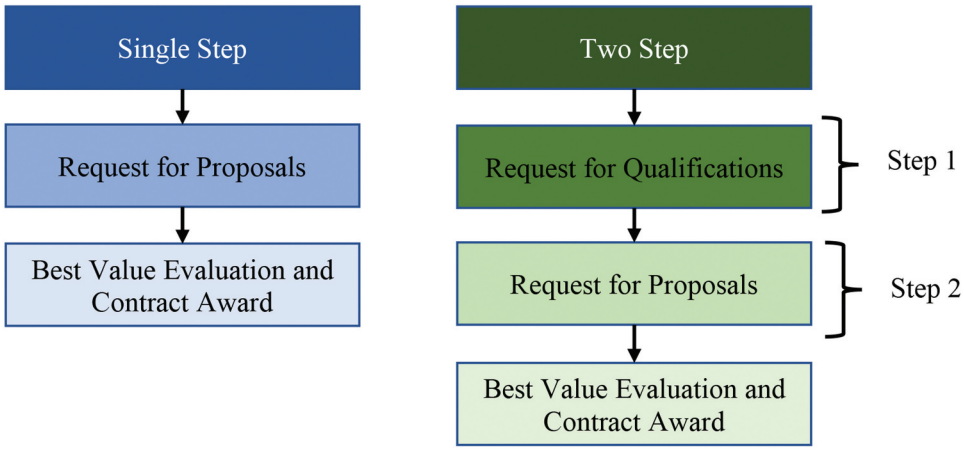

Figure 1. One-step and two-step procurement processes.

the project (American Society of Civil Engineers, 2012). The owner then issues an RFP only to the short-listed firms. Typically, the proposals are required to have about 35% of the design complete (Gransberg & Molenaar, 2019). Figure 1 illustrates the one and two-step selection processes. According to Haskell (2018), best value selection is most successful where project requirements can be identified and set forth in the criteria package. It is also deemed to be the superior approach where procurement policy (public or private) requires price-based competition (Haskell, 2018).

It is a common practice for owners to pay stipends to proposers to defray the cost of preparing their proposals, especially for large-scale DB projects in the private sector (Gehrig, 2015). The stipends are frequently set between 0.01% and 0.25% of the project budget, considering what is required to generate enough market interest from the most highly qualified design-build teams (DBIA, 2010). While some firms will submit proposals in the absence of a stipend, some qualified firms may stay away especially if the RFP requirements necessitate the expenditure of significant monies by the design-build proposers (DBIA, 2010). As such, the stipend does not only help to cover expenses incurred by proposers, but to provide an incentive for qualified design-builders, which will improve competition.

Qualification-based selection

Under qualification-based procurement, the owner selects the design-builder solely on qualifications or qualitative factors such as experience, financial capability, and proposed project team, without any price factor (Molenaar et al., 2009). This method allows owners to define their goals and selection criteria so that they can select the DB team that best responds to their criteria. In addition to the qualifications, experience and past performance of the DB team, qualification-based procurements for design-builders will often include such criteria as (a) the capacity of the DB team to perform the work; (b) the design-builder's management plan for the project; and (c) project-specific ideas that demonstrate the design-builder's ability to innovate and think outside the box (DBIA, 2012).

After selection, the owner often negotiates the contract directly with the team to a "fair and reasonable" price (El Wardani et al., 2006). The selected design-builder provides design services beginning with project definition and programing (Haskell, 2018). Since the qualification-based permits the owner to bring the design-builder into the project at the outset, this approach is particularly suited to projects where the complexity, technical risks, and/or evolving scope make it difficult to prepare a clear and stable criteria package at the outset (Haskell, 2018).

Sole source procurement

In sole-source procurement, the owner awards the contract through negotiation with one firm (Molenaar et al., 2009). Owners generally employ this when the scope is undeveloped and either there is only one known capable supplier (public projects) or the owner has a specific company that it trusts based on past experience (private projects) (Molenaar et al., 2009). This procurement method falls into the category of noncompetitive negotiation. Since public owners may have a limit of scope and price beyond which they must conduct competitive bidding, this method may not be favorable for most public DB contracts. The major drawback of this method is that the lack of a price competitiveness factor may not provide the best value for the owner.

Literature review

An extensive literature review was conducted to find related published research on DB procurement methods. Many studies have been conducted on DB and procurement methods for different alternative delivery methods. However, there was limited research on procurement methods specifically for DB. Since this study is focused on DB, only studies pertaining to DB procurement methods were reviewed. The goal of this review was to provide a foundation of knowledge on procurement methods in DB from previous studies and identify the gaps that this research is focused on filling. This section provides the surveyed literature.

A study by El Wardani et al. (2006) quantitatively analyzed the correlation between DB procurement methods and the performance of DB projects with regard to cost, time, and quality metrics. The authors collected data from 76 DB projects in the United States with completion dates ranging from 1984 to 1997 through surveys. With regard to the cost growth metric, the study found that low-bid-procured projects had the highest cost growth while qualification-based procurement had the lowest cost growth. In terms of schedule growth metric, best value procurement had the best outcomes, and qualification-based had the highest percent of schedule growth. The authors concluded that the data analysis did not show one procurement method to outperform the others with regard to all the metrics analyzed. However, a major limitation of this study was that the authors could not perform any statistical verification due to the small sample size.

Molenaar et al. (2010) synthesized the current state of practice for best value procurement of sustainable design-build projects within the public sector. The authors analyzed the procurement documents of 26 projects using content analysis. Although the best value procurement processes have adapted to the growing demands of efficiency, quality of work, and the overall success of green buildings, the results showed that significant opportunities for

improvement still exist. This is because owners are missing opportunities to evaluate design-builders on sustainable building experience and sustainability of the proposed design in project management plans. The study found that owners can better their project outcome by evaluating the design-build teams on sustainability aspects of the project such as sustainable building practices and sustainable project management techniques. Modifying the solicitation documents to include these elements could improve the overall success of delivery.

Sawyer et al. (2015) studied the qualification-based procurement method of construction by evaluating the three major criteria categories of past performance/technical capability, key personnel, and project cost. The data in this study was collected from 58 construction projects and was evaluated for which portions of the submitted proposals are the most important. The findings of this study revealed the following: (1) key personnel were statistically more important than the price of the project; (2) contractors should respond to qualification-based selection using their strongest team members; and (3) contractors should prepare their teams for the interview process. The data also indicated that for this style of procurement, price is a minimal factor when owners are considering contractors, but the interview process provides room for contractors to really set themselves apart from the competition.

A recent research was conducted by Shalwani et al. (2019) to provide practical guidance for owners and bidders regarding how to prioritize evaluation criteria and how to respond to them when using best value and qualification-based procurement on DB and construction manager at risk (CMAR) projects. The authors documented the selection outcomes of the bidders and identified which evaluation criteria had the greatest differentiation in scores for competing bidders. The results were compared with previous research on the procurement of architectural and engineering consultants and design-bid-build (DBB) contractors. The statistical analysis results showed that scores on interviews and technical proposals had the greatest differentiation, while cost proposal scores had minimal differentiation.

Gaps in previous studies

The reviewed literature did not only reveal that there is limited research addressing the relationship between the use of a particular procurement method and project performance but it also showed that there is no comprehensive study comparing procurement methods taking into consideration project characteristics such as contract type, type of owner and type of projects. The one study by El Wardani et al. (2006), which involved performance comparison of the procurement methods did not only include any statistical analysis due to limitations on the sample size, but also did not consider the influence of project characteristics on the choice of procurement method. This study fills this gap by analyzing the data collected from real DB projects with statistical tests to determine the performance comparison of the procurement methods and the effect of the associated project characteristics on procurement method selection. In addition, this study investigates whether there is an interaction between project characteristics and procurement methods regarding project cost and time performance.

Research method and data description

This research employed quantitative data analysis using statistical methods to achieve the research objectives. Quantitative research is about collecting and analyzing data to explain

a phenomenon (Carr, 1994). The research approach involved the collection of data followed by statistical analysis using ANOVA and Chi-square test.

One of the most important and vital aspects of any research study is the identification and collection of the appropriate data. According to Leedy and Ormrod (2010), there are two main sources of data, namely, primary and secondary data. While primary data is collected using methods such as surveys, experiments, or direct observations, secondary data is derived from primary data and may include diverse sources of documents or electronically stored information. Although primary data is considered closer to the "truth" (Leedy & Ormrod, 2010), secondary data is equally acceptable and has been used in many studies.

The data used for this research was secondary data collected from the Design Build Institute of America (DBIA) database, which is available at https://projects.dbia.org/Home/Search. The secondary data was used because of its accessibility, which is critical for any research, and the acceptance of secondary data in many studies. The DBIA, founded in 1993, defines, teaches, and promotes best practices in design-build. It is comprised of architectural, engineering, and construction professionals, as well as academics, students, and project owners. At the time of the data collection in February 2020, there were 251 DB projects in the database. However, only 160 projects had all the information needed for the analysis. Thus, projects missing relevant information were not selected for this research. One project constructed in Singapore was also removed from the data. The 160 projects were completed between 2008 and 2019 and worth over 14 USD billion. The projects were constructed in the following 34 states: Arizona, Alaska, California, Connecticut, Colorado, Florida, Georgia, Hawaii, Illinois, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Missouri, Minnesota, New Hampshire, Nevada, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Texas, Tennessee, Vermont, Virginia, Washington, and Washington, DC.

A simple tabulation method in Microsoft Excel was used for the data collection. The tabulation was divided into the three procurement methods and projects were put into their respective methods. After the data collection, a cross-check was conducted by comparing the collected quantitative data with the data in the database to ensure accuracy before performing the data analysis. The following information was collected on each project: project name/description, project location, project size, type of project, type of owner, procurement method, contract method, contracted start date, contracted completion date, actual start date, actual completion date, contracted project cost, and actual project cost.

Data description

The distributions of project characteristics in terms of project type, owner type, procurement method, and contract method are summarized in Table 1. DB has been used to construct almost all types of projects. The most dominant project type in the data is institutional buildings, followed by civil infrastructure projects and industrial facilities. Only one residential project was found in the data.

The owners were grouped into public and private. The public owners include federal, state agencies, and local or municipal governments while the private owners include private corporations or organizations, individuals, developers, and nonprofit organizations. The number of public projects in the data is more than twice that of the private owners. This is

Table 1. Distribution of project characteristics.

Characteristic	Frequency	Percent (%)
Project type		
Civil infrastructure projects	36	22.5
Commercial buildings	23	14.38
Institutional buildings	51	31.88
Residential buildings	1	0.68
Industrial facilities	34	21.25
Healthcare buildings	15	9.38
Owner type		
Public	109	68.13
Private	51	31.88
Procurement method		
Best value	86	54.00
Qualification based	56	35.00
Sole source	18	11.00
Contract method		
Lump sum	70	43.75
Guaranteed maximum price (GMP)	51	31.88
Cost-plus fee	13	8.13
Other	26	16.25

contrary to the fact that DB is relatively new in the public sector but has been a common delivery method in the private sector for several decades (Gehrig, 2015) thus it is expected to have more completed projects than the public sector. Perhaps, the majority number of public owners in the data could be due to the fact that it is relatively easy to access public data.

Of the procurement methods used, best value is the most common method, followed by qualification-based and then sole source as shown in Table 1. As noted by Gransberg and Senadheera (1999), the best value procurement method preserves the benefit of being able to tailor the evaluation plan to the specific needs of each project, and rate the qualifications of both designer and builder. This flexibility may be a contributing factor to be the most dominant procurement for DB projects. Additionally, best value selection has been known to provide owners with the best combination of performance qualifications and price (Nguyen et al., 2018).

Regarding the contract methods used, lump sum is the most dominant contract type in the database. This is consistent with Chen et al. (2016). With lump-sum contracts, the design-builder agrees to complete the project for a fixed price and assumes the risk of cost overruns. The second most popular contract, guaranteed maximum price (GMP), establishes a price that cannot be exceeded and is usually negotiated based on conceptual planning documents rather than the more detailed plans and specifications used in traditional competitive bidding (Xia et al., 2013). It provides owners with the benefit of an overall cap on project cost. For cost-plus-fee contracts, design–builders are paid based on their actual costs (subcontractor costs, labor, materials) plus a fee that can be a fixed amount, or a percentage of final cost, to cover overheads and profit.

Statistical analysis

The Pearson Chi-square Test of cross-tabulations (contingency tables) was used to evaluate whether there were statistical relationships between project characteristics and procurement methods. The Pearson Chi-square Test is a statistical method that can be

Table 2. Levene's test.

Performance metrics	Levene Statistic	Degrees of freedom	*P* value
Cost	2.089	2	0.127
Schedule	2.409	2	0.093

used both as test of goodness-of-fit and as a test of independence (McDonald, 2009). As a test of independence, it is used to determine whether two categorical variables are associated with each other (Runyon et al., 2002). In this study, the project characteristics and procurement methods are categorical variables. The null hypothesis tested was that there was no relationship between project characteristics and procurement methods. For the null hypothesis to be false or to be rejected, the p value must be less than or equal to 0.05.

The one-way analysis of variance (ANOVA) test was conducted to determine whether there was any statistically significant difference in cost and schedule performance between the procurement methods. The null hypothesis was that there was no difference in the mean performance metrics (cost and schedule) of the procurement methods. For the null hypothesis to be false, the p value should be less than or equal to 0.05. To be able to conduct ANOVA, the following assumptions must be met: (1) the dependent variables must be continuous, (2) the dependent variables must be normally distributed, and (3) there must be homogeneity of variance among the groups. Although the first two assumptions have been met by the nature and the number of data in the sample, the third assumption had to be tested using the Levene's Test of homogeneity of variances as shown in Table 2. The null hypothesis for the Levene's Test was that the variances of the dependent variables (procurement methods) were equal. Since p (0.127 and 0.093) >0.05, the null hypothesis was not rejected. This means that the procurement methods have equal variances and hence the assumption is satisfied.

The two-way ANOVA was used to determine whether there was any interaction between procurement methods and project characteristics (project type, owner type, and contract method) regarding project cost and time performance. The assumptions for normality and variance equality are the same as the one-way ANOVA, which have been satisfied. The null hypothesis was that there was no interaction between the procurement methods and project characteristics.

Results

Relationship between project characteristics and procurement methods

The Chi-square Test performed between project type and procurement method indicates that the relationship between the two variables was significant ($p = .000 < 0.05$) as shown in Table 3. Therefore, the null hypothesis that there is no relationship between procurement method and project type is rejected. Based on the results in Table 3, it can clearly be seen that all project types, but industrial projects are more likely to use best value procurement. Industrial projects are more likely to use qualification-based procurement. Sole source, on the other hand, appears to be mostly used by commercial buildings. However, it is important to note that none of the project types shows a dominant use of sole source. Healthcare has significantly low usage of sole source than the others. The relatively low

Table 3. Relationship between procurement method and project type.

	Procurement method			
Project type	Best value	Qualification based	Sole source	Total
Civil infrastructure projects	29	4	3	36
	80.6%	11.1%	8.3%	100%
Commercial buildings	12	4	7	23
	52.2%	17.4%	30.4%	100%
Institutional buildings	32	16	3	51
	62.7%	31.4%	5.9%	100%
Residential buildings	0	1	0	1
	0%	100%	0%	100%
Industrial facilities	4	26	4	34
	11.8%	76.5%	11.8%	100%
Healthcare buildings	9	5	1	15
	60%	33.3%	6.7%	100%
Total project number	86	56	18	160
	54.8%	35%	11.3%	100%

X^2(df = 10, n = 160) = 52.916, p = 0.000 (7 cells have expected count less than 5)

number of sole source DB projects in the database may also point to the fact that it is not a frequently used procurement method.

The results in Table 4 show there is a statistically significant relationship between procurement methods and owner type and hence the null hypothesis is rejected (p = .000 < 0.05). This implies that the owner type significantly affects the selection of a procurement method. Public owners are more likely to use best value procurement while private owners are more likely to use qualification-based procurement. This is not surprising since most public owners and agencies advocate the use of best value procurement (Nguyen et al., 2018) and hence they are more likely to procure DB projects using best value selection. The results also indicate that private owners are more likely to use sole source than public owners.

Table 5 shows the Chi-square test results between procurement method and contract type. The significance level of p = .008 < 0.05 indicates that contract types affect the selection of procurement methods significantly. Hence, the null hypothesis that there is no statistically significant relationship between procurement method and contract type is rejected. From the results, best value is more likely to use lump sum contracts while qualification based is more likely to use GMP. It also appears that sole source tends to use GMP more frequently than lump sum, but none is significantly dominant. The "other" under contract method includes projects with no information on the contract method and those indicated as using county written contracts.

Table 4. Relationship between procurement method and owner type.

	Procurement method			
Owner type	Best value	Qualification based	Sole source	Total
Public	78	36	7	121
	64.5%	29.8%	5.8%	100%
Private	8	20	11	39
	20.5%	51.3%	28.2%	100%
Total project number	86	56	18	160
	54.8%	35%	11.3%	100%

X^2(df = 2, n = 160) = 27.683, p = 0.000 (1cell has expected count less than 5)

Table 5. Relationship between procurement method and contract method.

	Procurement method			
Contract method	Best value	Qualification based	Sole source	Total
Lump sum	50	16	4	70
	71.4%	22.9%	5.7%	100%
GMP	19	24	8	51
	37.3%	47.1%	15.7%	100%
Cost-plus fee	6	6	1	13
	46.2%	46.2%	7.7%	100%
Other	11	10	5	26
	42.3%	38.5%	19.2%	100%
Total project number	86	56	18	160
	54.8%	35%	11.3%	100%

$X^2(df = 6, n = 160) = 52.916$, $p = 0.008$ (3 cells have expected count less than 5)

Cost and schedule performance between procurement methods

Two metrics were used to compare the performance of the procurement methods: schedule overrun percentage and cost overrun percentage. The metrics were calculated using equations (1) and (2). To allow for a fair comparison of the project costs, the RS Means historical cost indexes were used to convert the final total cost of each project to 2019. First, the cost inflation factor was calculated by dividing the 2019 cost index by the cost index of the year and month the project was completed. Then, the inflation factor was multiplied by the final total cost of the DB project to get the total cost equivalent to the 2019 cost. The converted costs and the schedule data for the procurement methods are presented in Table 6.

$$\text{Scheduleoverrun}(\%) = \frac{\text{Actualprojectduration} - \text{Contractedprojectduration}}{\text{Contractedprojectduration}} \times 100 \quad (1)$$

$$\text{Costoverrun}(\%) = \frac{\text{Actualprojectcost} - \text{Contractedprojectcost}}{\text{Contractedprojectcost}} \times 100 \quad (2)$$

Table 7 presents the results of the schedule overrun calculation between the procurement methods. The results indicate that DB projects with qualification-based procurement performed better in terms of schedule (1.03% time-saving) than those with sole source (1.91% time overrun) and best value procurement (4.54% time overrun). Recognizing the small number of sole source projects, the variance of performance was only analyzed between qualification-based and best value procurement. The one-way ANOVA test

Table 6. Schedule and converted cost data.

Procurement method	Contracted duration	Actual duration	Contracted cost	Actual cost
Best value	837 days	875 days	$130,069,815.04	$138,215,050.64
Qualification based	776 days	768 days	$78,928,039.40	$82,719,433.07
Sole source	575 days	586 days	$147,678,526.69	$148,013,441.86

Table 7. Schedule overrun between procurement methods.

Procurement method	Number	Schedule overrun	*P* value (exclude sole source)	*P* value
Best value	86	4.54%	0.165	0.364
Qualification based	56	−1.03%		
Sole source	18	1.91%		

Table 8. Cost overrun between procurement methods.

Procurement method	Number	Cost overrun	*P* value (exclude sole source)	*P* value
Best value	86	6.26%	0.215	0.127
Qualification based	56	4.80%		
Sole source	18	0.23%		

indicates that there is no statistically significant difference in schedule performance between projects with qualification-based and best value procurements ($p = .165 > 0.05$). Hence, the null hypothesis that there is no difference in the schedule performance between the procurement methods is not rejected.

The cost performance comparison between the procurement methods is shown in Table 8. The results show that DB projects with sole source have better cost performance (0.23% cost overrun) than those with qualification-based procurement (4.80% cost overrun) and best value (6.26% cost overrun). It is important to state that none of the procurement methods have cost savings on the projects. However, the one-way ANOVA indicates that there is no statistically significant difference in cost performance between projects with qualification-based and best value procurements ($p = .215 > 0.05$).

Interaction between project characteristics and procurement methods regarding cost and time performance

The two-way ANOVA was used to determine whether project characteristics have any interaction effects on procurement methods relating to cost and schedule performance. According to Rutherford (2011), the two-way ANOVA compares the mean dependent variable scores across two independent groups. The primary purpose of a two-way ANOVA is to understand if there is an interaction between the two independent variables on the dependent variable. In this study, the project characteristics (project type, owner type, contract method, and procurement method) are the independent variables while the schedule overrun, and cost overrun are the dependent variables.

The results in Table 9 show all p values greater than 0.05. Therefore, the null hypotheses that there is no interaction between procurement method and other project characteristics (project type, owner type, and contract method) regarding schedule and cost performance is not rejected. This indicates that the difference in schedule and cost performance between the procurement methods is not statistically significant within the different project characteristics.

Table 9. Interaction between project characteristics on project performance.

	Significance level (schedule overrun as dependent variable)	Significance level (cost overrun as dependent variable)
Pairing		
Procurement method x project type	0.629	0.976
Procurement method x owner type	0.369	0.376
Procurement method x contract method	0.348	0.730

Discussion

Regarding the relationship between procurement methods and other project characteristics, all the project characteristics (project type, owner type, and contract method) have a statistically significant impact on the selection of a procurement method. This indicates that these project characteristics influence the choice of procurement methods for DB projects.

In terms of project type, it was clear that all project types except industrial are more likely to use best value procurement. Industrial projects are more likely to use qualification-based procurement. This could be because the design/engineering process in industrial processing projects can be very complicated (Chen et al., 2016) and it will be more beneficial to qualify contractors without any design allowing the owner to work with the contractor on the project programming and design. Another reason could be since most industrial projects are huge undertakings that require a unique level of expertise across a variety of fields focused on specialized design and construction capabilities, it may be quite challenging for contractors to propose any lump sum or GMP before substantial design completion. Thus, it is more appropriate to hire the contractors based on qualifications alone.

According to the results, public owners are more likely to use best value than qualification-based procurement. This could be because many public agencies are required by statute to evaluate price in selecting a design-builder (Adamtey & Onsarigo, 2019). For example, the Commonwealth of Virginia does not expressly permit qualification-based procurement because it requires price consideration in the evaluation of proposals. However, those agencies that have procurement flexibility may also use qualification-based procurement. In the private sector, there is no statute restricting the use of qualification-based and hence it appears private owners tend to use qualification-based more frequently. Perhaps, it could be due to the fact that most private projects are profit-driven requiring early completion and the qualification-based procurement is relatively inexpensive and far quicker than a typical best value process (DBIA, 2012). This is particularly because qualification-based does not require the type of detailed criteria package often associated with a best value process (DBIA, 2012). The streamlined nature of a qualification-based competition also benefits the private owners since it precludes the need for costly design effort during the competition itself. Private owners are also more likely to use sole source because public owners have statutes that mandate them to competitively bid all projects beyond a certain scope and dollar limit (Onsarigo & Adamtey, 2020) thereby limiting the number of projects they can sole source.

From the results, best value is more likely to use lump sum contracts while qualification based is more likely to use GMP. While price and cost are not selection criteria under pure qualification-based procurement, they are considered during contract negotiation (DBIA, 2012). At that stage, contractors are more comfortable providing a GMP. For sole source, it is clear there is no dominant contract method because sole source typically involves the direct selection of the design-builder based on factors such as past performance, technical qualifications, and established relationship through previous projects without any price competitiveness (Beard et al., 2001).

Regarding schedule performance between the procurement methods, the results of this study found that projects completed with qualification-based procurement had better schedule performance than those with sole source and best value procurement. In fact,

projects completed with qualification-based procurement resulted in cost savings (1.03%) while the rest had cost overruns. However, the results did not find schedule overrun to be statistically significantly different between the procurement methods at alpha level 0.05. Nonetheless, for an owner with a tight schedule, having 1.03%-time savings would be a significant advantage for using qualification-based procurement compared to using sole source with 1.91% time overrun and best value procurement with 4.54% time overrun. It is important to point out that the results of this study on schedule performance of procurement methods is contrary to the findings of the study conducted by El Wardani et al. (2006), which found best value procurement to result in the least schedule growth (an average of 0%) compared to the qualification-based procurement and sole source. The qualification-based and sole source performed 6% and 1% higher than best value procurement, respectively. However, the authors did not conduct any tests to determine if the difference in performance is statistically significant.

With regard to cost performance, this study found that there was no statistically significant difference in cost overrun between the procurement methods at alpha level 0.05. However, on average, projects completed with sole source had better cost performance (0.23% cost overrun), followed by projects completed with qualification-based procurement (4.80% cost overrun), which also had slightly better cost performance than projects completed with best value procurement (6.26% cost overrun). None of the procurement methods resulted in cost savings. The cost overrun could be due to many reasons including change orders and claims (Larsen et al., 2016; Semple et al., 1994). However, for large or big projects, it would make a significant difference having a 0.23% cost growth compared to 4% or 6%. It is recognized that the use of sole source may be restricted on certain public projects exceeding a certain dollar amount or scope and in which case qualification based may be used. For this study, qualification-based procurement performed better in terms of cost compared to best value procurement. This is contrary to the findings of the study conducted by Molenaar et al. (1999) on public projects that found the qualifications-based procedure to perform the worst in terms of budget and schedule.

The two-way ANOVA tests results on the interaction between project characteristics and procurement methods regarding project cost and schedule performance show that the effect of procurement methods on schedule and cost performance seems to be similar within different project characteristics (project type, owner type, and contract method). Although project characteristics affect the selection of a particular procurement method as shown with the Chi-square test of cross-tabulations (two-way contingency tables), these project characteristics within the procurement methods do not affect cost and schedule performance.

Table 10 provides a summary of the findings on the procurement method performance for owners to consider when selecting a procurement method for their DB projects. It is important to note that there was no statistically significant difference between the performance of the procurement methods and this summary is based on the cost and schedule overrun calculations as shown in Table 7 and Table 8. The results suggest that qualification-based procurement method should be preferred on schedule-sensitive projects while sole source should be selected where completion on the budget is critical. However, for projects where sole source may not be permitted, qualification-based should be selected.

Table 10. Summary of procurement method selection.

	Project outcome	
Procurement method	Less cost overruns	Less schedule delays
Best-value	X	X
Qualification based[a]		
Sole source		X

[a]For less cost overruns, use where sole source is not permitted

Conclusions

While the low-bid procurement has a long-standing legal precedence and has promoted open competition, it has also been recognized to have some major drawbacks. As such, alternative project delivery methods such as DB tend to use other procurement methods such as best-value, qualification-based and sole sourcing to offer a more objective approach when evaluating a prospective contractor by allowing the incorporation of different evaluation factors in addition to cost.

The aim of this study was to provide an empirical evidence that can assist the procurement method decision by an owner for a design-build project. The research, therefore, investigated whether project characteristics such as project type, owner type, and contract method influence the choice of procurement method; compared the project performance in terms of cost and schedule performances between the different procurement methods for DB; and also investigated whether there was an interaction between project characteristics and procurement methods regarding project cost and time performance. This study examined 160 DB projects obtained from the DBIA database completed between 2008 and 2019 and worth over 14 USD billion. These projects were from 34 states and cover different sectors including health care commercial, industrial, and civil.

The results showed that best-value procurement is the most predominantly used procurement for DB projects accounting for more than 50% of all DB projects in the database. The Chi-square tests of cross-tabulations revealed that all the project characteristics (project type, owner type, and contract method) have a statistically significant impact on the selection of procurement methods. All project types except industrial facilities are more likely to use best value procurement and public owners are more likely to use best value than qualification-based procurement. Additionally, the results showed that best value procurement is more likely to use lump sum contracts while qualification based is more likely to use GMP.

Regarding total cost and schedule performance, the statistical analysis revealed that no one DB procurement method outperformed the other methods. This is consistent with the findings of El Wardani et al. (2006). However, qualification-based procurement method resulted in time-saving while best value and sole source had schedule overruns. Similarly, projects completed with qualification-based procurement had better cost performance than those of best value procurement. Additionally, different project characteristics appear to have no interaction effect on procurement methods relating to project performance.

The selection of the appropriate procurement method for DB projects is an important decision for owners because the selection of an ill-qualified DB team can have serious negative implications on the outcome of the project. Since one team performs both design and construction services, the procurement method must be comprehensive enough to ensure the success of the projects. It is therefore important for an owner to include

appropriate criteria in the procurement selection to assist in hiring the right team for the project. This research has provided a comprehensive consideration for owners by first identifying project characteristics that affect the selection of DB procurement methods and second, providing an empirical evidence on the effect of procurement methods on DB project outcomes. From the results, owners should consider the qualification-based procurement method whenever completion on schedule is very critical (schedule-sensitive projects). Since sole source resulted in the least cost overrun, it should be considered when completion on the budget is critical. For public owners, although best value is the preferred procurement, the results showed that projects completed with qualification-based procurement have better cost performance than those of best value procurement. It is also noted that public owners may be restricted on the use of sole source and qualification-based due to the requirement for competitive bidding and price consideration in evaluation.

In terms of limitations, factors such as quality, safety, and design proportion required in RFP were not considered, which could affect the cost and schedule performance. Another limitation of this study is the small sample size, especially for sole source. Although the sample sizes were large enough to conduct the statistical analysis, they may not be a fair representation of the performance of DB procurement methods in the industry. As such, the results should be treated as introductory evidence for further research.

For further research, it is recommended that a larger sample size, which would be a better representation of the industry, should be used for the statistical analysis to confirm the findings of this study. Surveys can also be conducted to investigate other project objectives such as quality to provide a holistic analysis and comparison. In addition, investigation should be conducted to determine the impact of the type of design-build firm (contractor-led, designer-led, integrated-firm-led, or a joint venture) on the performance of DB projects.

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