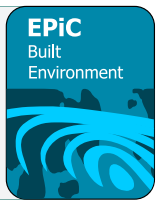
EPiC Series in Built Environment

Volume 2, 2021, Pages 146–155

ASC 2021. 57th Annual Associated Schools of Construction International Conference



Does Using BIM Application to Automate Quantity Surveying Increase Bidding Success?

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Anecdotal evidence exists claiming the benefits of technology regarding efficiency and overall competitiveness of contractors. However, there is lack of empirical evidence demonstrating that technology improves contractors' efficiency, especially as it relates to their bidding success. This study explores the association of a specific BIM application that automates the extraction of quantities from virtual models to bidding successes on public projects. Information from public projects in the state of Texas that used the BIM application in 2016 were analyzed. The contractors who used the application showed an overall increase in their success rate in public bids. Analysis indicates that the success rates of winning bids using the application are not equal for all public project types. Additionally, the results suggest that the odds of winning bids are higher for projects under $100 million as opposed to projects valued in excess of $100 million. The empirical evidence presented suggests that the use of the BIM application is related to winning Public work in Texas; however due to the limitation of the data it cannot indicate causation. Nevertheless, the results should encourage contractors to use the BIM application during bidding.

Key Words: Bidding, Building Information Model (BIM), Quantity surveying, Estimating

Introduction

The construction industry is governed by three simple dictums: get work, do work, and get paid. While contractors work to efficiently do all three, perhaps the most critical is getting work, which requires successfully bidding for and winning projects. For most general contractors, more bids are lost than won. As a result, success and profitability requires an investment in bid preparation. Bid preparation (estimating and preconstruction processes) requires time and manpower. Some contractors' strategy is to simply pursue as much work as they can, while others have adopted more strategic approaches. One such strategic approach is the use of complex decision-making tools that aid in the process of bidding different projects. Some of these tools have specifically aimed at determining margin on a bid (Marzouk & Moselhi, 2003; Fayek, 1998; Pannell & Murphy, 1994). However, evidence is lacking whether these tools lead to an increase in bidding success.

Beyond decision making tools, there have been advances in technology to assist estimators in performing different tasks related to preparing bids. There are programs that facilitate different aspects of estimating and preconstruction processes, such as: quantity surveying, bidder qualification, pricing, bid solicitation, estimate organization, and other functions. While these technologies have the potential to make contractors more competitive in preparing bids, their ability to positively impact a contractor's success in winning a bid has not been the subject of empirical exploration. Anecdotal evidence and claims by technology vendors about the benefits of these technologies can be found, however these claims are empirically unsubstantiated.

The lack of empirical research exploring the impacts of different technologies in bidding can likely be connected to the fact that academic research often does not directly relate to the practical needs of the construction industry (Bigelow, Bilbo, Baker, 2016; Graham, Christofferson, Reginato, 2011). This study was designed specifically to add value to the construction industry by investigating one potential way to increase efficiency in getting work. Specifically, it explored winning bids on public projects, exploring the relationship between bidding success and the use of building information model (BIM) application in preparing bids. There is an industry wide push to adopt BIM stemming from the United States General Services Administration. Since 2003, the GSA has required the creation, review, storage and management of building information models for all federal buildings (GSA BIM Guide 07). The guide mandates the use of BIM for all federally funded projects in the United States. Internationally, there is also a trend for publicly funded projects to follow BIM requirement (Lam, Mahdjoubi, & Mason, 2017). The researchers sought to identify any relationships that might exist between the applications that automate extraction of reliable quantities from models to create accurate estimates and bidding success.

This study explored the association of bidding success and the use of one such application that automate the extraction of quantities from models. For this study, the authors identified the winning bids on public projects where the particular application had been used. Even though in public work, contractors are traditionally chosen by the lowest bid (Yu and Wang, 2011), winning the bid for a project can depend on a variety of factors (Kramer & White-McCurry, 2002; Akalp & Ozbek, 2017). The authors acknowledge the plethora of other factors that impact bidding success, but this study did not collect data on those factors or attempt to evaluate their roles in bidding success.

BIM has been identified as a possible solution to improve productivity in construction, however that claim has not been tested as it relates to success in bidding. This study is intended to help fill the gap in the body of knowledge by evaluating a specific application that automate the extraction of quantities from models and its users' success in bidding. The significance of this study is that it represents the first empirical study of its kind evaluating a BIM application and its association to successful bidding. It attempts to fill the gap in the current body of knowledge identifying a positive association between bidding and use of a BIM application, emphasizing the claim that BIM can add value to construction projects. The following sections present an overview of the literature related to bidding and BIM applications in the construction industry followed by the research methods used for this study. The outcome of the study and subsequent discussions are presented to evaluate the association of the BIM application to bidding success.

Review of Literature

Technology in the form of BIM applications have been promoted heavily in their ability to positively impact construction. Unlike other technologies, BIM applications have seen considerable amount of

research relating to their impact on the construction industry, particularly as their use is steadily increasing. In 2018, only 28% of builders reported that they did not bid on projects where BIM was required (JBKnowledge, 2018).

BIM has been claimed to be applicable in a broad range of activities for construction contractors, but documentation of use of BIM applications in estimating has been limited (Farnsworth, Beveridge, Miller, Christofferson, 2014). BIM's adoption in estimating by the construction industry also appears to be limited. In the 2018 Construction Technology Report (JBKnowledge, 2018), only 4% of respondents included BIM applications in the list of estimating software being utilized in the construction industry.

Performing quantity surveying, which is an integral part of construction estimating, is time consuming and error prone (Karshenas, 2014); improving how to perform these tasks should benefit the industry. Virtual models facilitate the quantification process as the virtual models with all building elements carry assigned data that can be extracted instantly (Azhar et. al. 2008). Once these "data rich digital representations" have been created, quantities of resources can be extracted, and in-turn prices can be assigned. Sylvester & Dietrich (2010) concurred that using BIM in estimating can contribute to more accurate estimates, which is likely because the information stored in the model could make quantification effortless (Nassar, 2012). While data rich virtual models of the structures can prove helpful in the estimating process, there are challenges as well. Sattineni & Bradford (2011) reported that BIM does not increase estimate quality or reduce the time required to produce estimates for two primary reasons. First, there is typically a disconnect between estimators and BIM technicians (each skill set is unique and occupied by different individuals). Secondly, building information models generally must be created from scratch because designer's models are not functional for construction management purposes. Unfortunately, these studies did not address whether usage of building information model could also lead to increased success in bidding. So, companies continue to pursue work in whatever manner they think best.

Most of the published research integrating BIM and construction estimating has been related to education. Investigation of computer application in teaching estimating to students was a focus in the 1990's. Mathewson (1990), Caldwell (1991), and Mead (1995) explored how computers impacted teaching estimating and the bidding process to the students. These literatures predate the advent of BIM and also didn't consider actual bidding successes. They only focused on teaching methods, giving them less applicability to the current study. More recently, Regmi & Wilis (2018) investigated teaching estimating and bidding, however that study was also focused only on teaching, not looking into actual bidding successes. Gier (2008) and Liu & Killingsworth (2012) reported that visualization programs like BIM can positively influence students learning to estimate. While their studies represent some of the only research found specifically considering BIM and estimating, they were again focused on teaching and did not collect data or report on professional practice.

Contractors adopting BIM have reported several benefits due to its usage. Azhar (2011) reported that contractors experienced a reduction in time needed to create estimates, elimination of unbudgeted changes, a reduction in the project budget through clash detection, and a reduction in project schedule. Although these benefits have been documented, they do not relate directly to success in bidding. Similarly, there is a gap in the empirical evaluation of factors that increase success in bids. Marzouk & Moselhi (2003), Fayek (1998), and Pannell & Murphy (1994) explored bid mark up and margin. Nassar (2003) presented how a spreadsheet could be used to unbalance a bid. There is also a body of research on how bid shopping affects the industry (Smith & Clarke, 2007; Degn & Miller, 2003). Research has also been conducted on the general subject of whether to bid or not (Lesniak & Plebankiewicz, 2013), and more specifically on the analysis of competitors in bidding (Oo, Drew, &

Runeson, 2010). Further, the identification of decision-making factors in bidding have been explored (Akalp & Ozbek, 2017; Ahmad & Minkarah, 1988).

Despite an expanding body of knowledge relating to BIM and bidding separately, as well as integrating BIM with estimating and bidding, no quantitative research could be found identifying a relationship between any specific factor and bidding success. This lack of research aimed at how contractors get work, and specifically how to be more efficient in getting work, demonstrates a gap in the body of knowledge on this subject and supports the need for research on how contractors can be more effective in winning bids.

The BIM application evaluated for this study was Assemble. Assemble has tools that can be utilized throughout the project life cycle to access BIM data. However, it is primarily an application that can export model information for quantity surveying. So, this study only considered its use in preparing bids as it can be used in quantity surveying, plan and model sharing with subcontractors, and has a direct interface with an estimating software. It should be noted that the application under consideration is one that accesses and pulls information from a BIM created in Revit. According to the Construction Technology Report (2018) only 3.2% of respondents reported using Assemble as a BIM tool.

Research Method

This research represents an exploratory evaluation of empirical data provided by the vendor of the BIM application that automates the extraction of quantities from models. It also used publicly available information on bid awards and bid amounts. A database containing all projects that utilized the application in 2016 was provided to the authors. Using the project descriptions found in the database, the authors used public records to identify the successful bidders and the bid amounts. Using that information, the authors could determine the frequency with which companies using the BIM application were successful in winning bids. The authors want to reiterate that this study only considered the usage of the BIM application in bid preparation as the independent variable for bidding success.

The BIM application in consideration is a cloud-based application that requires users to create a new project when a new BIM model is introduced. As such, the vendor maintains a database containing not only all of their clients, but also all of the projects for which their clients have used the application to automate quantity extraction from BIM models. The authors did not have a way to verify the extent of the application's use by the contractors on each project. Also, it could not be verified whether the quantities extracted through the application were actually used in the bids. The raw database of users and projects was provided to the authors. Additionally, bid data was public information, collected independently of the vendor provided database. Based on these details the authors consider the data to be reliable.

The application under consideration is not a stand-alone application that can be used to create a virtual model, rather it is an application that pulls data from a virtual model. As such a bid that requires the use and/or submission of a building information model does not necessarily mean a contractor will use the application. However, it could increase the likelihood of the application's use on a project.

This study was delimited to the use of one specific application that automates the extraction of quantities from models during the bidding stage of a project. Data from other similar applications were not available to the authors and as such were not considered. To evaluate the association of the application's use to bidding successes of the users, two additional delimitations were implemented.

First, only projects in the State of Texas were used. Due to potential regional variability in bidding processes a single state was sought for analysis. The state of Texas had more projects in the vendor provided database than any other state, so it was selected. Further, the geographic proximity of the authors to the state of Texas provided assurance that bid data not readily available online could be easily collected. Due to this delimitation, generalization of the study findings beyond the state of Texas should be done with caution. The second delimitation was to use only public projects. This delimitation was imposed to ensure that the authors could identify bid amounts and winning bidders (public works typically have formal bid opening that is public information, and the authors could ensure the correctness of the vendor provided database). Further, because public works also have bid deadlines, which allowed the authors to ensure that the application was used in the preconstruction stage and not adopted after the bid award had been made.

The specifics of the data used are protected by a non-disclosure agreement so references to any projects or companies has been anonymized. The data was analyzed using descriptive statistics and basic inferential statistics as the analysis is only intended to summarize and present the data (Morgan, Leech, Gloeckner, Barrett, 2004). Further, because of the non-disclosure agreement the researchers could not reach out to the individual companies seeking additional information on factors that may have impacted their bid strategy, the extent of their use of the application in bid preparation, or any other factors.

Results and Discussion

Sample Description

The database provided by the vendor included over 2900 projects being bid or managed by over 110 companies. After filtering the data, based on the delimitations imposed on the project, there were 85 public projects in the state of Texas, and 19 different companies using the application. The projects consisted primarily of higher education, followed by K-12, and lastly municipal projects. Table 1 breaks down the sample by project type, sample size, mean value, minimum value, maximum value, and standard deviation.

Table 1

Project Types and Sizes in Sample

Project Type	*n*	Mean Value	Min Value	Max Value	Std. Dev.
Municipal	8	$158,325,000	$10,100,000	$450,000,000	185,066,000
K-12 Education	24	$51,992,704	$1,673,210	$157,900,000	42,186,194
Higher Education	53	$77,490,087	$2,252,630	$532,500,000	101,594,964
Total	85	$77,898,818	$1,673,210	$532,500,000	102,658,827

Among the 19 companies using the application, identified from the database that were in Texas, there was considerable variation on the scale of use, as well as the types of projects. While some companies were using the application across multiple projects, others were using it on only one or two projects. Further it appears that different contractors focused on different types of public work, with only one contractor having bid on all three types in 2016. However, it should be noted that contractors may have pursued all three types of projects but did not use the application in the bidding process. Table 2

displays the use of the application that automates the extraction of quantities from models by the companies in the sample.

Table 2

Company usage of Assemble

Company	Municipal	K-12	Higher Ed	Total	Mean Value of Projects	Range
A	1	0	0	1	$10,100,000	n/a
B	1	0	7	8	$65,836,125	$20 - $152m
C	0	2	1	3	$28,010,180	$5.8 - $60m
D	1	0	2	3	$84,333,333	$63 - $113m
E	0	0	2	2	$36,500,000	$19 - $54m
F	0	0	12	12	$40,771,053	$2.25 - $101m
G	0	0	1	1	$134,160,000	n/a
H	0	0	1	1	$32,000,000	n/a
I	0	0	1	1	$367,000,000	n/a
J	0	0	2	2	$285,912,500	$39.3 - $532.5m
K	0	0	1	1	$32,000,000	n/a
L	0	0	1	1	$20,000,000	n/a
M	1	1	0	2	$365,000,000	$80 - $450m
N	0	19	4	23	$56,367,516	$1.67 - $200m
O	1	0	2	3	$75,566,667	$32 - $135m
P	1	0	5	6	$22,811,020	$12 - $65m
Q	1	0	3	4	$266,125,000	$67.5 – $450m
R	1	2	2	5	$51,504,198	$9.27 – $77m
S	0	2	8	10	$58,757,338	$10.7 - $168m

Analysis

Information on bidding success were collected from the award agencies to identify bid winners and bid amounts. This information was summarized to see the effect of the use of the application on the proportion of bid awards. Although this study considered 85 different projects, there were some projects where multiple bidders used the application under consideration. As a result, the application was used 89 times on 85 projects. Of the 89 times included in this study, that the application was used on public projects, 71 were successful in winning the bid, a success rate of 80%. Within the project types, municipal projects showed the highest success rate (100%) from using the application. In comparison to the other two project types: higher education (71%) and K-12 education (92%). Table 3 presents the success rates based on the different project types when the application was used. It should be noted that with such a small sample (n = 8) of municipal projects, the success rate in bidding should be interpreted with caution.

Table 3
Success rates based on project type

Project Type	N	Unsuccessful	Successful	Success Rate (%)
Municipal	8	0	8	100
K-12 Education	26	2	24	92
Higher Education	55	16	39	71
Total	89	18	71	80

While Table 3 provides a trend of the success rates, the authors sought to determine whether there is any association between the project type and the respective success rates in bid awards. If S_M, $S_{K\text{-}12}$, and S_{HEd} are the success rates of the municipal, K-12, and higher education projects respectively, under the null hypothesis, there is no difference in the success rates.

H_0: $S_M = S_{K\text{-}12} = S_{HEd}$ (reject if $p > 0.05$)

A Chi-square test was conducted to determine the association and the null hypothesis was rejected as $p > 0.05$ [chi-square statistic of 5.22, $p = 0.07 > 0.05$]. While rejecting the null hypothesis the authors could conclude that the success rates of winning a bid using the application were not equal for all project types; however, it does not indicate which success rates differ.

Secondly, the authors wanted to test if the bid amount had any association with the success of winning bids using the application. The 85 projects included in this study were divided into two categories: projects with bid value less than 100 million USD and those with value of more than 100 million USD. Odds Ratio was calculated to test whether the amount of bid value is a determining factor for the success in bid awards among the projects that used the application. In other words, the authors wanted to see if the use of the application increased the chances of winning bids for projects less than or more than 100 million USD. Calculating Odds Ratio, the odds of winning the bid for a project of less than 100 million USD using the application was 0.15 higher than that of a project more than 100 million USD bid value. The calculated Odds Ratio is significant at 10% confidence interval. These results suggest that the odds of winning bids are higher on projects valued at less than 100 million USD than for projects valued at over 100 million USD.

Conclusions

The authors recognize the limitations of the data presented and the analysis used. Nevertheless, the results are an important contribution to the body of knowledge on this subject for two reasons. First, no research could be found demonstrating a relationship between BIM or BIM applications and bidding success, or quantitatively any other factor in bidding. As such this study represents a first step in filling the gap in that area. Second, bidding along with the strategies and tactics used by contractors to get work are closely guarded trade secrets. As such, bidding processes and technology used by contractors represent data that is difficult if not impossible to obtain, particularly on a scale that includes 85 different projects and 19 different companies.

In the construction industry, contractors have to continuously pursue work and win bids in order to stay in business and make profits. A tool that can increase the possibility of bidding success should gain prominence among contractors and increase their efficiency in getting work. A strength of this first of a kind study is the reliability of the information provided by the vendor of the application and

the bid details gathered from publicly available information. The study was not experimental and does not indicate causation, but only indicates association. A relationship exists between the use of the application and bidding success; however, there are many variables that influence bid selection that were not addressed in this research. As such the application under consideration should not be construed as the cause of bid awards, only related to them.

In this study, the authors found empirical evidence that on public projects where the application that automates the extraction of quantities from models was used a high percentage of bids were won. On 80% of the public bids in Texas, where the application was used, the bid was won. Although the extent of contractor's use of the application is not known, the data suggests that using the application to automate the extraction of quantities from models can lead to increased bidding success. This finding should encourage construction companies to use similar applications during bid preparation to increase their bidding success.

The results reported should not be construed with contractors' overall bidding success as the number of other projects and bid awards for each company were not known or evaluated in this study, only the association between the application's use and bidding success was explored. When contractors used the application under consideration, they were more likely to win the bid. However, because the authors could not contact the companies directly (due to the non-disclosure agreement), it is not known what their extent of usage was.

This study could not attempt to quantify bidder interest, also because of the non-disclosure agreement. At times a contractor may bid a project with no legitimate interest in winning the bid (for a variety of reasons). It is not known if the users were highly interested and/or if other contractors were not, which would have some effect on bid awards.

The authors recommend future research in the following areas: an exploration of bidding success for contractors bidding work both with and without the application; investigation into how contractors pay for the additional cost involved in preconstruction by modeling and using BIM applications, especially if those additional costs are recovered elsewhere or represent an additional expense to win the bid; investigation in bid award prevalence outside of the state of Texas. Finally, the authors recommend replication of this study to explore support or refute the findings presented here.

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