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IMPACT OF BIDDING ENVIRONMENT ON CHANGE ORDERS

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Change orders occur during construction, and usually increase both construction cost and project duration. This paper investigates how change orders are related to the bidding environment. The data used in this study were collected from 74 public building construction projects awarded by the Public Building Commission of Chicago in the seven-year period 2008-2015. The contract values range between $0.3 - $70 million, and the total worth of the projects is a little over $1.1 billion. While delay may result in liquidated damages for contractors, increase in project cost can cause financial problems for owners. It is in the interest of owners and contractors to study similar past projects, and to observe how change orders are affected by the level of competition in bidding. Owners must budget for contingencies, and contractors must adjust their resources in anticipation of change orders. It would therefore be quite desirable for owners and contractors to be able to predict the dollar amount and duration implications of potential change orders by making use of past historical data. The prediction of the dollar amount and duration implications of potential change orders before the construction starts can alert construction owners and contractors to potential delays in total project completion time and potential overruns in total project cost. Knowledge about potential change orders creates a predictable environment and improves the relationship between owners and contractors. The results of this study indicate that contractor-driven change orders are positively related to the difference between the lowest and the second lowest bids.

Keywords: Contract changes, Public building construction, Bidding climate, Prediction models, Cost overruns, Bid spread.

1 INTRODUCTION

Competitive bidding is the most commonly used procurement method in public works projects, where contracts are awarded to the lowest qualified bidder. However, the total cost of a project often exceeds the lowest bid due to change orders. In a highly competitive bidding environment, bidders may lower their bids, and expect to regain profit by submitting claims and change orders (Wright and Williams 2001). Lower bids create higher cost deviations between the bids. According to Chaovalitwongse *et al.* (2011), there is a trade-off between the average cost deviation and cost overruns. The larger cost deviation between bids may increase the number of change orders, and actual project cost. The difference between the lowest and second lowest bids is commonly used in the literature to measure deviation between bids, also called "spread", "bid-spread", and "money left on the table" (Skitmore *et al.* 2001).

The average number of bidders per project is expected to be high when the number of available construction projects on the market is low. In such situations, bidders lower their mark-ups to increase their chances of winning. However, the lowest bidder may tend to regain their foregone profit by submitting change orders during contraction. The objective of the study presented in this paper is to investigate the impact of the bidding environment on contractor-driven change orders. This paper is organized as follows: the next section briefly reviews the literature on the bidding environment, bid competitiveness measures, and contractor- driven change orders. The succeeding section describes how the data are collected and used in order to test the research hypothesis. This section is followed by the "Conclusion" that presents the results, discusses the limitations of the study, and provides suggestions for future studies.

2 LITERATURE REVIEW

The relationship between bid prices and bid competition was analyzed in several studies. Factors that were used as measures of competition in the literature include, but are not limited to number of bidders, need-for-work, market conditions, availability of other projects, project's public exposure, and prestige.

A statistical analysis conducted by de Neufville and King (1991) found that the relationship between the "need-for-work" and bid mark-up is statistically significant. In other words, bid mark-up decreases as need-for-work increases. The study also showed that the lowest bid decreases as the number of bidders increases. Factors affecting "need-for-work" were identified by Chua and Li (2000) as current workload of projects, need for continuity in employment of key personnel and workforce, relationship with owner, and required rate of return in investment. Similar to the study of de Neufville and King (1991), Carr (2005) examined the statistical relationship between the number of bidders and bid prices. The interaction found in the study was statistically significant; an increase in the number of bids caused a lowering of the lowest bid. Awwad *et al.* (2014) studied the relation between risk attitudes and the mark-up decision, and found that contractors tend to lower their mark-ups as the intensity of the competition increases, regardless of their risk attitudes. Oo *et al.* (2010) found that in addition to the number of bidders, market condition, as well, is a measure of competitiveness that is significantly effective on mark-up decisions. Oo *et al.* (2010) found that contractors lower their mark-ups in recessionary environments; their study also showed that mark-up decisions were related with project size but not project type.

Chua *et al.* (2001) studied the impact of competition on contractor profits. Nine factors that are related to competition in lump sum contracts were listed as availability of other projects, cash flow requirements, degree of technological difficulty, identity of owner/consultant, project public exposure and prestige, project time scale and penalty of non-completion, safety hazards, size of project, and time allowed for bid preparation. The result of the study showed that expected profits are considerably lower in high-competition environments.

The negative effects of low bid mark-ups are emphasized in several studies. Lo *et al.* (2007) state that the excessive number of bidders may cause abnormally low bids, and some of the contractors that submit abnormally low bids try to get extra profit cutting corners to lower their costs, and submitting claims and subsequent change

orders. According to Meulen and Money (1984), the number of bidders per bid is high because of high competition during recession, and some contractors purposely submit low bids in such an economic environment. It is suggested that contractors' opportunistic behavior negatively affects the quality of public works. Submitting unrealistically low bids makes it impossible for contractors to complete projects according to plans and specifications. Due to the sacrifice made in profit, contractors submit claims and change orders that lead to schedule delays (Ioannau and Leu 1993). Owners carry a large risk when they select a contractor that submits an unusually low bid and will not complete the project as planned.

3 DATA COLLECTION AND EXPLORATION

This study analyzed information about 74 public building construction projects awarded by the Public Building Commission of Chicago (PBC), including 434 bids and a little over $1.1 billion in construction value over a seven year period 2008-2015. These projects are of eight types, namely elementary schools, high schools, parks and playgrounds, libraries, fire stations, police stations, community centers and field houses, and other facilities. Each project involves either construction of a new structure, or renovation of an existing structure, or construction of an annex/addition to an existing structure. Information was extracted from bid tabulations and meeting minutes available on the PBC's website. This information was used to evaluate the impact of the bidding environment on the number and magnitude of contractor-driven change orders. Table 1 shows a summary of the bid data collected in this study.

Table 1. Bid data summary (2008-2015).

Construction Type	Total Contract Value	Number of Bidders	Number of Contracts Awarded
New Construction	$949,657,312	292	52
Addition/Annex	$135,043,186	84	11
Renovation	$102,912,407	58	11

The amounts and types of change orders were identified for each project by examining the minutes of the meetings of the Board of Commissioners of the PBC. The change orders approved by the Board were grouped in six categories including owner-directed changes, client-directed changes, errors and omissions in contract documents, discovered conditions/differing site conditions, code compliance issues, and other changes. The change orders that were not specified under any of these categories were labeled "non-categorized changes" and then removed from the dataset. Client-directed and owner-directed change orders were removed from the dataset, and the remaining change orders were labeled under the name of contractor-driven change orders. In the 2008-2015 study period, the yearly average of contractor-driven change orders expressed in percent of contract value ranged between 0.54% and 1.92%.

The hypothesis of the study is that the amount of contractor-driven change orders during construction increases with increased competition at the time of bidding. In this study, the indicators of competition at bidding were selected based on the literature cited in Table 2 as annual number of available bids, annual average number of bidders per bid, number of bidders in the bid, money left on the table (the difference between

the lowest and the second lowest bids in percent of the lowest bid), number of works under contract, total uncompleted works under contract in percent of contract value, and number of recently completed contracts.

Table 2. Indicators of competition at bidding.

Literature	Factor	Corresponding Indicator Used in the Study
• Chua *et al.* (2001)	Availability of other projects	• Annual number of available bids
• Meulen and Money (1984) • De Neufville and King (1991) • Carr (2005) • Loe et al (2007) • Oo *et al.* (2010) • Chaovalitwongse *et al.* (2011)	Number of bidders	• Annual average number of bidders per bid • Number of bidders in the bid
• Skitmore et al (2001) • Chaovalitwongse *et al.* (2011)	Bid-spread, cost deviation	• Money left on the table
• De Neufville and King (1991) • Chua and Li (2000)	Need for work	• Number of works under contract in percent of contract value • Total uncompleted work under contract • Number of recently completed contracts

A stepwise regression was performed using SPSS to create a predictive model. The bid competition indicators were regressed against the predictor variable of contractor-driven change orders in percent of contract value. As seen in Table 3, the only predictor included in the model is "money left on the table". The rest of the variables are not in the model because some of the information contained in them is already present in the model. The reason why the remaining independent variables did not make it to the model is because of the high inter-correlations between some of these variables. For example, the Pearson correlation coefficients between "money left on the table" and "annual average number of bidders per bid", and between "money left on the table" and "number of bidders in the bid" were respectively -0.321 and -0.266, both significant at $\alpha = 0.05$.

The model accounts for 13.2% of the variance in contractor-driven change orders in percent of contract value. The model is statistically significant $F(1,50) = 8.621$, $p = 0.005 < 0.05$. The coefficient (B) of the independent variable is presented in Table 4. The low coefficient of determination ($R^2 = 13.2\%$) in this study can be due to the fact that the dollar value of change orders may be related to a multitude of other factors than "money left on the table" such as project characteristics, completeness and quality of design, opportunities to cut costs or improve quality, and other reasons that were not investigated in this study. The fact that the model is statistically significant constitutes evidence that competition at the time of bidding (as measured by "money left on the table") is an important predictor of the magnitude of change orders to come in the construction phase.

Table 3. Stepwise regression model to predict the value of change orders in percent of contract value.

Model	*r*	*R* Square	Adjusted *R* Square	Standard Error	Significant *F* Change
1	0.387	0.150	0.132	2.68864	0.005

Table 4. Regression coefficients.

Model	*B*	Standard Error	*β*	*t*	*p*
(Constant)	0.741	0.743		1.567	0.124
Money left on the table	0.229	0.078	0.387	2.936	0.005

The model presented in Table 3 indicates that the dollar amount of contractor-driven change orders increases as the "money left on the table" increases. This finding suggests that bidders who bid low are expected to recover the lost profits through the change orders they initiate. Why would the money left on the table be higher in some circumstances? The "money left on the table" is a measure of competitiveness. It is known that in competitive environments, bidders are likely to bid lower than normal (Meulen and Money 1984; de Neufville and King 1991; Chua *et al.* 2001; Carr 2005; Lo *et al.* 2007; Oo *et. al* 2010; Awwad *et al.* 2014). Also, judging from the correlation coefficient of -0.265 ($\alpha = 0.05$) between "money left on the table" and "number of years the lowest bidder has been active in the industry", the money left on the table appears to be higher if the lowest bidder has fewer years of experience. Indeed, inexperienced contractors lack external legitimacy; i.e., they lack a good understanding of owner requirements, and subcontractor operations (Fu *et al.* 2003).

4 CONCLUSION

The impact of the bidding environment on contractor-driven change orders was investigated in this study. The annual number of available bids, the annual average number of bidders per bid, the number of bidders in the bid, the money left on the table, the number of works under contract, total uncompleted works under contract in percent of contract value, and the number of recently completed contracts were identified as potential independent variables effecting the amount of contractor driven change orders. A stepwise regression analyses was performed, and a statistically significant relationship was found between contractor-driven change orders and "money left on the table". The prediction model showed that as the difference between the lowest and the second lowest bids increase, the amount of change orders goes up. A correlation analysis indicated that "money left on the table", is correlated with "company experience" at $\alpha = 0.05$. In other words, the more experienced the company, the less difference between the lowest and the second lowest bids even in times of economic downturn.

As found in several studies in the literature and in this study, unusually low bids can be a sign of upcoming change orders. Owners must be prepared for potential change orders and adjust their budget contingencies by making use of historical data. They should also be prepared for delays in the work schedule. Contractors must avoid

submitting unrealistically low bids that may affect the company's survival in the industry.

The findings of this study suggest that a more detailed future study may investigate the impact of project characteristics such as project type and contract value on contractor-driven change orders. Exploratory research found that the study of project type and contract value in the context of contractor-driven change orders is expected to result in interesting findings.

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