The Effect of Construction Demand on Bidders' Mark-up Decision

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Abstract

Construction demand is a core component of the construction market and affects the behavior and decision making of contractors in bid pricing. Much of the investigation performed to date, focus on the extremities of general market conditions such as the peak and trough of a boom or recession but provide little empirical support to describe the effects of the intermediary. That is, the effects of varying levels of construction demand on bidders' mark-up decision. An experimental approach that allows active manipulation of variables for hypothesis testing is adopted for this study. A controlled laboratory environment was used to simulate construction bidding with participation from 55 inexperienced bidders with a construction project management background. Construction demand is modeled as the availability of projects in any instance of time. Over the 20 rounds of the experiment, the bidders were separated into two treatment groups, one with a continually increasing level of construction demand and the other case, a continually decreasing level of construction demand. The results suggest that the level of construction demand does have an effect on the bidders' mark-up level and that periods of greater demand lead to a higher overall mark-up level, whilst lower mark-up levels are characterized by a lower level of construction demand. These findings provide empirical support for describing the effect of varying construction demand on the bid price level and allow for clients to better understand and incorporate this component that may affect their procurement strategy.

Keywords: construction bidding, construction demand, experiment, mark-up

1. Introduction

For the construction industry, descending sealed-bid auctions are the contractors' main method of acquiring work. Part of this process involves formulating a bid that incorporates the cost of construction and a mark-up accounting for risk and profit (Dyer and Kagel, 1996). However, formulating an effective bid is complex and requires an accurate estimate of the cost of construction, in addition to a suitable mark-up with due consideration to the competitors' prices (de Neufville et al., 1977). As de Neufville et al. (1977) summarize the outcome of the process; submitting an uncompetitive bid results in failure to attain the contract as well as forfeiting the time and cost of preparing the bid proposal, and submitting

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a highly competitive bid may result in unrealized profit. Part of this dilemma is due to price forecasting being an inexact science, based on historical data and limited information (Flanagan and Norman, 1983).

Amidst the main factors to be considered in bid price estimation, Runeson and Skitmore (1999) suggest that market conditions have a profound effect on bidder behavior and the price level. The difficulty associated with considering market conditions is due to there being no standardized measure of “market conditions”, rather it is necessary to identify a indicator variable that provides an indirect measure for “market conditions” (Flanagan and Norman, 1983). Such is the basis for many empirical works investigating the effects of market conditions on construction bidders, such as; Runeson (1988) in his development of a price-level forecasting model based on a Market Conditions Index reflecting the degree of competition and capacity utilization; Chan et al. (1996) in their analysis of changes in profits of construction firms, considering market conditions as a function of price indexes, GDP and inflation; and Oo et al. (2007, 2010) in their analysis of contractors’ mark-up behavior, with market conditions being reflected by the need for work.

When considering possible indicator variables representing market conditions, the neoclassical microeconomic forces of supply and demand have been investigated to be a suitable explanation for changes in the bid price level (Skitmore et al., 2006; Runeson and Skitmore, 1999). Skitmore (1987) defined supply as the availability of contractors and demand was defined by de Neufville et al. (1977) as the level of contractor activity. Much research has been performed to date describing the effect of the number of competitors on the bid price level and all have suggested that the number of competitors has a direct effect on the bid price level, for example; Carr (1983), Brannman et al. (1987); and Kagel et al. (1995). In terms of the effect of construction demand, the need for work and workload have also been shown to be correlated to the bid price level with a focus directly on “good years” and “bad years” or the peak and trough of a boom and recession (de Neufville et al., 1977 and Oo et al., 2007, 2010).

This study focuses on construction demand effects on bidders’ mark-up with the number of available projects (the need for construction work to be completed) being the indicator variable for market conditions. Following the work by Oo et al. (2007), an experimental approach is adopted to investigate the effect of varying levels of construction demand on bidders’ mark-up levels. Extending on the previous works, a complete observation is made from a boom period (good economic periods) to a recession and vice versa, thus incorporating the intermediate occurrences in the analysis. The paper begins with a literature review on mark-up decisions and construction demand, moving onto the research method adopted for the study and finally the results and conclusions.

2. Bidders’ Mark-up Decision

A typical bid mark-up consists of profit, general overheads and contingency (Kerzner, 2005). The decision to balance all three elements is complex, especially when uncertainty is involved (Li and Love, 1999). They suggest that mark-up decisions are based on past experience and unstructured problem solving activities. This is in agreement with Ahmad and Minkarah (1988) whom also suggest that bid decisions are heuristic in nature and are made on the basis of “experience, judgement and perception”. They also investigated the important factors considered in mark-up decisions through questionnaire surveys received from the top 400 contractors in the United States and found that the top factors affecting such decisions included the degree of difficulty, uncertainty in estimate, historic profit, current workload and need for work. Similarly, in a study by Shash (1993), where the top 300 contractors in the UK were mailed a questionnaire survey, they found that the top five factors that affected the mark-up size decision included: 1) degree of difficulty; 2) risk involved in the work; 3) current workload; 4) need for work; 5) contract conditions. These survey findings are in agreement with the general studies that show mark-up decisions being dominated by a set of key factors related to uncertainty and risk for each unique construction project (McCaffer, 1976; Harris and McCaffer, 1983). These factors can be separated into two categories, i.e., internal and external, where internal factors incorporate design specific issues such as project complexity and external factors related to economic conditions and similar less controllable elements (Skitmore, 1989).

In terms of bidders’ mark-up strategies, Skitmore and Pemberton (1994) summarize that the purpose is to provide a balance between the probability of winning the bid and the potential profit gained if success is achieved. Male (1991) identified that construction bidders operated at three levels: the corporate strategy level; business strategy level; and operational strategy level. At the corporate strategy level, he suggested that contractors define the market domains for which the firm is to operate and compete within. At the business strategy level, contractors determine which contracts to aim and submit bids for (such as project type, size, location). Finally, at the operational strategy level, if the firm decides to bid for a project, a cost estimate is developed which is passed back to the business strategy level where executives apply a mark-up accounting for profit and contingencies. At the corporate and business strategy levels, decisions can be adopted such as random bidding during times of low demand , selective bidding and competitive bidding (characterized by fluctuations in the bid price level) (Fine, 1975) and submission of a cover bid (non-serious bid) (Skitmore, 1989). Three common bidding mark-up strategies were outlined by Boughton (1987) including the “adaptive approach”, “quantitative approach” and “strategic approach”. He describes the adaptive approach being similar to a learning theory model, where the primary goal is to win as many project as possible, with the mark-up percentage being based on the most recent bid and current market conditions. This has the advantage of a competitive bid price, however relies on winning many projects to be effective. The quantitative approach has the primary goal of profit maximization, with the mark-up percentage based on the size of the bid, number of competitors and past performance. The strategic approach has the primary goal of creating long run benefits for the contractor, with the mark-up percentage applied being based on milestones required to achieve the long-term goal. The factors considered in the strategic approach are similar to the adaptive approach and include assessments of competitors and the external environment. Best (1997) identified two pricing strategies similar to Boughton (1987), being cost-based and market based pricing, where cost based pricing is the total cost of service plus an additional mark-up (desired profit) and market based pricing based on competitors’ situation and the client. However, Phillips (2005) suggests that it is not uncommon for firms to use a combination of approaches with the addition of some improvisation.

3. Construction Demand

Construction demand is vital information for contractors as it provides indicators for their current and future workload and can be used to develop effective pricing strategies (Carr and Sandahl, 1978). This is made possible through industry reports and forecasts available (e.g. in Australia, Davis Langdon, 2011a; Davis Langdon 2011b; Australian Industry Group Report, 2011). Akintoye and Skitmore (1994) segregated construction demand into two sectors, public and private, with the construction demand varying differently between the two due to inherent differences in their physical environments and requirements. Runeson and Skitmore (1999) noted that for the industry as a whole, changes in effective demand for building and construction services could be ten percent of more per year, and up to fifty percent or more for individual markets. They suggested that a change in demand lead to a change in bidder behavior and strategy. Many empirical studies have suggested and shown similar relationships. Stone (1983) found a functional relationship suggesting that construction prices increased with increases in demand and prices decreased when demand declined (in line with the law of supply and demand). Runeson and Bennett (1983) considered demand as a function of capacity utilization and found that increases and decreases in the level of activity (demand) resulted in price changes due to the changing number of bidders. De Neufville et al. (1977) in their investigation of 167 building construction and 691 highway projects found that mark-up ratio differed between “good” years and “bad” years (with good years having more projects available for bidding and bad years having less). They concluded that in “good” years, bidders applied high mark-ups in their bidding attempts, whilst in “bad” years, they applied lower mark-ups. Oo et al. (2007) performed an experiment involving senior managers of Hong Kong and Singapore construction firms and found that during booming market condition, the lowest mark-up percentage applied by bidders was higher than that during a recession period. Flanagan and Norman (1985) performed mathematical models on the bid price level and concluded that the current and projected workload affected the bid price, with a higher current workload leading to higher bid prices.

It is interesting to note that that the questionnaire surveys performed by Ahmad and Minkarah (1988) and Shash (1993) both contained indicators of construction demand (such as workload and need for work) as the more important factors considered by contractors in formulating the bid mark-up. In terms of location specific questionnaire surveys performed, Fayek et al. (1999) investigated bidding practices of 58 Canadian civil engineering construction firms and also found that potential profit, need for work, familiarity with market and competitors were the top factors influencing the mark-up size. Shash and Abdul-Hadi (1992) surveyed 71 contractors in Saudi Arabia and found that strength in industry, need for work, competition and the economic situation to be important factors considered in the mark-up size decision. Dulaimi and Shan (2002) investigated 32 medium and large sized contractors in Singapore and discovered that the availability of work was the most important factor considered by the medium sized contractors followed by the need for work and client relations. For large sized contractors they found that the degree of difficulty was most important followed by the availability of work and the competitors in the market. In order to isolate the possible geographic bias from the questionnaire survey results, Ling (2005) performed a meta-analysis on similar surveys performed in Australia, Canada, Saudi Arabia, Singapore, United Kingdom and the United States. She found that five global (restricted to aforementioned locations) factors included: i) risk; ii) current workload; iii) need for work; iv) reliability of company pricing; and v) competition.

When considering the factors affecting the level of construction demand, Akintoye and Skitmore (1994) suggested that these could be categorized as general and local factors. Local factors include the geographical location of the project, project type (e.g. infrastructure or building) and procurement types (Skitmore, 1987), whereas general factors cover the generic PESTL framework containing political, economic, social, technological and legal factors (Akintoye and Skitmore. 1994). Hillebrandt (2000) identified the key factors affecting construction demand to include: i) population; ii) interest rate; iii) health of the economy; iv) demand for goods; v)renovation demand; vi) government and tax policies; and vii) expectations of demand and profit.

From the literature review, it is clear that mark-up and construction demand work in tandem to directly affect the contractors' profits and survivability. Whilst there have been many studies into the effects and causes of construction demand on bidders' behavior, there are little empirical studies attempting to quantify and observe the specific effects. Although construction demand is often deemed as a factor that cannot be controlled (Skitmore, 1987), its effects on contractors are real and understanding how price levels change with the level of construction demand has clear managerial implications for both construction bidders and clients in formulating their bid pricing and procurement strategies, respectively

4. Research Method

In order to test for the specific construction demand effects on bidder mark-up, an experimental approach was used. As de Vaus (2001) states, using an experimental approach allows us to focus on specific variables (i.e. the dependent and independent variables) that are likely to be the cause and effect of the study. This allows the filtering of external variables such that the effect(s) of the intervention can be clearly observed.

4.1 Experiment Design

There were a total of 55 participants for the experiment. These participants were final year undergraduate students with a construction project management background. The indicator variable representing construction demand is the number of available projects (or number of projects released in each bidding round). Two hypothetical demand curves were generated, one starting off from a recessionary point (low level of construction demand) and continually increasing towards a booming point (high level of construction demand). This curve was called the "booming" scenario. The other demand curve was a direct reflection of the booming scenario curve, starting off from a booming point and continually decreasing to a low point (see Figure 1). This curve was called the "recession scenario". The 55 participants were randomly assigned to both scenarios, with 28 bidders experiencing the booming scenario and 27 bidders experiencing the recession scenario. Nested within these two groups were five subgroups consisting of five to six bidders each. The purpose of these subgroups were to simulate a realistic number of bidders competing for each project as it is unlikely for 27-28 bidders competing for a single project (see McAfee and McMillan, 1987 and Ngai et al., 2002). The experiment was conducted in a controlled laboratory environment and no communication was allowed between the groups.

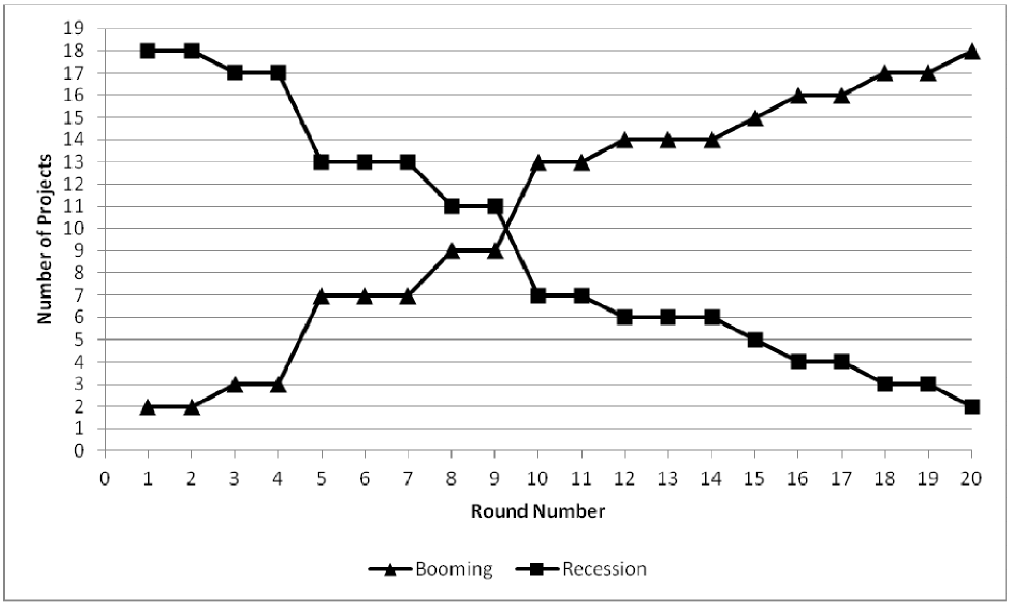

Figure 1: Experimental Treatment Scenarios

The experiment duration was 20 rounds with each round representing a “quarter” of real time (total simulated time is 5 years). Each bidder was provided with a start-up capital of $800,000 and was required to bid for hypothetical building projects. These projects were based on past real projects obtained from the NSW e-tendering website (https://tenders.nsw.gov.au) and project types selected were restricted to general building projects. The construction cost estimate for these projects ranged from approximately AUD 4 - 14 million. Overheads were required to be paid every bidding round and each bidder had a capacity limit of five projects on hand in any one round. If the bidder chose to exceed their capacity, each additional project taken aboard was penalized with a percentage cost representing outsourcing and additional management costs.

In every bidding round, bidders were provided with one hour to decide which projects to bid for and the price to submit for each project. The bid price submitted was expected to include the construction cost in addition for an allowance for profit, overheads and contingency, with due respect for the competition. As the experiment simulates a first price sealed-bid auction, the lowest bidder wins the project, but how this was achieved was left up to them. The general guideline provided to all bidders was that their goal was to prosper and survive.

A market outlook indicator that provided a brief idea of the future construction demand expectation was provided to all bidders at the beginning of each round. From round two onwards, feedback information of preceding rounds was communicated privately to each bidder. These include the winners and the winning bid prices, an up to date statement on the bidders' current account balance, profit/loss from projects won and their current capacity utilization. An incentives scheme was also implemented in order to promote serious participation and to minimize dropouts, this was in the form of a "mystery prize" not revealed until the conclusion of the experiment.

5. Results and Discussion

The results and discussion begins with an exploratory analysis of the bid dataset obtained, followed by a more detailed statistical correlation test of bidders' mark-up trend. Finally, a between treatments comparison is performed between the booming and recession groups.

5.1 Exploratory Analysis

The sample size for both the booming and recession scenarios is shown in Table 1. In total, 11,598 bid and no-bid observations were collected with 4106 and 3269 bids from the booming and recession groups, respectively. A possible explanation for the higher number of bids received from the booming group is because of the difference in the experiment design. As the recession scenario is a direct reflection of the booming demand curve, less number of projects was released to the recession group (184 vs. 216 projects). For the booming group there were 2156 no-bid decisions and 2067 for the recession group. Although the booming group has a higher number of bids, a simple ratio measure considering the experiment design and difference in the total number of projects released reveals that comparatively, there were more no-bid decisions in the recession group compared to the booming group (2067/2156 vs. 184/216, i.e. 0.96 > 0.85). This can be explained in terms of the need for work, where there was a large number of projects released to the recession group early in the experiment, bidders were likely to win jobs at the early stage of the 20-round experiment and remain occupied for a certain period of time (i.e. operate within their capacity) with more no-bids decisions recorded. A Kolmogorov-Smirnov test on the two sample groups revealed that both distributions were not normally distributed (booming: $Z = 9.658$, $p = 0.000$ & recession: $Z = 7.102$, $p < 0.05$), thus non-parametric were used for subsequent statistical analysis.

Table 1: Experiment Sample Size

	Bid		No-bid		Total	
Scenario	N	Percent	N	Percent	N	Percent
Booming	4106	65.6%	2156	34.4%	6262	100.0%
Recession	3269	61.3%	2067	38.7%	5336	100.0%

Figure 2 shows the scatter plots for the bid dataset obtained from both the booming and recession scenarios. The x-axis represents the time scale and is a function of the bidding round number. The y-axis is the mark-up ratio and is calculated as the contractors' bid divided by the unbiased project cost estimate of a project. A mark-up ratio greater than one represents a mark-up being applied by the bidder (on top of the cost estimate) and a mark-up ratio less than one indicates that the bidder is bidding below cost. A reference line at the mark-up ratio of one is added on the scatter plots. Fitted to the data-points is a LOWESS curve (locally weighted scatter plot smoothing) and is based on a local polynomial least squares fit to set of data points. The fit is re-smoothed for several iterations to make it more resilient to the effects of noise and marginal outliers (Hardle, 1990).

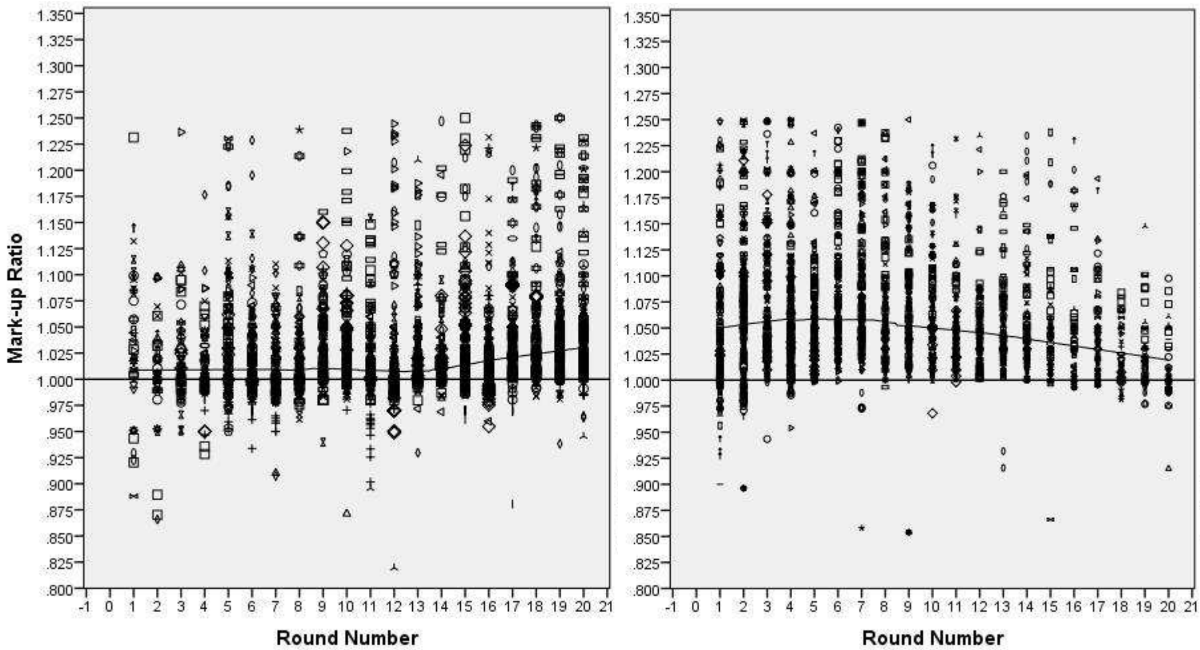

Figure 2: Scatter Plots for Booming (left) and Recession (right) Scenarios

The LOWESS curve for the booming group shows an interesting trend. The mark-up ratio profile appears to be relatively static from rounds one to fourteen. This represents little change in the mark-up trend, most likely stemming from the continual need for work up until round fourteen. Considering that for the first four rounds of the booming scenario only two to three projects were released, the majority of the bidders would have been in high need of work to win job(s) in order to cover overhead costs. From round fourteen and onwards, there is a steady increase in the mark-up ratio being applied by bidders, most likely in response to the increased level of construction demand, and also less competition in the market. That is, at this time, many bidders' would have had enough jobs on hand and less incentive in continuing to bid aggressively. In order to investigate the seemingly static trend from rounds one to fourteen, a Spearman's correlation test was performed in this range in examining the correlation between the mark-up ratio and the number of available projects (see Table 2). Analyzing rounds 1-14 revealed a small overall change in this region (r_s = -0.010) with the correlation between the mark-up ratio and the number of available projects being insignificant (p = 0.604). This indicates an unvarying mark-up trend in this region and a "cut" was needed to explore the trend further. Closer inspection of the LOWESS curve shows a slight "kink" at round 10, indicating changes in the mark-up trend, thus this round was chosen as the cutting point. Performing the same test on rounds 1-10 revealed a positive correlation between the mark-up ratio and the number of available projects at a significant level (r_s = 0.074, p = 0.005). And testing rounds 11-14 reveals a slightly positive correlation between the two variables at a non-significant level (r_s = 0.009, p = 0.762). The results are interesting in that between rounds 11 and 14 there is an adjustment in the bidders' mark-up behavior before the steady increase in the mark-up ratio observed in Figure 2. A possible conjecture to explain this lies in the bidders' current workload, whereby through learning and assessing their current position and the expected construction demand, they were able to optimize their mark-up in response to the flourishing market conditions.

Table 2: Spearman's Correlation Test for Booming Scenario Rounds 1-14

Mark-up Ratio vs. Number of Projects	Rounds 1-14	Rounds 1-10	Rounds 11-14
N	2484	1440	1044
Spearman's rho	-0.010	0.074	0.009
p-value	0.604	0.005	0.762

As per theoretical expectation, the LOWESS curve for the recession group shows an overall opposite trend compared to the booming group. The trend line shows a steady increase initially from rounds 1 to 4 before steadily decreasing up to round 20. This may indicate a learning curve for the recession group, with the initial four rounds used to learn about the bidding environment and market conditions. With strong construction demand starting from round one for the recession group, there was likely to be enough work to go around thus keeping most bidders with a healthy workload. This is indicated by the initially high level of mark-up being applied in bidding attempts. As the construction demand decreased over the time, the need for work and competition in the market increased, thus bidders would have needed to adjust their bidding strategies accordingly in order to sustain or maximize the efficiency of their workload.

An overall comparison between the scatter plots of the booming and recession groups suggests that the overall mark-up ratio for the recession group is higher than the booming group. This again is the result of the treatment effect of the varying levels of construction demand, where for the booming group, the initial low demand would have likely "starved" many bidders at the early stage of the experiment. Since the need for work was high, the competition was high thus driving the bid prices at an aggressive level. Conversely, for the recession group, initial high demand is likely to have provided many bidders with a healthy workload, with an inherently less competitive market, mark-up levels are able to stay high, until changes in the level of construction demand that forced a change in mark-up strategy (i.e. lower mark-up), a product of learning and adaptation. These findings are consistent with the results from Oo et al. (2007, 2010) and de Neufville et al. (1977) in that during "good" years or booming times (strong market conditions/high demand) the level of mark-up percentage is higher in contrast with the times of poor market conditions or low demand.

5.2 Correlation Tests

To relate the observed mark-up trends from the scatter plots (Figure 2) to the experimental treatment scenarios (Figure 1) , Spearman's correlation test was performed on each dataset obtained from the booming and recession groups. The results show that, for the booming group, the correlation between the mark-up ratio and the number of available projects is positive and significant (r_s = 0.206, p=0.000) and similarly for the recession group, the correlation coefficient is also positive and significant (r_s = 0.118, p=0.000). The findings show that mark-up applied to projects increases as the level of construction demand increases The results also show that on average, the bidders were behaving in a rational manner. These findings are in line with the study performed by Ball et al. (2000) on the UK construction industry. They examined the performance of 32 medium size public construction firms and found that mark-ups were positively correlated with the construction cycle (in terms of the availability of new work).

5.3 Between Treatments Comparison

Table 3 shows the descriptive statistics for both the booming and recession groups. It can be seen that the mean mark-up ratio is higher overall for bidders subjected to the recession scenario compared to the booming scenario. The standard deviation shows that bidders were more consistent in their bidding attempts in the booming group compared to the recession group. The removal of outliers was based on a criterion set forth by the Hong Kong SAR government, which considers all bids that are 25% above the lowest bid to be non-serious bids (Skitmore, 2002). Due to the nesting of subgroups for this experiment, the criterion was modified such that bids with a mark-up of 25% above the cost estimate were considered as outliers, this explains the maximum mark-up ratio for both the booming and recession groups being identical at 1.250. The Mann-Whitney U test was utilized for comparing the difference in distributions of the mark-up ratio for both the booming and recession groups. The results support the descriptive statistics, and it was found that the mean mark-up ratio for the recession group was higher than the booming group at $p < 0.05$ (U = 3522650 , Z = -35.107, P = 0.000). This provides strong evidence that that both groups come from different distributions (statistically), suggesting that the treatment effects (varying levels of construction demand) did have an effect on bidders' mark-up behavior. In other words, bidders do consider the level of construction demand in their bidding attempts and have formulated their bidding strategies accordingly. This finding is similar to that of King and Mercer (1990) whom applied mathematical analysis to a bidding model and found that bidders adjusted their mark-up in response to changes in the current market and also cost estimate variability.

Table 3: Descriptive Statistics

	Mark-up Ratio				
Scenario Type	N	Mean	Std. Deviation	Minimum	Maximum
Booming	4106	1.02603	0.04464	0.820	1.250
Recession	3269	1.06060	0.05952	0.854	1.250

6. Conclusion

This study investigated the effect of construction demand on bidders' mark-up behavior. Utilizing an experimental approach, 55 inexperienced bidders were placed into two different construction demand scenarios and bid for projects in an environment simulating construction bidding in practice. It was found that bidders did consider the level of construction demand in their bidding attempts and this was reflected by changes in their mark-up strategy. Correlation tests performed suggest that the mark-up increases as the number of available projects (level of demand) increases. The experiment design allows for intermediary observations between the peak and trough of a typical construction demand cycle. The findings provide empirical support on explaining how varying levels of construction demand affects the bid mark-up level. It is identified that a limitation of this study is the use of student subjects for the experiment, thus limiting the generalization from this study to inexperienced bidders. Suggestions for further studies include repeating the experiment with different demand curves, running the experiment for a longer period of time and use of experienced industry practitioners in similar experiments are all likely to produce useful insights that will further our empirical understanding on how construction demand affects bidder behavior. The results of this study are of importance to contractors and clients, particularly in formulating bidding or procurement strategies to take advantage of or to mitigate the effects of market demand.

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