

# ANALYSIS OF THE LOW-BID AWARD SYSTEM IN PUBLIC SECTOR CONSTRUCTION PROCUREMENT

by

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A thesis submitted in conformity with the requirements  
for the degree of Master's of Applied Science  
Graduate Department of Civil Engineering  
University of Toronto

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## Abstract

Canadian construction participants have long recognized that accepting the lowest price bid does not guarantee maximum value. Achieving a value-based procurement approach is a challenge, particularly for the Canadian public sector clients who are limited in their ability to evaluate the competitive bids based solely on the low-bid award system. Bid and cost data from 218 projects from three major public sector construction clients in the Greater Toronto Area are evaluated. Compared to the other clients, the cost escalation is significantly higher for the client that does not have a standard prequalification policy. Increased contractor competition (high number of bids) and a large price gap between low bid and other bids are correlated to higher cost escalation for the non-prequalifying client. Also, the organizational culture of the non-prequalifying client is less results-oriented. The research demonstrates the importance of prequalifying for clients that award based solely on the low bid.

## Acknowledgments

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I would like to thank my wife, Kathleen, who has provided a tremendous amount of love and support throughout this journey. On a final note... Hi Tavish (my five month old son)!

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# 1 Introduction

Striving to improve the procurement of construction by the public sector (municipal, provincial and federal agencies) is in the best interest of both the public and the construction industry.

Currently, the public sector procurement of construction is largely based on the low bid award system. It is important to review and evaluate the current performance of the procurement process to work toward the public sector obtaining greater value for money in their construction projects.

The low bid award system fosters competition amongst contractors attempting to secure the project. This competition can have both positive and negative effects for the client. As the public sector client is accountable to the public, an open competitive bidding process that is awarded based only on price is highly transparent. However, selecting a contractor based solely on price greatly diminishes the significance of important such as criteria, time and quality. Low bid price as the sole award criterion encourages unqualified contractors to submit bids (Herbsman and Ellis, 1992) along with bidders that submit a very low bid with the intent of recovering their losses through change orders and claims, also known as predatory bidding (Crowley and Hancher, 1995). Therefore, low bid is not necessarily the best value.

This research hypothesizes that there is potential for too much open competition in public sector construction procurement. By examining past construction project data from several public sector agencies, this research hopes to identify a threshold at which price cutting by the winning contractor is no longer fair competition but predatory bidding. More specifically, the research will investigate whether there is a correlation between the size of gap between the low bid and

other bidders and the cost escalation of a project. Also, the research plans to demonstrate that too many bidders is correlated to predatory bidding and the associated higher cost escalation.

It is generally recognized that both the performance of an organization and its long-term effectiveness are impacted by organizational culture. Culture is a key factor in the success of organizations in many different industries, including the public sector (Cameron and Quinn, 2002). Although public sector organizations have different mandates than private sector organizations, their organizational culture will dictate the values held, the leadership style, and how problem solving is approached within the organization. All of these factors contribute greatly to the performance of public sector organizations. A common performance metric for public sector clients is the ability to minimize the amount of cost escalation on projects. This research hypothesizes that differences amongst the clients' ability to control cost escalation of projects is correlated with some differences in organizational culture.

Overall, this research demonstrates that valuable information pertaining to the final cost and possible cost escalations can be obtained from the bidding process. The potential end result is that clients could utilize the findings to alert themselves of projects that are prone to cost escalation based on the bid data. Also, the research provides insight into the possible correlation between organizational culture and cost escalation with the potential benefit of identifying characteristics that are key to maintaining tight cost controls.

## 2 Literature Review

The public sector is a major purchaser of construction in Canada. Even with the continued growth of alternative delivery models for construction projects (e.g. design-build, construction management) a considerable amount of work is still being delivered via the traditional design-bid-build model, especially by the public sector.

There is clearly no one project delivery and finance model that is preferable across all projects, yet the public sector for the past few decades has adopted the design-bid-build delivery model almost exclusively (Miller *et al.*, 2000). The means of obtaining the best value under this system is to award a contract to the responsive and compliant bidder that is willing to fulfill the terms of the contract for the lowest dollar value.

There are definite benefits and drawbacks to the low bid award system. Fostering competition amongst contractors is a clear benefit to the process. It compels the contractors to lower their costs, often through innovation, to ensure they win bids and maintain their profit margins. Also, the process is beneficial specifically to the public sector because of the transparency, an important criterion of public policy. However, allowing projects to be awarded based solely on one criterion has inherent flaws. Criteria such as time and quality are negated. Also, the low bid award system encourages unqualified bidders (Carr, 2005).

## 2.1 Bid Gap

There are definite risks associated with the low bid award system. A number of studies have shown that the lowest bid does not guarantee the lowest cost. Also, the lowest bidder is subject to the *winner's curse*; the contractor with the lowest bid is the one most likely to have underestimated the cost of the project (Capen *et al.*, 1971). They are required to complete a construction project that no one else was willing to do at that price (Wolfsetter, 1996).

If a contractor submits a bid that is significantly lower than the client's estimate and the other bidders, it is difficult to understand how that contractor could complete the job profitably. The European Union defines those bids as *Abnormally Low Tenders* (DGIII, 1999). The EU introduced legislation to allow public sector clients the option of awarding a construction project using either the traditional low bid or the Economically Most Advantageous Tender (EMAT). The legislation allowed public sector clients to reduce their exposure to some of the adverse effects of abnormally low tenders (ALT), including:

- Unsatisfactory quality through the need to reduce construction costs (Winch 2000);
- Predatory pricing and unfair competition that distorts the market, negatively affecting the other bidders (Alexandersson, 2006).

Researchers have summarized the long list of factors that can influence a contractor's decision to bid and the price they submit (Chua, 2000; Fayek, 1998). In addition to the many factors involved in determining a price, there are a number of reasons that the bid submitted could be considered abnormally low. Imprecise and ambiguous contract documentation (including

incomplete drawings) may cause a contractor to make a serious omission in calculating costs.

Errors may also arise due to insufficient time to prepare the bid.

One of the most concerning reasons is the practice of a contractor intentionally submitting an artificially low bid in anticipation of making their profit through change orders and claims (Zack, 1993). Some bidders carefully review the bid documents searching for mistakes and ambiguity in areas that could lead to change orders and claims during the project (Doyle and DeStephanis, 1990). These bidders can then use this knowledge to submit a lower bid with the expectation of recouping the money later. This practice can be equated to a gambit strategy in chess: making a small sacrifice early to setup up the opponent to be in a vulnerable position later (Crowley and Hancher, 1995). In all cases, the abnormally low bid is not reflective of the final contract cost or the hidden costs incurred by the client when dealing with numerous change orders and claims.

The median bid submitted may be considered a reflection of the fair market value for a project. Of the bidders competing for a project, half of the contractors would be willing to take the job at the median price, while the other half of the bidders would not. The median bid is more reflective of the market value than the mean because it is not influenced by outlying high and low bids. For example, it is common for contractors to submit a “courtesy” bid that is high with no expectation of winning the tender to remain in good standing with the owner.

Using the postulate that the median bid reflects the fair market value, one could expect that if all of the bidders are tightly clustered around the median, then they have a general consensus of the complexity and the costs of the project. With this scenario, one would expect that the cost escalation of the project would be small. While a large gap between the low bid and the other

bids would suggest a greater chance that the abnormally low bidder is not bidding on the same project as the rest of the bidders. Higher cost escalation for those projects is conceivable.

Highway road construction projects that were awarded to low bidders that were significantly lower than the median bidder experienced 3.5 to 4 times the cost escalation (from the low bid) than projects where the low bidder was close in price to the median bid price (Crowley and Hancher, 1995).

The current research will attempt to identify if the trend identified by Crowley and Hancher (1995) is applicable to public sector industrial, commercial and institutional (ICI) construction projects in the Greater Toronto Area.

## 2.2 Number of Bidders

A study of public projects bid under a condition of free, open, unfettered competition in upstate New York included 428 bids on 19 educational building projects (\$158M total), and 84 prime contract awards (Carr, 2005). There was a statistically significant negative correlation between the number of bidders on a project and the difference between the low bid and the project budget. Unfortunately, the study did not evaluate the final cost compared to the bids received. The findings were dependant on the accuracy of the prebid estimates but not the final cost. The accuracy of budgets are affected by three main factors: who prepared the estimate; how it was prepared; and the level of information known at the time of the estimate (Oberlender and Trost 2001).

The current research will examine the correlation between the number of bidders and the difference between the final cost and the low bid. Two outcomes are possible. First, the increased competition can encourage innovation and cost saving measures by the contractors, resulting in a lower project cost. Second, a large number of competitors may encourage some of the contractors to artificially lower their price in an attempt to secure the contract and then rely on change orders or claims to recoup their losses. In this scenario, the final cost may be higher than expected.

## 2.3 Estimating

In addition to examining the bid spread for the different public sector construction projects, the ability to predict final cost based on the bids received is of interest. The best predictive model of final costs for highway construction projects in the United States using bid data was a linear regression based solely on the low bid (Williams, 2002). The model was able to predict approximately 70-85% of the projects within 10% of the final cost (Williams, 2003). However, the model did a poor job of predicting final project costs that had particularly large cost increases. It was also found that a natural log transformation of the original bid data and final cost data normalized the data allowing a simple linear regression to be performed with the low bid as the independent variable and the final cost as the dependent variable.

The linear relationship between the normalized low bid and final cost can be expressed as:

$$\text{LN}(Y) = A(\text{LN}(X)) + B \quad \text{Eq. 1}$$

Where Y is the final cost, X is the low bid, and A and B are constants. The equation can be converted back to dollars by taking the exponential of each side of the equation to make the model more user friendly:

$$Y = BX^A \qquad \text{Eq. 2}$$

A model that could provide an accurate estimate of the final cost would provide considerable assistance to the owners' construction budget planning. Currently, the approach for estimating a budget contingency at the time of bid for the clients participating in the research is a percentage of the low bid price (most commonly 10%). However, the value for the contingency is selected based on general past experience and not a detailed examination of past projects.

The accuracy of final cost estimates at different stages of projects for a range of municipal projects varies greatly by type of project (Abourizk *et al.*, 2002). The direct applicability to this research is data on building projects (including new building construction, additions, renovations, and alterations to existing city-owned and leased buildings). Comparing the pre-tender estimates to final costs, a municipal client's building projects that used a pre-tender estimate range of +/- 10% should be adjusted to +/- 15% (Abourizk *et al.*, 2002).

This research will help validate the contingencies used by the public sector clients at the bidding stage. Also, when not limited by a small number of projects, the prediction model will be applied to specific project types to determine if different contingencies should be utilized for different ICI project types.

## 2.4 Organizational Culture

There are traditional keys to a company's success (Porter, 1980):

1. High barriers to entry
2. Non-substitutable products
3. Large market share
4. Low level of bargaining power for buyers
5. Suppliers have low levels of bargaining power
6. Rivalry among competitors

Yet some highly successful companies are able to perform exceedingly well in oversaturated markets (e.g. Wal-Mart, Southwest Airlines). Often, these companies that are highly successful in difficult markets attribute a large part of their success to their organizational culture (Cameron and Quinn, 2002). The importance of culture does not only affect the success of private sector companies, but also the effectiveness of public sector organizations.

Identifying the type of culture that dominates is important to determine if the culture is aligned with the predominant culture of an organization's competitive environment. Understanding the differences between how an organization perceives itself and how it wants to be is a first step towards aligning those two aspects to help long-term success. Finally, identifying similarities and differences between an organization and the industry in general may provide insight into possible changes that would enhance an organization's effectiveness.

The *Competing Values Framework* is a method of assessing organizational culture that has been tested and validated on thousands of organizations. The primary focus of the method is to

identify and compare the importance of values within an organization that partially conflict with each other. The framework contributed to the development of an assessment tool to determine the relative importance of culture characteristics that exist within an organization (Cameron and Quinn, 2002). They classified culture characteristics into four categories for comparison purposes – Clan, Hierarchy, Market and Adhocracy. A brief description of these competing characteristics is provided.

Clan – A *Clan* culture is similar to an extended family, where the organization focuses on the long-term benefit of individual development, while high cohesion and morale are also important. Leaders are viewed as mentors. Teamwork, participation and consensus are highly important within the organization.

Hierarchy – A *Hierarchy* culture is governed by formal structure and procedures. Relationships within the organization are formalized. Leaders need to be good coordinators and organizers. Formal rules, regulations and policies are relied upon to maintain the smooth running of the organization.

Market – A *Market* culture is driven by an emphasis on winning. The results oriented workplace requires tough, demanding leaders that are hard-driving producers and competitors. The goals of the organization are defined by market share and penetration.

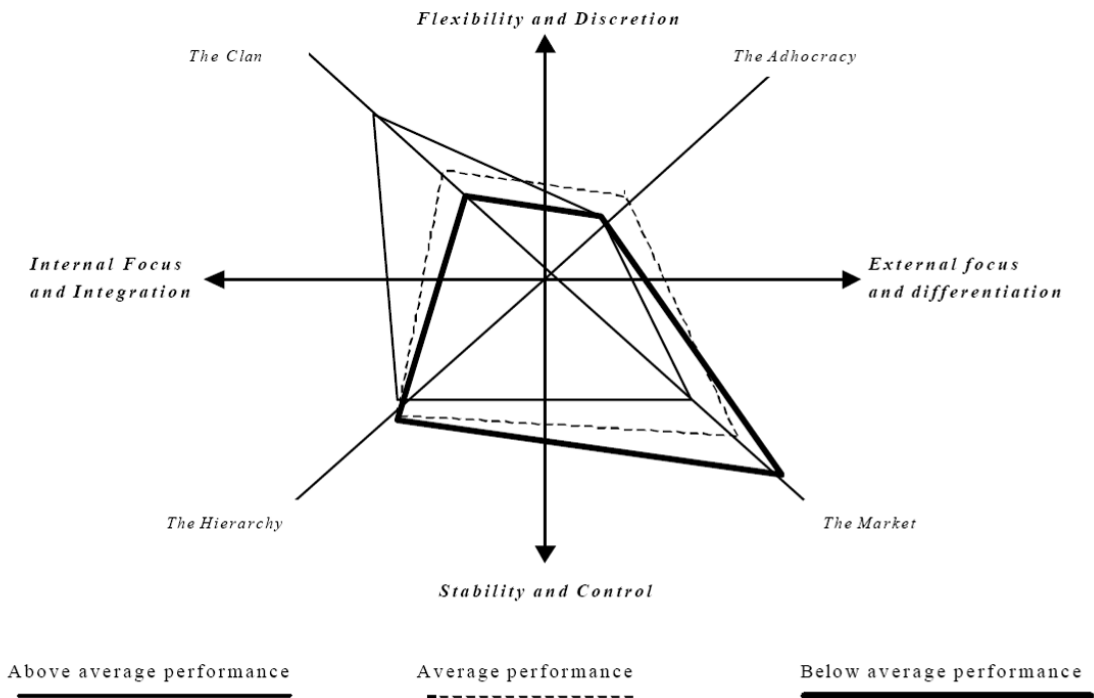
Adhocracy – An *Adhocracy* culture can be characterized by a dynamic, entrepreneurial and creative workplace. Leadership within the culture relies on innovation and risk-taking. Agility, readiness for change and meeting new challenges are valued within the culture.

Research has also been undertaken to develop instruments and methods to identify how closely and strongly certain values and characteristics are held within an organization. Among the research, the *Organizational Culture Assessment Instrument* (OCAI) (Cameron and Quinn, 2002) has become the most popular tool and has been used in approximately 10,000 organizations across the globe in many sectors (e.g. private sector, public sector, education, healthcare, new businesses, NGOs). It was developed from Campbell's (1974) 39 organizational effectiveness indicators. The organizational effectiveness indicators were then combined with the *Competing Values Framework* to establish the relative importance of cultural indicators within an organization and determine the organization's overall cultural profile using the four cultural forms listed above and six key dimensions of organizational culture (Quinn and Cameron, 1983):

1. Dominant Characteristics
2. Organizational Leadership
3. Management of Employees
4. Organizational Glue
5. Strategic Emphases
6. Criteria for Success

The *Competing Values Framework* has been used to assess the organizational culture characteristics of design and construction organizations that participated in 13 construction projects (Thomas *et al.*, 2002). The culture within the projects that experienced poor performance showed a strong orientation toward *Market* culture, while above average performing projects were more strongly *Clan* oriented (Figure 1). These results are somewhat counter intuitive as the *Market* culture is results-focused. The major weakness of the research is

that project performance is not well defined. It is unclear whether the criteria for success were focused toward cost, schedule or quality.



**Figure 1 – The relationship between project performance and project culture (Thomas *et al.*, 2002)**

Utilizing the competing values framework, a survey using the *Organizational Cultural Assessment Instrument* (OCAI) helped identify that an Australian Engineering, Procurement and Construction management consultancy company under study had a definite market-oriented culture (Igo and Skitmore, 2006). This finding contrasted with the respondents' desire of an employee focused culture, indicating a gap between what the employees perceive as needed and how they view the firm now. It was argued that the market-oriented cultures have a detrimental

effect on achieving quality construction project outcomes, unlike a culture that is employee focused.

## 2.5 Summary

There has been a considerable amount of research performed regarding the procurement of construction, ranging from delivery models to contractor selection methods. However, there remain areas worthy of investigation utilizing the information available to the client at the bid opening. This is not surprising considering the relative secrecy of the bids, schedules and costs. In this research, the information obtained from the bid openings will be compared to the completed schedules and costs for projects from three public sector clients in the Greater Toronto Area. The research will build upon some of the prior research pertaining to the correlation between cost and schedule escalation and:

1. The price gap between the low bidder and other bidders
2. The number of bidders

The ability to predict the final cost based on the bid data will be examined. Finally, the organizational characteristics of the three participating clients will be examined using the OCAI to provide potential context to some of the identifiable differences between the clients.

### 3 Scientific Methods

The ability to conduct the research was dependent on the participation of public sector clients that are both major purchasers of construction and conduct internal project management. In partnership with the Ontario Construction Secretariat, I established contacts, proposed a plan and reached agreements with several major public sector clients who value the potential for public policy development. One of the primary challenges with reaching the agreements was finding the correct person within an organization who has both the authority to approve the disclosure of project data along with the time and interest in participating in research. Typically, two to three preliminary meetings were held over the phone and in person before approvals were granted. These agreements enabled me to access their construction archives for analysis. The agreement to participate in the research by the three clients was conditional on anonymity.

All three clients were major institutional public sector construction clients that operate in the Greater Toronto Area (GTA). The annual construction budgets for the three clients ranged from approximately \$15M for Client A, \$40M for Client B and \$100M for Client C. The clients had similar methods of archiving their projects. The most recent projects were accessible to the project management staff in both electronic and hard copy formats, while older project files were stored in boxes. Projects included in this research from the clients ranged from 2001 to 2008.

The following information was available from the archives:

- Type of project
- Bid prices received
- Number of bidders
- Planned Schedule start and finish

- Actual schedule start and finish
- Final Cost

Client B provided data retrieved by their project management staff while the other clients required that I personally retrieve the information from the archives. This presented an added challenge. The cataloguing system of the clients was thorough; however documents were often not located in the appropriate files. The completeness of the project files for Clients A and C project data was an issue, especially regarding scheduling. Unfortunately, the missing schedule data precluded an in depth analysis into possible correlations between bid data and schedule overrun.

The engineer's estimate for each project would have been of interest to compare not only the accuracy of the estimates, but also to measure any cost escalation in relation to the engineer's estimate in addition to the low bid price. However, the method and consistency of reporting the estimate among the participating clients was too varied to include it in the analysis.

The data was initially trimmed to only include projects with three or more bidders to facilitate the remainder of the data analysis. Based on similar research utilizing a significance level of 0.05, that value will be used throughout this research (Crowley and Hancher, 1995; Williams, 2003). A survey of the procurement practices and procedures of the three clients was conducted to provide further context to the results.

### 3.1 Bid Gap

To determine if a correlation exists between the size of price gap between the low and the other bids and the cost escalation of a project the following ratios were used:

$$\text{Bid Gap} = \text{Median Bid} / \text{Low Bid} \quad \text{Eq. 3}$$

$$\text{Cost Escalation} = \text{Final Cost} / \text{Low Bid} \quad \text{Eq. 4}$$

The ratios were used to eliminate the effect of project size when comparing the data. Ratios other than median bid to low bid (second bid, mean bid, and highest bid) were included in the preliminary analysis but were eliminated because they were not nearly as relevant as the median bid. As stated in the Literature Review, the median bid can be considered the “market” price. The ratio in Eq. 3 represents the low bid’s departure from the “market” price. The larger the ratio, the larger the price discrepancy between the low bid and the median bid.

### 3.2 Number of Bidders

The correlation between the number of bidders and cost escalation was observed graphically for each client, using Eq. 4 for the cost escalation. Where a trend existed, a logistic regression was performed to determine the probability of a project experiencing a large cost escalation based on the number of bidders. A large cost escalation is defined as double the normal contingency used by the clients, or 20%.

### 3.3 Final Cost Estimating

This research utilized the modeling technique used for United States highway construction projects (Williams, 2003) and applied it to the ICI construction projects of the three participating public sector clients. Although the non-winning bids did not affect the predictive model for United States highway construction projects study, this research investigated whether that bidding information provides any insight into the final cost of the ICI projects under study.

To develop a model that estimates the final cost using the bid data using linear regression, the data needed to be normalized. A stepwise linear regression was then performed for each client with normalized versions of the low bid, second lowest bid, median bid, highest bid, and number of bidders as independent variables while the normalized final cost values were the dependent variable. The regression estimate (in natural log dollars) was converted to provide the estimate equation in dollars for ease of use by the clients.

### 3.4 Organizational Culture

The correlation between the organizational culture of a public sector construction client and the cost escalation that their projects experience was investigated using the *Competing Values Framework*. The standard OCAI survey was used to identify the organizational characteristics of the participating clients, details of which can be found in Cameron and Quinn (2002).

The questionnaire was composed of questions that ask the respondent to provide a weighting to each of the four possible answers as to how that answer reflects their current organization and another weighting to reflect how the answer reflects how they prefer their organization to be in

five years. The questionnaire was initially intended to be conducted in person at the end of staff meetings, however due to scheduling difficulties, the questionnaire was provided electronically to 5-10 project management staff of each client.

The OCAI method was chosen because it has been tested on several thousand organizations and it is able to provide an accurate representation of the culture of the organizations under study.

There are a number of other approaches to studying organizational culture; however this method was not intrusive or time consuming which ensured that the clients would not hesitate to participate. From the completed questionnaire, the method provides a number of comparisons including: the type of culture that dominates the organization; the differences between the actual and desired future culture; a comparison of the organizations' cultures with culture profiles of previous studies (Cameron and Quinn, 2002).

## 4 Results and Discussion

Through the participation of the public sector clients, project data from over 200 public sector ICI projects was collected and examined in this research. Project size ranged from \$25,800 to over \$20 million. The median project size was between \$167,000 and approximately \$335,000, depending on the client. The entire data set can be seen in Appendix A – Project Bid and Cost Data. Further summary statistics are provided in Table 1.

A preliminary investigation into analyzing all of the projects combined from the different clients produced no discernable trends. Thus, the following results treat each of the clients separately. For a segment of the research, the respective median project size of each client was chosen to split the projects into large and small projects for analysis. The median was chosen because several project managers from different clients used it as a dividing point. The analysis was also attempted using \$170,000 as a split for all clients, yielding very little difference in the results.

**Table 1 – Summary Statistics for Participating Clients**

		Number of projects	Low Bids			
			Minimum	Maximum	Mean	Median
Client	A	57	\$25,800	\$6,130,000	\$435,262	\$171,500
	B	87	\$28,000	\$1,557,000	\$250,756	\$167,000
	C	70	\$52,430	\$20,410,000	\$1,700,942	\$334,918

A questionnaire completed by a director from each client revealed several differences in the practices and procedures of the project management departments of the clients. Some of the most

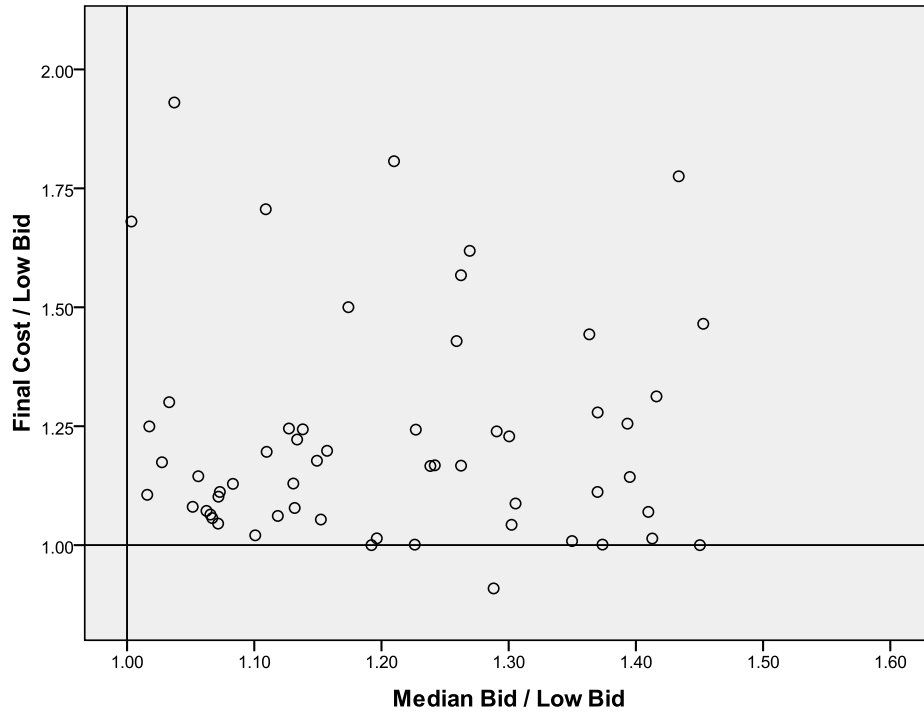
significant results of the survey are included in Table 2. Importantly, only Client A does not have a prequalification policy in place.

**Table 2 – Client procurement practices survey**

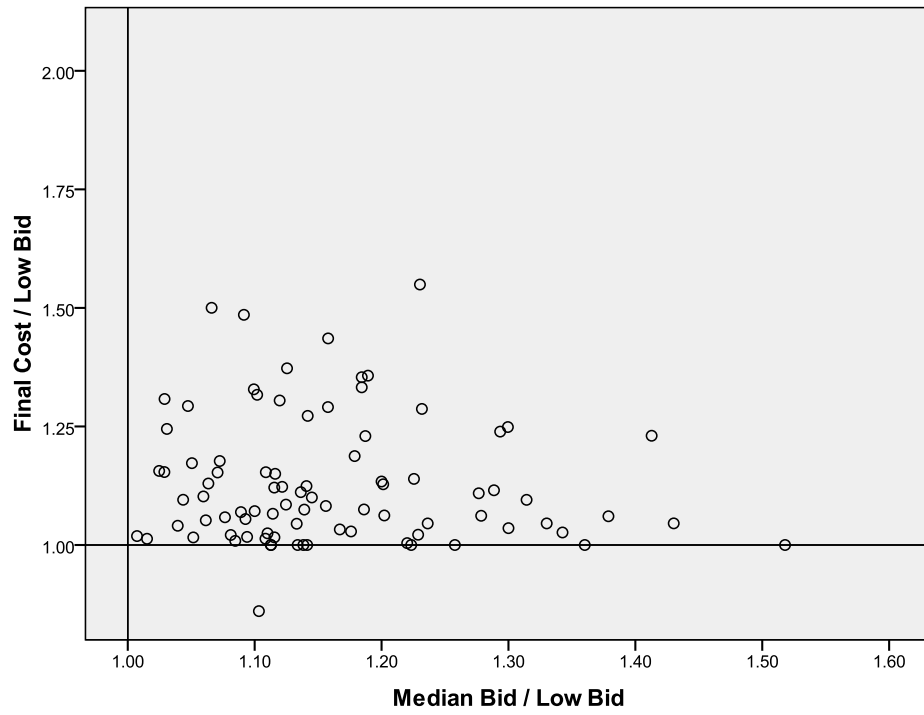
	Client A	Client B	Client C
Minimum project size to prequalify contractors	N/A	\$0	\$100,000
% of project managers with more than five years experience	20%	100%	100%

## 4.1 Bid Gap

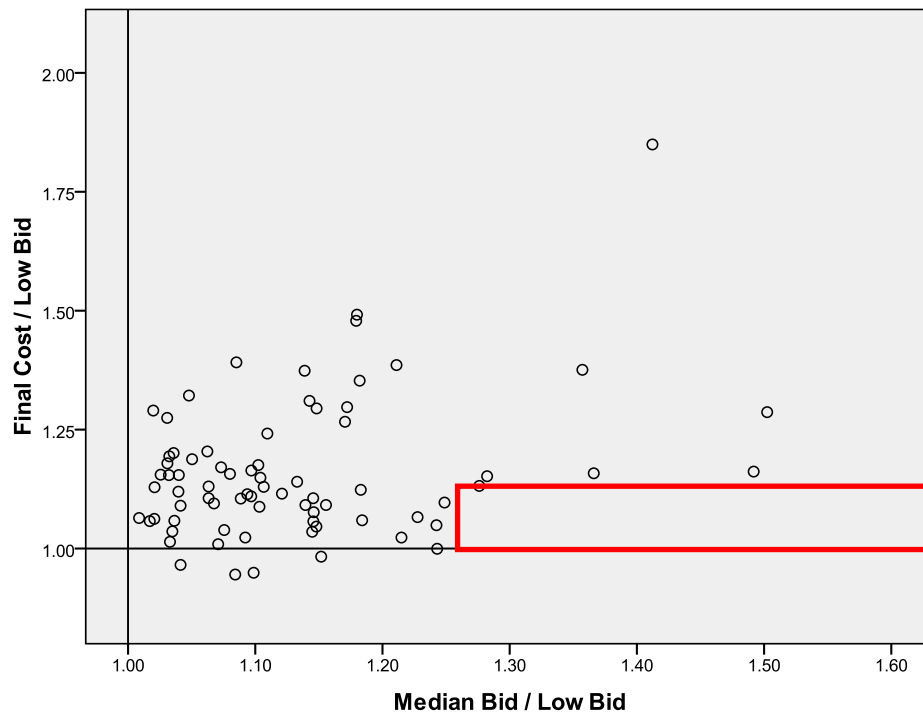
The relationship between the bid gap and the cost escalation was initially investigated for each client separately. Figure 2 - Figure 4 demonstrate the relationship for all of the projects for each client. The only major trend identified is that none of the projects by Client C with a bid gap ratio over 1.25 had cost escalation lower than 1.1, as outlined in red in Figure 4. The projects that had both a large bid gap ratio and large cost escalation included internal renovations, mechanical and envelope work. Although there are not many data points, the trend suggests that Client C does not obtain good value on projects where the low bidder is much lower than the median bidder. It is recommended that the client monitor this trend to determine if the median to low bid ratio can be used as a warning for some projects that may experience large cost overruns. In surveying the procurement practices of the clients, there was no explanation found as to why this trend is only visible in one client.



**Figure 2 – Bid gap ratio and cost escalation for Client A**

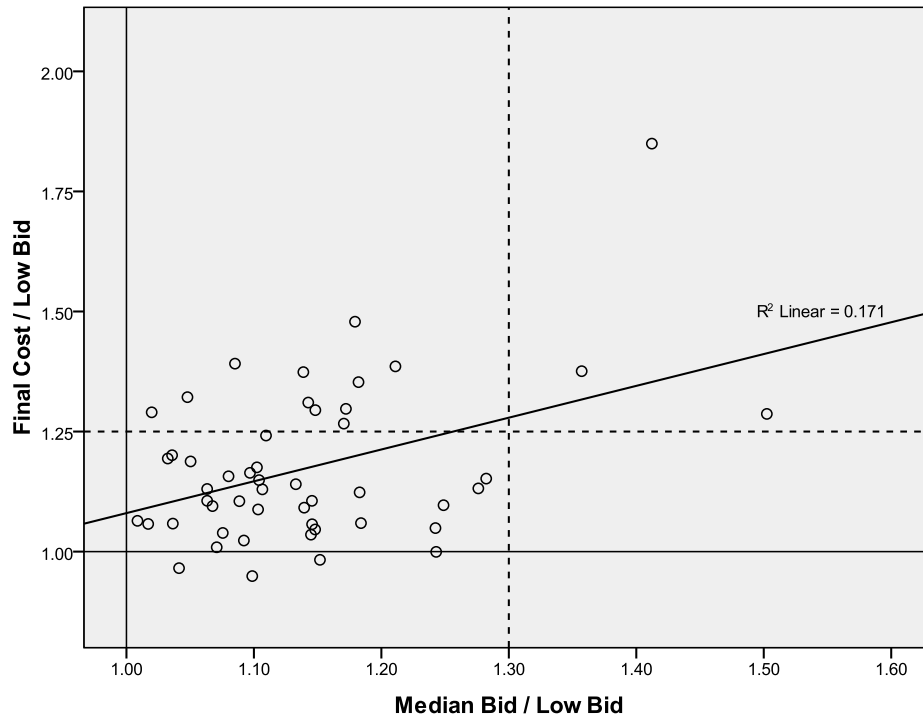


**Figure 3 – Bid gap ratio and cost escalation for Client B**



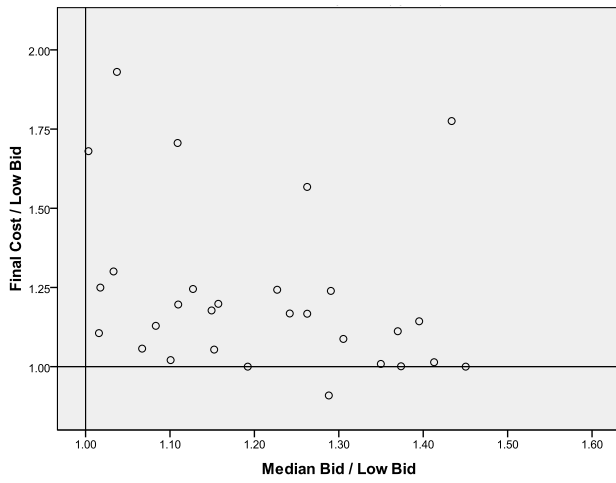
**Figure 4 – Bid gap ratio and cost escalation for Client C**

Upon further investigation of the bid gap and cost escalation relationship for Client C, there was found to be a reasonably high correlation between the size of the bid gap and the amount of cost escalation for internal renovation projects of Client C (Pearson's correlation = 0.414, p-value = 0.05) (Figure 5). This relationship is significant as it may provide a warning for future projects that have a bid gap ratio greater than 1.25.

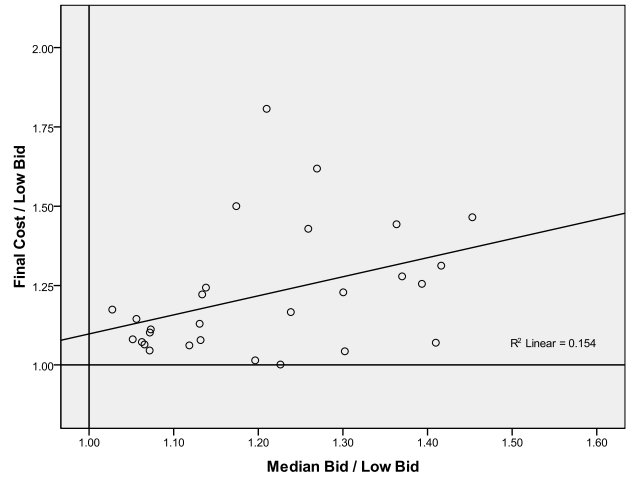


**Figure 5 – Client C internal renovation projects with large bid gaps incurred high cost escalation**

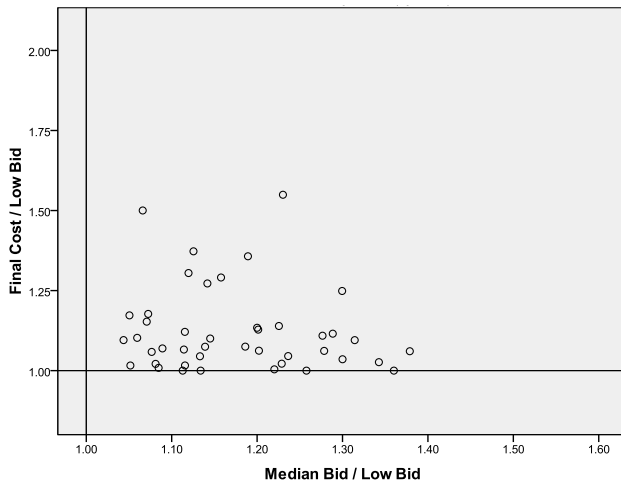
Dividing the projects of each client into groups higher or lower than their respective median project size allowed investigation of whether project size affects the cost escalation / bid gap relationship. Figure 6 - Figure 11 display the relationship for each client. Of major interest is the trend for large Client A projects: if a project had a small gap between the bidders, it did not experience large cost escalation (Figure 6).



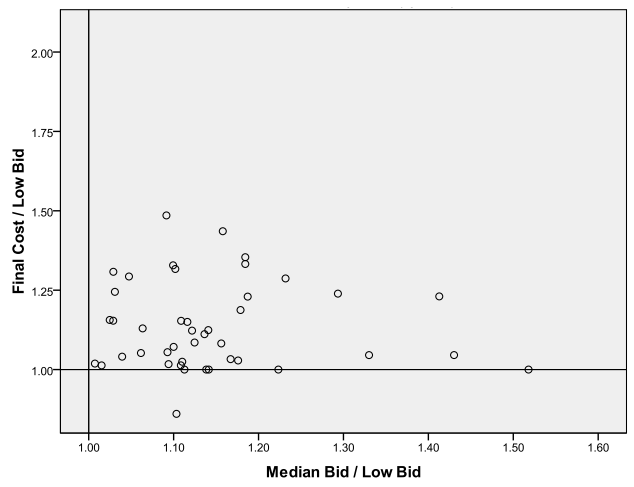
**Figure 6 – Small Client A projects**



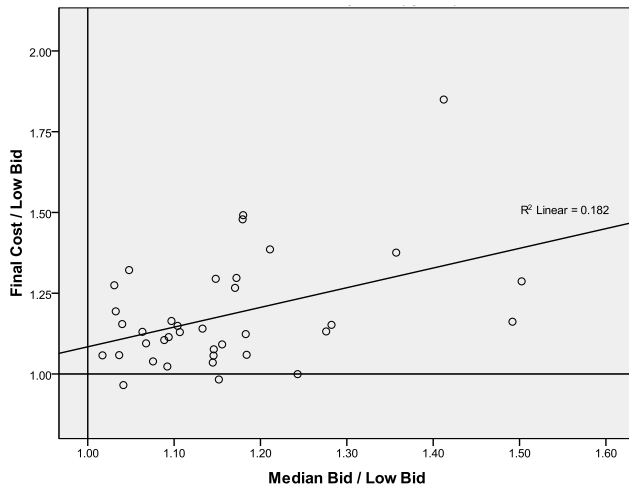
**Figure 7 – Large Client A projects**



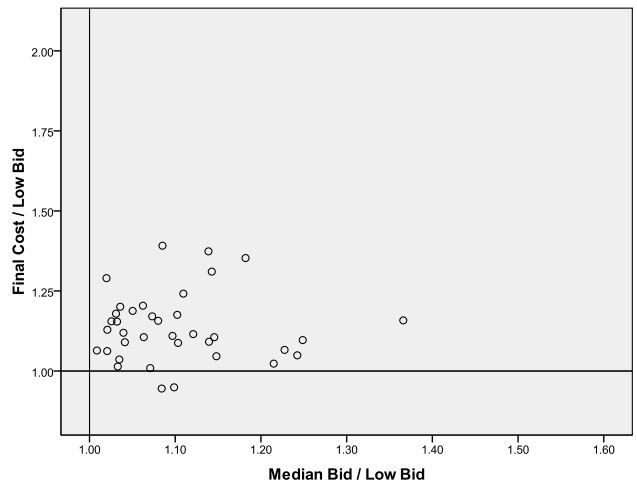
**Figure 8 – Small Client B projects**



**Figure 9- Large Client B projects**



**Figure 10 – Small Client C projects**



**Figure 11 – Large Client C projects**

The expected correlation between the gap in bid prices and the amount of cost escalation a project experienced only occurred on a limited subset of some of the clients' projects (large Client A projects and Client C internal renovations). Although the correlation was shown to exist in U.S. highway projects (Crowley, 1995), the wide range of types of projects contained within the ICI sector and the large amount of unknowns contained within some projects (particularly internal renovation and work involving underground conditions) lead to a large amount of variability in the amount of cost escalation of a project. The lack of consistency in the trend prevents the clients from using the median to low bid gap ratio as a red flag for projects that would be more likely to experience higher cost escalation. In general, examining only the bid gap for all ICI projects of a public sector client does not provide an indication as to the expected cost escalation that a particular project will incur.

The other trend of note is that all of the large Client C projects had both a tight distribution of the bids and little cost escalation (Figure 11). In general, the decreased cost escalation may be explained by utilizing more experienced project managers on the larger projects. Also, the smaller bid distribution of the large projects may be attributable to Client C requiring that contractors must be prequalified for projects over \$100,000.

## 4.2 Number of Bidders

Examining each client separately, the cost escalation of a project as a function of the number of bidders reveals several trends. Client A is the only client that received more than nine bids on a project. In surveying the procurement practices of the clients, Client A is unique. Client B and

Client C have a policy requiring contractors to prequalify for any project greater than \$100,000. The lack of prequalification opens the bidding process to many more contractors.

As shown in Figure 12, Client A experiences slightly less cost escalation on projects that receive more bids from contractors. This trend is unique to Client A (Figure 13 and Figure 14).

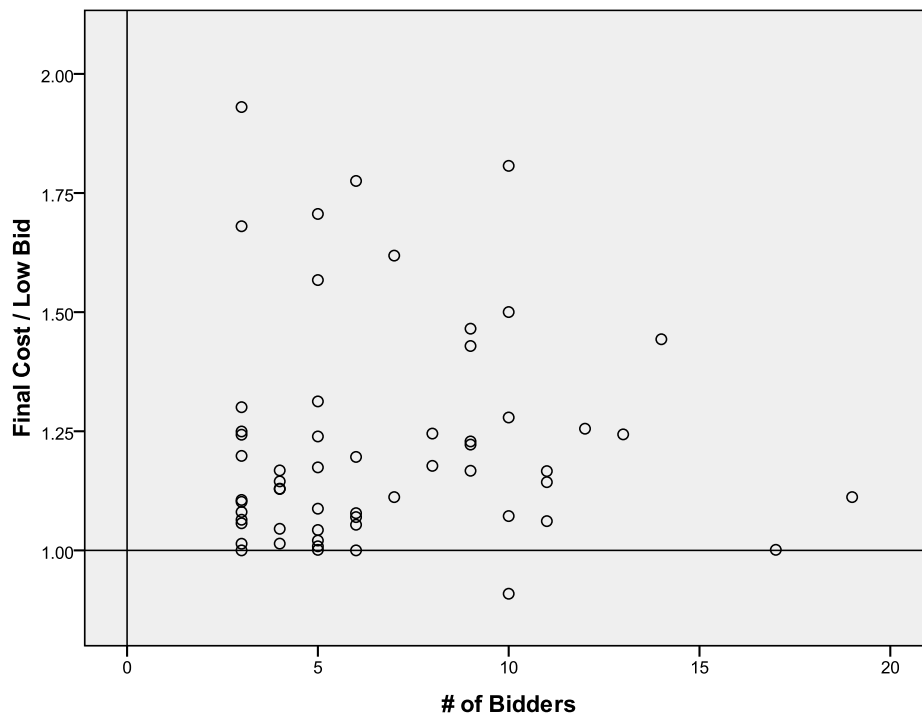


Figure 12 – Client A number of bidders and cost escalation on all projects

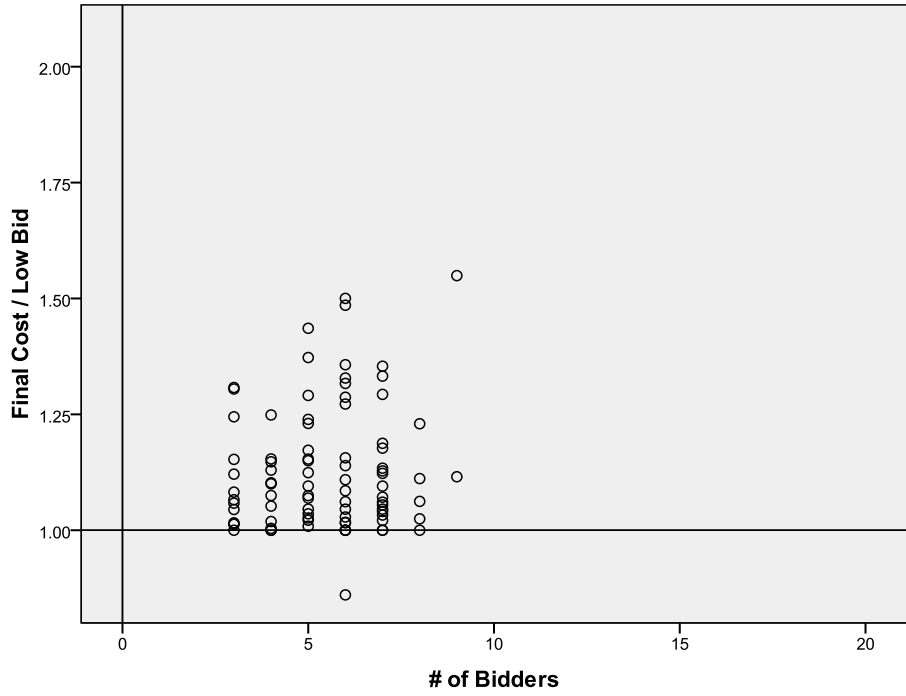


Figure 13 – Client B number of bidders and cost escalation on all projects

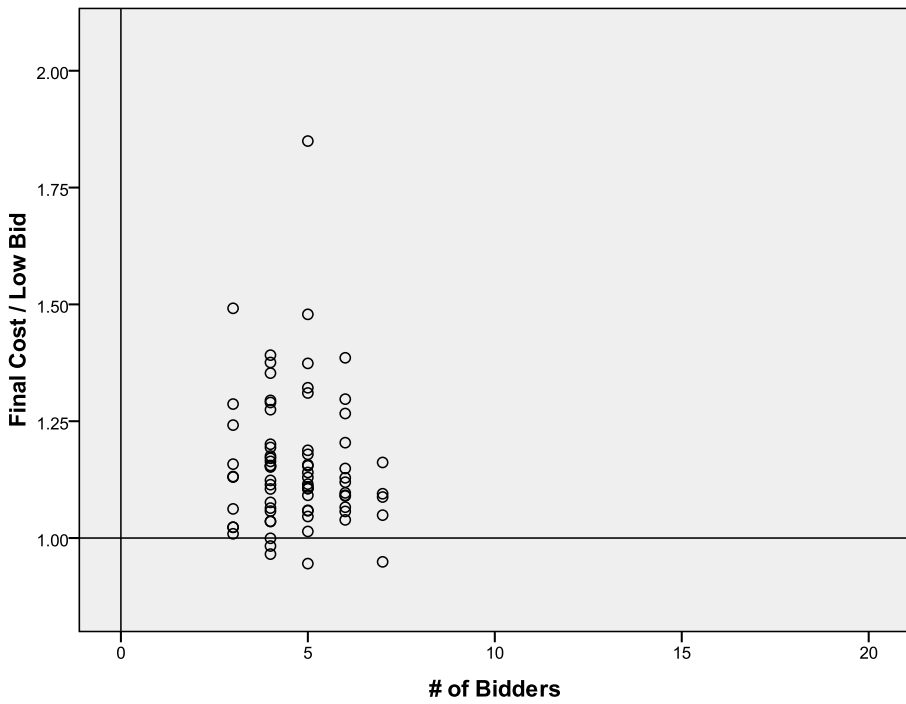
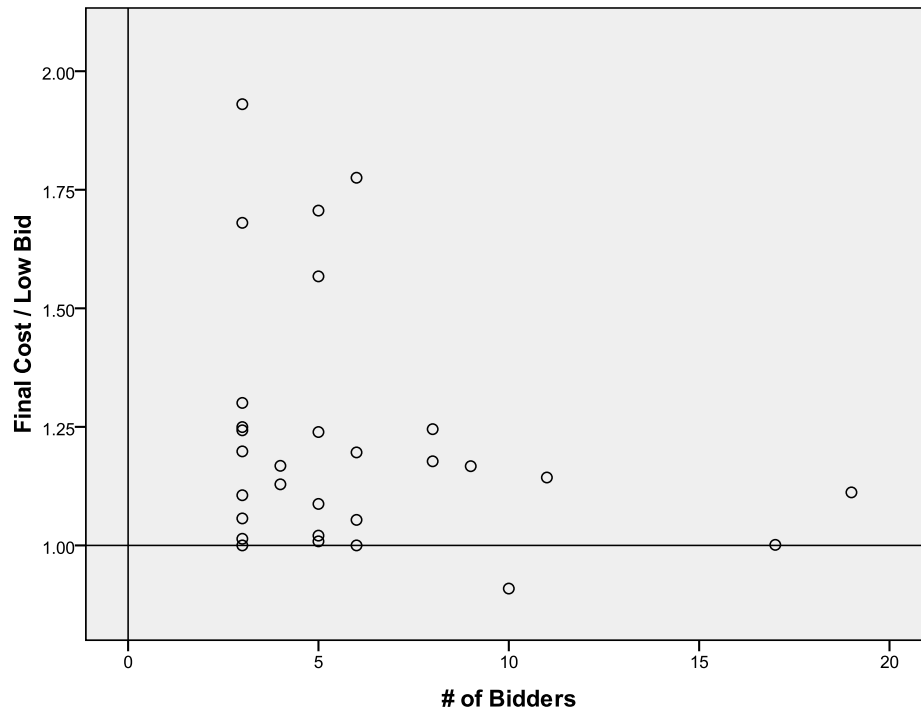
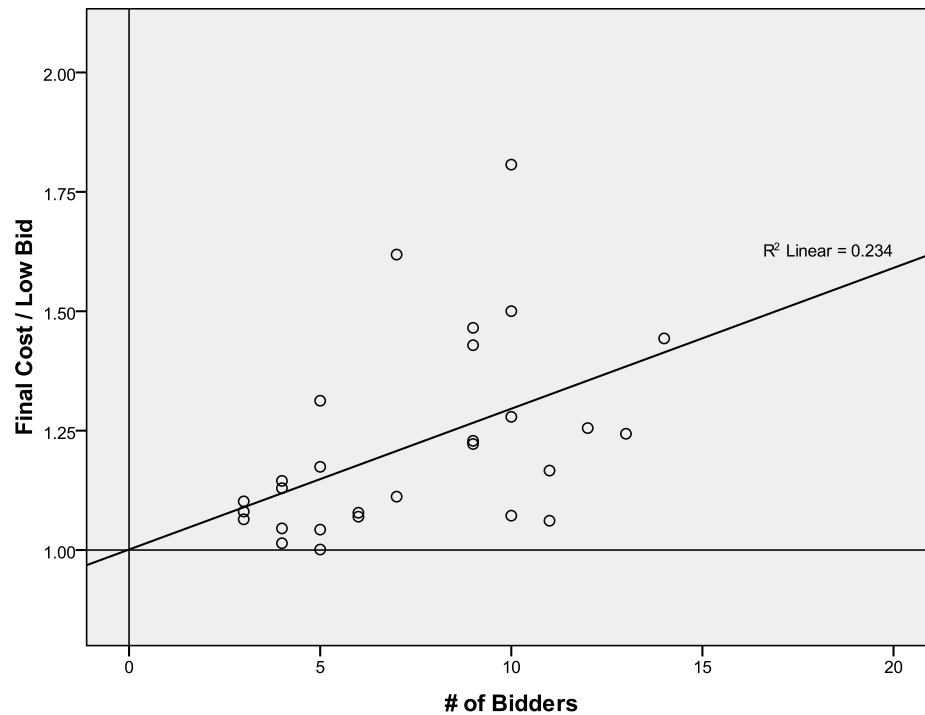


Figure 14 – Client C number of bidders and cost escalation on all projects

However, looking at all of the projects of Client A hides that the trend of lower cost escalation is most evident for the smaller half of the projects based on dollar value (Figure 15) while the larger half of the projects display a trend toward increased cost escalation with more bidders (Figure 16). This trend exhibited by Client A does not exist for the other clients.



**Figure 15 – Client A small projects**



**Figure 16 – Client A large projects, cost escalation as a function of the number of bidders**

The trend seen in Figure 16 should be of concern for Client A. The more competition amongst contractors to win the bid is correlated to increased cost escalation. A plausible explanation for this trend is that the contractors are underbidding the large projects in order to win the bid. The winning contractor then recoups money through change orders and claims. Currently, Client A is not receiving good value on large projects that have a high number of bidders.

### 4.3 Multivariate Analysis

In Figure 7 and Figure 16, there is a definite trend that the large projects of Client A that experience a large cost escalation are more likely to have received a greater number of bids and the gap between the median bidder and the low bidder is large. A common contingency value used for budgeting at the time of bid is 10% (Abourizk, 2002). For the purposes of this research, a large cost escalation will be defined as twice the “common contingency”, 20%. A stepwise logistic regression was performed to determine the likelihood of a large Client A project incurring a large cost escalation using the number of bidders and the bid gap ratio as independent variables. SPSS Statistics 17.0 was used for all of the logistic regression calculations (SPSS, 2008). The logistic regression produces an equation of the form:

$$P = \frac{e^{A+BX_1+CX_2}}{1 + e^{A+BX_1+CX_2}} \quad \text{Eq. 5}$$

Where P = the probability that a project will incur large cost escalation given that  $X_1$  = the number of bidders on a project; and  $X_2$  = the bid gap ratio; and A, B and C are constants. The Wald stepwise logistic regression found both independent variables to be part of the equation with the respective constants and significance seen in Table 3.

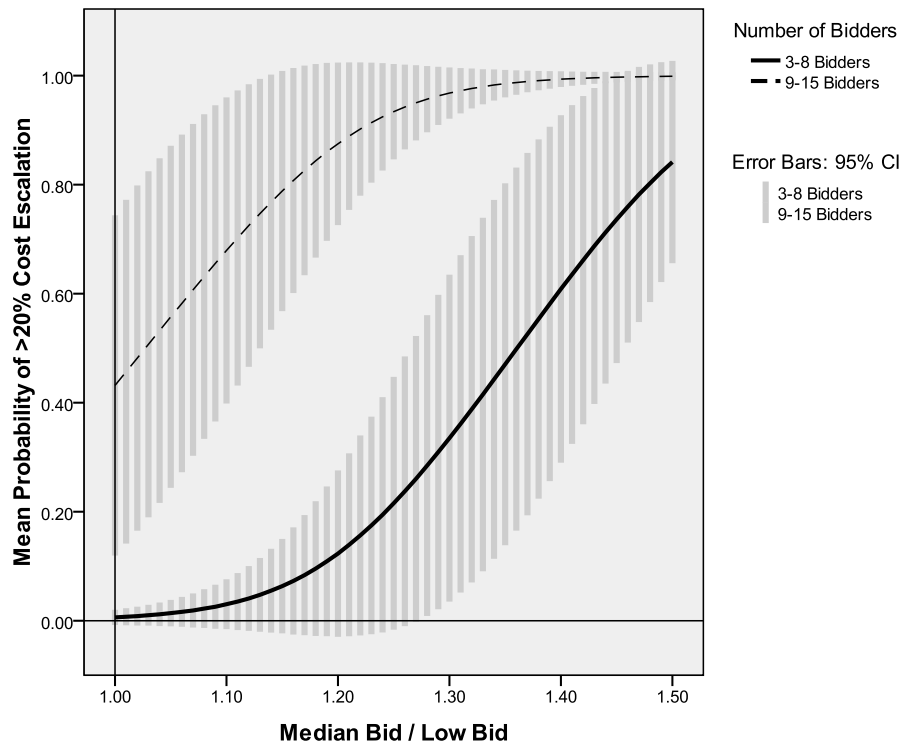
**Table 3 – Variables in the Logistic Regression Equation**

Client	Value	Sig.
A	-21.487	.019
B	.634	.025
C	13.255	.034

From Figure 16, most of the projects that had large cost escalation had more than eight bidders enabling the projects to be divided into two groups: eight or less bids, and more than 8 bids. Inputting the constants and the range of values for both the number of bidders and the bid gap ratio enables the production of probability curves for a project to incur greater than 20% cost escalation from the lowest bid price (Figure 17). At the mean bid gap ratio for the large projects of Client A (1.20, median = 1.19), projects that had 3-8 bids had a 12% (s.d. 14) probability of greater than 20% cost escalation while projects that had 9-15 bids had a 88% (s.d. 16) probability of greater than 20% cost escalation.

This finding emphasizes the lack of value that Client A is getting on large projects that have many bidders. Although past research found that the more bids a client receives for a project, the lower the low bid will be compared to the budget; this research indicates that too much competition is correlated with cost escalation. Both Client B and Client C have contractor prequalification policies in place and did not receive greater than 9 bids on any project in the study. The lack of prequalification requirement is the likely reason for Client A receiving so many bids on some projects. The prequalification in place at Client B and Client C restricts

competition by eliminating bidders that either do not qualify or do not attempt to qualify because of the extra work required to be allowed to submit a bid.



**Figure 17 – Probability curve for a large Client A project incurring a cost escalation over 20%**

Testing a prequalification system for large projects is recommended for Client A to eliminate some bidders that may be undercutting prices to win the bid and then make their profit through change orders and claims. This lesson may be applied more broadly within the ICI sector to clients that award based on the low bid and have a limited or no prequalification policy in place. It is recommended that similar clients review their past projects to determine if they experienced the same cost escalation pattern as Client A.

This research demonstrates that a lack of a prequalification policy increased the exposure to “predatory bidding” due to excessive competition amongst contractors for a particular public sector client. In an era of great transparency within the public sector and significant pressure to maximize the value for money in all public sector endeavors, a prequalification policy is a great tool to maximize the value for money by public sector clients because it can be implemented with a minimal commitment of resources. Also, the potential prequalification benefits of minimizing “predatory bidding” is easily measured, allowing the public sector client to promote their cost saving measures and results.

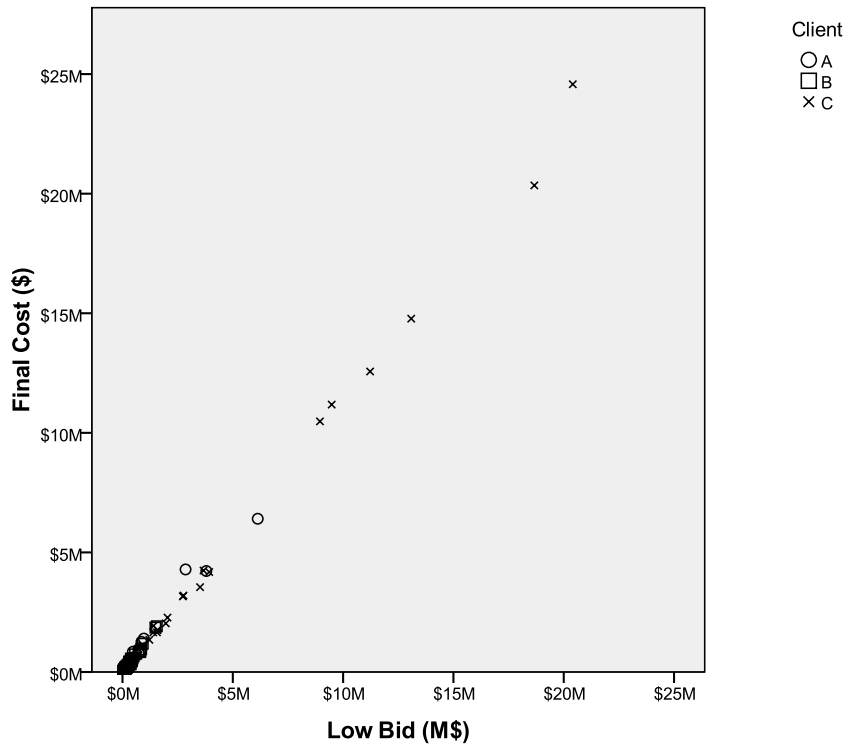
The main drawbacks of prequalification included the aforementioned required resources to develop and implement a policy. Also, the public sector has an added challenge to ensure that the criteria used for the prequalification are as objective as possible (Russell, 1996).

Overall, the research indicates that prequalification is correlated with lower cost escalation. This finding is expected as some of the goals of prequalification are to assess the ability, competency and capability of potential contractors prior to entering into contract. Other clients that award based solely on the low bid can utilize these results to determine if they experience similar trends and whether action should be taken.

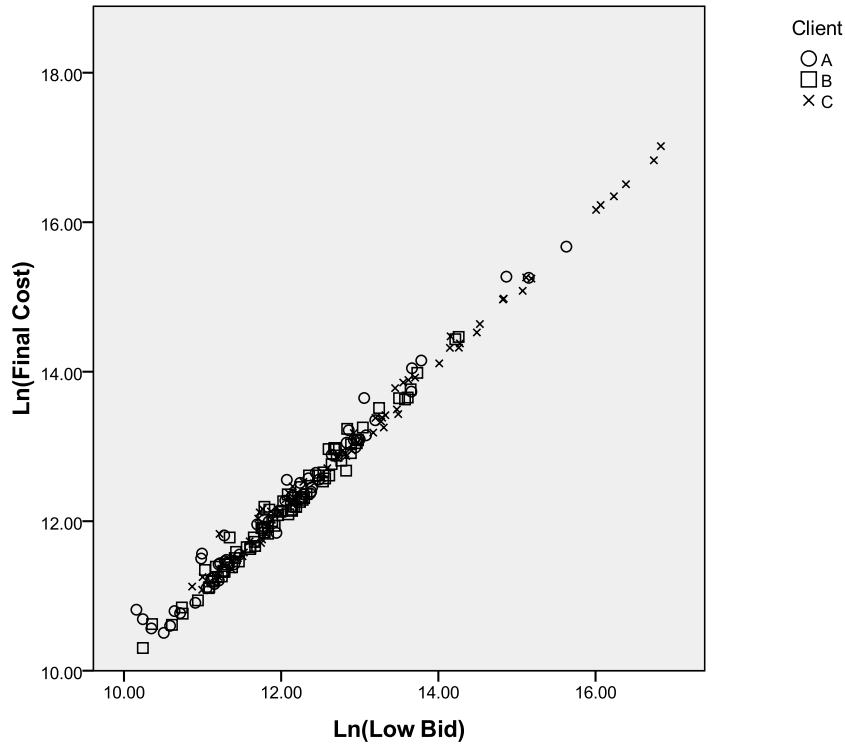
#### 4.4 Final Cost Estimating

Checking the correlation between the low bid and final cost of projects for each of the clients provides an indication of the viability of the linear regression models to be used to estimate the

final cost of a project. The dollar sizes of projects are highly skewed, and a transformation to the natural log helps the data approximate normality (Figure 18 and Figure 19). The  $R^2$  values of the equations for each client demonstrate that both the untransformed and transformed low bid prices are highly correlated with the final cost of a project for each client (Table 4).



**Figure 18 – Untransformed final cost vs. low bid for all clients**



**Figure 19 – Transformed final cost vs. low bid for all clients**

**Table 4 – Linear correlation between low bid price and final cost ( $R^2$  values)**

Client	\$	Ln(\$)
A	0.988	0.990
B	0.993	0.991
C	0.999	0.997

Stepwise linear regression models were developed for each of the clients using the transformed variables because they better approximate a normal distribution. The only variable found to enter the equations was Ln(Low Bid). The linear regression equations for each client can be found in Table 5. Due to the small sample size of each client, there were not enough projects to set aside a

group of projects to test the regression equations produced. All of the models had high R and R<sup>2</sup> values indicating that most of the variation about the mean of the final cost variable can be explained by the regression models (Table 5).

**Table 5 – Linear Regression Equations for each client with respective R<sup>2</sup> values**

Client	Linear Regression Equation	R <sup>2</sup>
A	$\ln(\text{Final Cost}) = 0.994\ln(\text{Low Bid}) + 0.253$	0.980
B	$\ln(\text{Final Cost}) = 1.022\ln(\text{Low Bid}) - 0.154$	0.983
C	$\ln(\text{Final Cost}) = 0.990\ln(\text{Low Bid}) + 0.264$	0.994

For ease of use for the clients, the linear regression equations were converted into power functions (Table 6).

**Table 6 – Power functions of regression equations for client use**

Client	Linear Regression Equation
A	$\text{Final Cost} = 1.29\text{Low Bid}^{0.994}$
B	$\text{Final Cost} = 0.87\text{Low Bid}^{1.022}$
C	$\text{Final Cost} = 1.30\text{Low Bid}^{0.990}$

If the exponent of the power functions were one, the client should expect no change in final cost with respect to the low bid price. When the exponent is less than one, the percentage that the final cost is greater than the low bid decreases as the project size is increased. The opposite is

true for when the exponent is greater than one. The percentage that the final cost is greater than the low bid increases with project size.

The application of the linear regression does not have predictive capability for a future project because it will be inaccurate for projects that incur large cost overruns. A more practical application of the model is to provide an estimate of final cost for a group of projects. Essentially, the application is a form of client pooling the cost escalation risk of each project. A client can use the regression model as a budgeting tool for their construction projects.

The client would apply the regression model equation to each project individually and the sum of the regression model estimates of the final costs would be the budget estimate. If the equation were only applied to the sum of a group of projects' low bids, the budget estimate produced would be too heavily influenced by the exponent portions of the power equations in Table 6. If the exponent of the power equation is greater than 1, then applying the equation to the sum would overestimate the final cost for the client. Conversely, if the exponent were less than 1, the equation would underestimate if it used only the sum of the projects that are of interest. Overall, it is recommended that a client utilize the information about their own processes, specifically the ability of their past projects to control cost escalation when forming capital planning budgets.

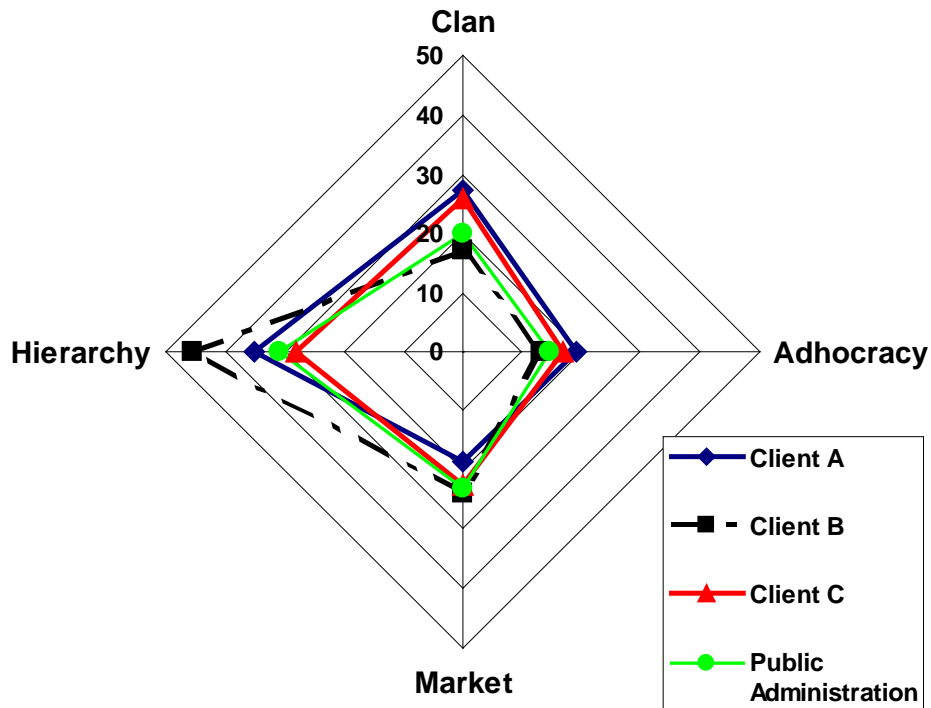
## 4.5 Organizational Culture

The organizational culture survey was conducted using the Organizational Culture Assessment Instrument (OCAI) (Cameron and Quinn, 2002). Five participants from Client A's project

management staff, ten from Client B, and seven from Client C completed the survey electronically.

The profiles of all the clients are weighted towards *Hierarchy* as their dominant organizational culture type (Figure 20). This result is expected as *Hierarchy* was found to be the strongly dominant culture in the profiles of public administrations (Cameron and Quinn, 2002).

Understanding one's own culture can be beneficial towards increasing an organization's effectiveness. The clients can utilize their knowledge of their culture being hierarchical. It was found that the most successful leadership attributes in a hierarchy cultures include organizing, monitoring, administering and coordinating. This is to be expected as effective leadership style coincides with the organizational culture profile. Also, a hierarchy culture thrives on efficiency, timeliness and predictability (Cameron and Quinn, 2002).



**Figure 20 – OCAI responses for “Now” compared to public administrations**

A primary measure of success for the clients is to limit the amount of cost escalation on projects. Client A has slightly less leaning toward the *Market* type culture than the other clients (Figure 21) while the average cost escalation is 6% higher than either of the other clients (Table 7). Even though this finding contradicts past research (Thomas, 2002), it is intuitive. A results-oriented culture (*Market*) would likely have greater emphasis on meeting budget numbers as bottom-line results are a primary objective of the organization. This results oriented culture of a *Market* culture is common throughout the construction industry (Cameron and Quinn, 2002). Public sector clients that have a decreased *Market* culture can utilize these findings to develop internal initiatives to enhance their focus on achievement of measurable goals and targets.

**Table 7 – Mean cost escalation for all projects**

		Final Cost / Low Bid	
		Mean	Standard Deviation
Client	A	1.22	.23
	B	1.13	.13
	C	1.16	.15

Given that the environment the three clients operate in by dealing with the *Market* oriented culture of the construction industry, it is not surprising that the underperforming organization not only is less *Market* oriented, but that it also has a discrepancy between their scoring of “Now” and “Preferred” in the *Market* culture. Client A employees have identified this need for change as their “Preferred” *Market* score is higher by approximately 5 points than “Now” (Figure 21).

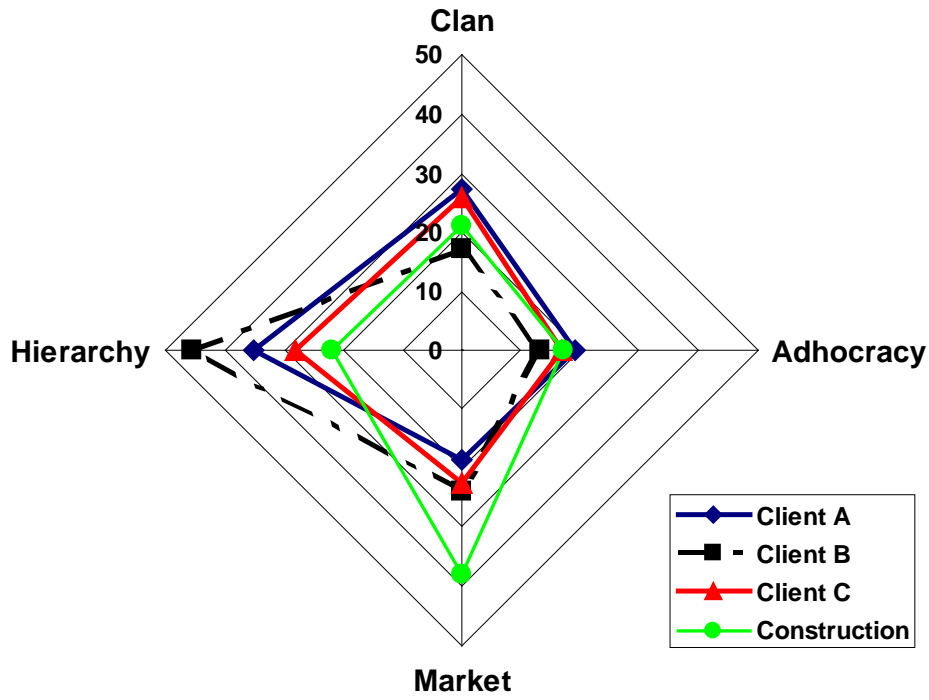


Figure 21 – OCAI responses for “Now” compared to construction industry

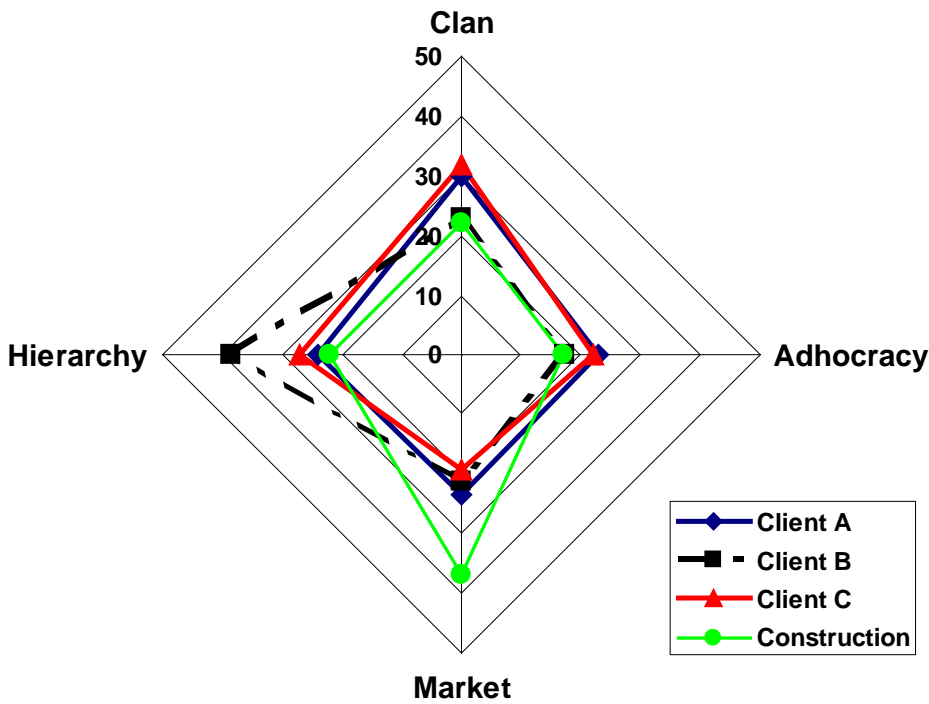


Figure 22 – OCAI responses for “Preferred” compared to construction industry

This examination of organizational culture of public sector construction clients demonstrates a particular challenge for these clients and likely public sector construction clients in general. They are operating and dealing with a highly results-oriented industry (construction) while their dominant organizational culture characteristic is rule and procedure oriented. These competing values across organizational lines can certainly contribute to conflict.

## 4.6 Limitations

A major limitation of the current research is the limited availability of past public sector construction project data. Even though the participating clients had similar types of construction needs, the different procurement practices of the clients require that the data for each client be treated separately. The wide type of construction work the clients' undertook along with the inherent amount of unknowns in a construction project lead to variability of cost overruns. With sufficient amount of data it is possible that further significant and important trends may have been identifiable. However, concerns about confidentiality and the scarcity of resources available to assist with the data collection are listed as the main reasons why other public sector clients that are major purchasers of construction services within the ICI sector declined to participate.

Further limitations to the current research include the inability to use the engineer's estimate in the data. The engineer's estimate was excluded primarily because the availability of the estimate and the stage of project in which the estimate was developed varied amongst the participating clients. Comparing the estimate to the final cost may have provided information to help improve the accuracy of a project's budget. Furthermore, testing whether or not the gap between the low

bid price and the engineer's estimate is correlated to the amount of cost escalation of a project would be of interest.

## 5 Conclusion

Overall, an objective of this research was to identify risks of excessive competition to public sector construction clients that award construction based solely on the low bid. This objective was achieved by demonstrating that insight into the final cost and possible cost escalations can be obtained from the bidding process. A potential end result is that clients can utilize the findings to alert themselves of projects that are prone to cost escalation. A secondary objective of the research was to find a correlation between organizational culture characteristics and cost escalation. This objective was met by demonstrating through the *Competing Values Framework* that a public sector construction client experiences less cost escalation if their culture is similar to the culture of the construction industry. Specifically, the findings demonstrate that:

- An open bidding process unrestricted by prequalification of contractors did not provide a public sector client with increased value. That client's large projects that had a large amount of competition (many bidders) were more prone to large cost escalation.
- Prequalification is correlated with lower cost escalation.
- Low bids from a client's past projects can assist in capital budget planning utilizing linear regression.
- A strong results-oriented culture possessed by the public sector client is correlated with less cost escalation.

## 6 References

- AbouRizk, S.M. *et al.* (2002). "Estimating the cost of capital projects: an empirical study of accuracy levels for municipal government projects". *Canadian Journal of Civil Engineering*. **29**: 653-661.
- Alexandersson, G. and Hultén, S. (2006). "Predatory bidding in competitive tenders: A Swedish case study". *European Journal of Law and Economics*. **22**(1): 73-94.
- Cameron, K.S. and Quinn, R.E. (2002). *Diagnosing and changing organisational culture: based on the competing values framework*. Addison-Wesley Publishing.
- Campbell, J.P. (1974). *The Measurement of Organizational Effectiveness: A Review of Relevant Research and Opinion*. Minneapolis. 13–55.
- Capen, E. C., Clapp, R. V., and Campbell, W. M. (1971). "Competitive bidding in high risk situations." *JPT, Journal of Petroleum Technology*. **23**(6): 641–653.
- Carr, P.G. (2005). "Investigation of Bid Price Competition Measured through Prebid Project Estimates, Actual Bid Prices, and Number of Bidders". *Journal of Construction Engineering and Management*. **131**(11): 1165-1172.
- Chua, D.K.H., Li, D. (2000), "Key factors in bid reasoning model", *Journal of Construction Engineering and Management*. **126**(5): 349-57.
- Crowley, L.G., and Hancher, D.E. (1995). "Risk Assessment of Competitive Procurement". *Journal of Construction Engineering and Management*. **121**(2): 230-237.
- DGIII Working Group on Abnormally Low Tenders. (1999). "Prevention, Detection and Elimination of Abnormally Low Tenders in the European Construction Industry", <http://europa.eu.int/comm/enterprise/construction/alo/altfin.htm>

- Dowle, W.J., and DeStephanis, A. (1990). "Preparing bids to avoid claims." *Construction Bidding Law*. John Wiley & Sons, Inc., New York, N.Y. 17-45.
- Fayek, A., Ghoshal, I., and Abourizk, S. (1998). "A survey of the bidding practices of Canadian civil engineering construction contractors". *Canadian Journal of Civil Engineering*, **26**: 13-25.
- Herbsman, Z., and Ellis, R. (1992). "Multi-parameter bidding system – Innovation in contract administration". *ASCE Journal of Construction Engineering and Management*, **118**(1): 142-150.
- Igo, T. and Skitmore, M. (2006). "Diagnosing the organizational culture of an Australian engineering consultancy using the competing values framework". *Construction Innovation 2006*, **6**: 121-139.
- Miller, J. B., Garvin, M. J., Ibbs, C. W., and Mahoney, S. E., (2000). "Toward a new paradigm: Simultaneous use of multiple project delivery methods." *Journal of Management Engineering*, **16**(3): 58–67.
- Oberlender, G.R. and Trost, S.M. (2001). "Predicting accuracy of early cost estimates based on estimate quality". *Journal of Construction Engineering and Management*, **127**(3): 173-182.
- Porter, M. (1980). *Competitive Strategy*. New York: Free Press.
- Quinn, R.E. and Cameron, K.S. (1983). "Organizational life cycles and some shifting criteria of effectiveness". *Management Science* **29**: 31–51.
- Russell, J. (1996). *Constructor prequalification: choosing the best constructor and avoiding constructor failure*. ASCE Publications. 9-10.
- SPSS for Windows, Rel. 17.0.0. 2008. Chicago: SPSS Inc.

- Thomas, R., Marosszeky, M., Karim, K., Davis, S. and McGeorge, D. (2002). "The importance of project culture in achieving quality outcomes in construction". *Proceedings IGLC*, 10, Aug, Gamado, Brasil.
- Williams, T. (2002). "Predicting completed project cost using bidding data". *Construction Management and Economics*. **20**: 225-235.
- Williams, T. (2003). "Predicting final cost for competitively bid construction projects using regression models". *International Journal of Project Management*. **21**: 593-599.
- Winch, G. M. (2000). "Institutional reform in British construction: Partnering and private finance." *Building Research Information*. **28**(2): 141-155.
- Wolfsetter, E. (1996). "Auctions; An Introduction," *Journal of Economic Surveys*, **10**(4): 367-420.
- Zack, James G. (1993). "Claimsmanship: Current Perspective." *Journal of Construction Engineering and Management*, **119**(3): 480-496.

## 7 Appendix A – Project Bid and Cost Data

Client	Project #	Final Cost	Bids				
A	1	\$921,728	\$853,000	\$897,000	\$964,000		
A	2	\$105,552	\$59,455	\$88,730	\$89,440	\$81,749	\$67,900
			\$89,900				
A	3	\$66,391	\$63,000	\$78,500	\$77,295	\$67,900	\$78,942
			\$65,500				
A	4	\$161,977	\$138,700	\$149,500	\$195,000	\$215,000	
A	5	\$43,886	\$28,000	\$28,250	\$35,350	\$36,000	\$35,850
A	6	\$36,541	\$36,540	\$38,500	\$64,589	\$48,990	\$57,000
			\$86,405				
A	7	\$92,448	\$83,600	\$97,925	\$84,925		
A	8	\$155,931	\$119,900	\$123,870	\$161,700		
A	9	\$91,420	\$73,420	\$80,125	\$74,734	\$208,700	\$85,400
			\$182,900	\$94,000	\$73,420		
A	10	\$47,546	\$44,986	\$68,500	\$48,000		
A	11	\$73,575	\$73,575	\$87,710	\$109,700		
A	12	\$4,222,647	\$3,798,000	\$3,983,000	\$4,075,000	\$4,312,817	\$4,197,000
			\$4,030,006	\$4,260,000			
A	13	\$549,425	\$384,500	\$695,000	\$484,109	\$398,371	\$518,000
			\$612,000	\$524,180	\$397,942	\$419,000	
A	14	\$76,659	\$68,949	\$98,875	\$124,890	\$89,000	\$87,663
			\$126,000	\$93,929	\$98,600	\$89,900	\$128,000
			\$76,800	\$94,450	\$86,868	\$116,778	\$106,584
			\$104,529	\$86,900	\$132,000	\$86,000	
A	15	\$284,303	\$263,700	\$440,000	\$282,900	\$267,000	\$398,743
			\$313,996				
A	16	\$139,246	\$153,183	\$206,700	\$192,350	\$172,000	\$198,800
			\$228,600	\$234,400	\$202,465	\$195,850	\$175,000
A	17	\$288,735	\$230,000	\$317,000	\$281,653	\$440,500	\$300,000
			\$267,000	\$279,900	\$323,950	\$328,900	\$330,400
			\$348,800	\$327,103			
A	18	\$436,401	\$418,500	\$430,000	\$545,000	\$594,000	\$648,000
A	19	\$845,679	\$468,000	\$529,000	\$532,400	\$533,000	\$562,630
			\$569,800	\$586,000	\$596,700	\$668,000	\$748,400
A	20	\$485,400	\$424,000	\$458,900	\$478,000	\$436,570	
A	21	\$310,851	\$253,000	\$282,500	\$292,730	\$296,000	\$329,000
			\$330,000	\$330,304	\$358,000	\$372,234	
A	22	\$134,529	\$78,853	\$123,260	\$84,732	\$87,450	\$127,920
A	23	\$91,425	\$89,575	\$98,600	\$99,556	\$134,292	\$95,562
A	24	\$465,054	\$374,000	\$400,880	\$405,562	\$408,171	\$409,409
			\$416,400	\$425,660	\$428,000	\$429,662	\$474,800
			\$477,800	494800	425660		
A	25	\$214,300	\$171,500	\$174,500	\$392,950		
A	26	\$93,582	\$81,859	\$115,200	\$99,950	\$116,110	\$95,000
			\$114,210	\$138,000	\$95,360	\$134,800	\$89,900

			\$116,000				
A	27	\$241,795	\$238,400	\$296,100	\$274,304	\$328,000	
A	28	\$395,825	\$309,500	\$423,000	\$408,175	\$437,300	\$429,800
			\$377,733	\$400,510	\$493,500	\$425,000	\$432,000
A	29	\$40,153	\$39,600	\$55,950	\$65,000		
A	30	\$151,883	\$129,000	\$146,600	\$149,909	\$169,890	\$184,980
			\$137,000	\$144,155	\$158,400		
A	31	\$104,136	\$95,757	\$99,700	\$125,000	\$281,000	\$131,878
A	32	\$38,774	\$31,200	\$38,282	\$41,800		
A	33	\$217,199	\$204,075	\$217,894	\$217,447		
A	34	\$70,238	\$69,640	\$94,000	\$179,213	\$79,750	\$94,900
A	35	\$256,179	\$241,360	\$263,983	\$345,400	\$251,396	\$288,023
			\$309,000	\$316,000	\$269,962	\$284,917	\$258,000
			\$269,500				
A	36	\$228,519	\$187,000	\$233,470	\$215,800	\$235,000	\$223,153
			\$191,100	\$212,000	\$188,900	\$206,888	
A	37	\$235,950	\$235,695	\$289,000	\$330,000	\$285,450	\$312,117
A	38	\$283,086	\$174,890	\$266,362	\$295,100	\$205,670	\$248,900
			\$222,000	\$212,444			
A	39	\$98,800	\$58,800	\$59,000	\$59,000		
A	40	\$271,718	\$207,000	\$337,900	\$219,680	\$295,300	\$293,150
A	41	\$95,265	\$79,500	\$98,000	\$92,000		
A	42	\$487,024	\$442,000	\$566,000	\$473,750		
A	43	\$92,748	\$74,850	\$96,600	\$100,000	\$147,000	\$74,850
A	44	\$482,017	\$410,500	\$421,763	\$414,200	\$580,000	\$684,000
A	45	\$484,009	\$428,511	\$454,511	\$529,511	\$514,511	
A	46	\$513,492	\$479,000	\$580,000	\$630,000	\$487,764	\$485,925
			\$566,000	\$487,404	\$506,000	\$511,800	\$530,148
A	47	\$232,551	\$217,366	\$249,000	\$269,180	\$343,700	\$367,000
			\$483,888				
A	48	\$97,007	\$92,000	\$102,315	\$85,203	\$81,100	\$88,000
			\$98,750				
A	49	\$1,396,510	\$1,427,856	\$1,443,250	\$1,369,000	\$1,181,169	\$1,300,000
			\$967,700	\$1,835,925	\$1,197,000	\$1,080,000	\$1,428,000
			\$1,318,682	\$1,537,900	\$1,284,546	\$1,320,000	
A	50	\$49,806	\$26,758	\$34,000	\$25,800		
A	51	\$1,259,566	\$859,613	\$1,248,983	\$1,230,000	\$887,000	\$1,461,000
			\$1,173,363	\$1,712,900	\$1,400,000	\$1,255,900	
A	52	\$628,436	\$658,310	\$645,000	\$755,649	\$637,944	\$538,800
			\$749,900	\$800,000	\$603,000	\$719,700	\$840,623
			\$667,263				
A	53	\$4,287,891	\$3,200,000	\$3,227,001	\$3,484,000	\$3,979,000	\$3,196,000
			\$3,972,564	\$2,988,650	\$2,858,213	\$3,877,118	\$4,118,000
A	54	\$48,900	\$150,000	\$55,536	\$41,899	\$43,000	\$52,900
			\$56,800	\$46,490	\$86,300	\$44,200	
A	55	\$75,406	\$71,816	\$66,800	\$72,899	\$74,000	
A	56	\$54,653	\$92,400	\$79,457	\$54,589	\$78,856	\$74,991
			\$69,755	\$71,150	\$73,497	\$75,980	\$89,125
			\$71,550	\$70,642	\$91,000	\$98,157	\$77,284

			\$68,800	\$68,900			
A	57	\$6,407,690	\$6,130,000	\$6,508,613	\$7,395,000	\$6,629,000	
B	1	\$91,329	\$82,347 \$95,000	\$108,300	\$148,544	\$106,109	\$104,136
B	2	\$73,144	\$68,400	\$118,300	\$84,500	\$74,500	\$68,455
B	3	\$462,283	\$426,000 \$797,688	\$456,900	\$475,215	\$483,000	\$659,980
B	4	\$222,628	\$193,000	\$205,000	\$220,400	\$214,000	\$225,000
B	5	\$455,439	\$396,000	\$442,000	\$582,100	\$559,000	\$428,000
B	6	\$162,818	\$145,233	\$162,000	\$182,000		
B	7	\$433,231	\$320,000 \$361,500	\$419,400 \$379,000	\$406,000	\$405,200	\$325,723
B	8	\$312,767	\$278,600 \$312,500	\$302,000 \$333,000	\$349,900	\$310,000	\$314,400
B	9	\$99,353	\$90,300	\$147,350	\$102,800	\$104,000	
B	10	\$233,066	\$177,000 \$205,800	\$196,900	\$189,400	\$193,196	\$202,200
B	11	\$1,857,195	\$1,492,000	\$1,614,000	\$1,538,000		
B	12	\$1,184,000	\$1,371,400 \$969,000	\$920,000	\$1,312,900	\$1,268,000	\$998,500
B	13	\$187,093	\$166,238 \$193,000	\$209,960 \$213,590	\$165,000	\$198,000	\$229,117
B	14	\$84,760	\$87,153	\$70,200	\$67,600	\$61,750	\$69,500
B	15	\$197,292	\$134,980 \$153,725	\$137,900	\$142,500	\$147,900	\$131,510
B	16	\$427,147	\$330,200	\$344,500	\$823,000	\$356,385	\$297,523
B	17	\$184,778	\$317,400	\$352,600	\$38,600	\$161,000	
B	18	\$222,406	\$228,900	\$211,400	\$219,900	\$280,000	
B	19	\$83,832	\$78,009	\$88,860	\$108,900	\$82,702	\$106,610
B	20	\$190,000	\$140,000 \$174,000	\$163,000	\$147,000	\$170,000	\$174,000
B	21	\$570,000	\$460,000	\$595,000	\$600,000	\$630,000	\$574,000
B	22	\$300,000	\$243,000 \$275,000	\$232,000 \$250,000	\$240,000	\$238,000	\$288,000
B	23	\$560,000	\$393,000 \$450,000	\$377,000	\$430,000	\$383,000	\$555,000
B	24	\$950,000	\$1,000,300	\$845,000	\$964,000	\$990,000	\$850,000
B	25	\$115,000	\$140,000 \$107,000	\$175,000 \$138,000	\$125,000	\$105,000	\$140,000
B	26	\$140,000	\$187,000 \$185,000	\$211,000 \$150,000	\$172,000	\$182,000	\$132,000
B	27	\$225,000	\$225,000 \$231,000	\$210,000 \$265,000	\$300,000	\$265,000	\$215,000
B	28	\$300,000	\$270,000	\$265,000	\$260,000	\$280,000	
B	29	\$115,000	\$137,000 \$110,000	\$140,000	\$152,000	\$135,000	\$125,000
B	30	\$740,010	\$565,800	\$582,200	\$584,200		
B	31	\$176,540	\$156,500	\$225,000	\$188,000	\$204,000	\$223,700

			\$164,800	\$160,000			
B	32	\$150,614	\$137,500	\$168,800	\$199,670	\$139,900	\$143,500
B	33	\$144,822	\$131,370	\$152,950	\$138,500	\$139,900	
B	34	\$221,717	\$218,000	\$228,600	\$235,000	\$242,000	\$258,000
			\$259,000				
B	35	\$256,907	\$208,800	\$249,700	\$295,000	\$302,000	\$325,000
B	36	\$433,166	\$326,100	\$433,000	\$346,500	\$425,000	\$356,000
			\$361,000				
B	37	\$1,914,707	\$1,557,000	\$2,065,591	\$1,619,800	\$2,675,000	\$1,686,504
			\$2,010,500	\$2,148,000	\$1,672,192		
B	38	\$212,472	\$167,000	\$198,860	\$245,665	\$182,500	\$178,800
			\$247,400				
B	39	\$148,450	\$126,600	\$126,950	\$133,000	\$135,000	\$139,000
B	40	\$187,000	\$187,000	\$283,860	\$367,500		
B	41	\$299,980	\$299,980	\$315,000	\$345,000	\$338,000	\$370,100
			\$373,000				
B	42	\$153,004	\$149,840	\$220,623	\$162,000	\$154,230	\$161,700
			\$167,500	\$171,700			
B	43	\$95,000	\$95,000	\$102,620	\$108,828	\$130,000	
B	44	\$77,233	\$72,750	\$94,500	\$75,900	\$91,523	\$98,000
			\$122,000				
B	45	\$391,881	\$330,000	\$430,000	\$361,053	\$357,700	\$415,500
			\$389,000	\$394,462			
B	46	\$843,820	\$729,800	\$768,000	\$1,225,000	\$751,700	\$744,000
			\$732,000				
B	47	\$210,700	\$206,800	\$207,700	\$208,913	\$221,550	
B	48	\$148,154	\$137,594	\$128,500	\$140,200		
B	49	\$426,408	\$419,400	\$406,000	\$320,000	\$405,200	\$325,723
			\$361,500	\$379,000			
B	50	\$56,428	\$56,428	\$64,860	\$65,000	\$75,400	\$78,100
			\$78,700	\$79,000	\$84,150		
B	51	\$481,079	\$432,830	\$454,000	\$472,000	\$440,000	\$516,240
			\$511,690	\$516,500	\$524,500		
B	52	\$47,250	\$46,500	\$46,900	\$49,900	\$56,117	\$53,848
			\$65,841				
B	53	\$116,868	\$116,868	\$139,690	\$146,988	\$147,000	\$156,890
			\$170,700				
B	54	\$288,423	\$284,680	\$289,000	\$295,400		
B	55	\$112,162	\$109,780	\$129,781	\$134,900	\$164,200	\$170,677
B	56	\$66,512	\$64,800	\$78,900	\$87,000	\$87,900	\$112,800
B	57	\$137,712	\$137,712	\$143,700	\$168,600	\$177,000	
B	58	\$199,131	\$184,000	\$212,723	\$247,400		
B	59	\$851,428	\$814,353	\$925,000	\$1,000,001	\$1,083,200	\$1,249,900
			\$1,257,700	\$1,265,000			
B	60	\$123,467	\$118,700	\$186,300	\$169,995	\$142,500	\$151,121
			\$116,228	\$136,950	\$134,534		
B	61	\$130,917	\$114,900	\$142,628	\$139,000	\$132,126	\$218,250
			\$186,627				
B	62	\$130,917	\$112,997	\$93,458	\$93,400	\$88,900	\$103,956

			\$84,500	\$115,000	\$114,860	\$112,938	
B	63	\$51,310	\$69,400	\$65,764	\$46,000	\$57,000	\$47,800
			\$51,400	\$74,000	\$61,480	\$59,275	
B	64	\$167,047	\$129,407	\$136,573	\$149,822	\$154,918	\$156,753
B	65	\$41,093	\$31,495	\$35,265	\$35,460		
B	66	\$107,945	\$98,350	\$98,044	\$99,568	\$93,200	\$131,704
			\$136,144	\$142,833			
B	67	\$40,700	\$55,880	\$46,228	\$40,538	\$52,700	
B	68	\$349,500	\$309,382	\$319,024	\$339,040	\$345,033	
B	69	\$87,865	\$94,488	\$100,482	\$93,600	\$87,109	\$95,504
B	70	\$88,549	\$87,275	\$97,028	\$70,910	\$105,000	
B	71	\$82,803	\$99,568	\$89,800	\$79,250		
B	72	\$233,976	\$224,848	\$233,700	\$265,500	\$231,000	\$247,536
			\$225,000	\$239,240			
B	73	\$197,000	\$197,000	\$208,102	\$208,300	\$219,206	\$220,000
			\$223,000	\$239,405			
B	74	\$178,400	\$178,400	\$202,980	\$252,482	\$247,000	\$204,260
			\$186,920				
B	75	\$82,562	\$78,000	\$83,974	\$93,994		
B	76	\$67,547	\$65,230	\$83,000	\$84,800	\$95,592	\$99,000
B	77	\$830,065	\$787,000	\$837,500	\$852,800	\$860,000	\$873,000
			\$917,600	\$959,000			
B	78	\$365,762	\$349,800	\$544,500	\$500,300	\$394,449	\$527,500
B	79	\$29,844	\$28,000	\$32,400	\$31,200		
B	80	\$277,000	\$397,000	\$311,700	\$338,867	\$368,750	\$349,520
			\$324,888	\$277,000			
B	81	\$77,724	\$80,450	\$76,500	\$87,500		
B	82	\$189,565	\$188,400	\$184,300	\$248,600	\$241,500	\$246,600
			\$191,950				
B	83	\$72,698	\$91,080	\$67,630	\$74,155	\$86,283	
B	84	\$216,642	\$213,800	\$23,700	\$285,000		
B	85	\$197,782	\$332,400	\$191,500	\$214,500	\$397,000	\$223,500
			\$293,800	\$211,475			
B	86	\$320,123	\$372,000	\$393,544	\$397,882	\$423,000	\$440,000
			\$472,000				
B	87	\$404,733	\$442,000	\$419,000	\$475,282	\$545,000	\$409,000
			\$395,000	\$435,000	\$598,900		
C	1	\$275,317	\$218,300	\$216,000	\$226,980	\$269,853	
C	2	\$1,040,370	\$983,000	\$835,000	\$989,000	\$768,993	
C	3	\$1,111,317	\$895,000	\$996,215	\$993,000		
C	4	\$528,738	\$409,859	\$548,027	\$418,950	\$417,000	
C	5	\$67,874	\$52,500	\$121,600	\$67,900	\$52,430	
C	6	\$186,765	\$200,000	\$188,900	\$163,100	\$160,450	
C	7	\$77,075	\$59,900	\$89,995	\$98,361		
C	8	\$682,318	\$721,800	\$782,598	\$749,000	\$915,000	\$933,000
C	9	\$165,954	\$187,000	\$165,496	\$153,369	\$173,834	\$153,460
			\$144,450				
C	10	\$155,813	\$152,917	\$153,000	\$173,843	\$139,850	

C	11	\$138,056	\$133,350	\$145,610	\$159,700	\$170,000	
C	12	\$259,294	\$188,482	\$297,440	\$271,600	\$240,000	
C	13	\$532,402	\$525,000	\$525,000	\$542,300	\$559,000	\$575,491
C	14	\$965,620	\$694,000	\$850,000	\$742,000	\$764,184	
C	15	\$570,101	\$676,000	\$600,711	\$601,300	\$712,600	\$615,350
			\$758,368	\$660,000			
C	16	\$183,065	\$123,800	\$183,400	\$169,900	\$133,776	\$146,000
C	17	\$2,275,292	\$2,040,000	\$2,200,000	\$2,286,778	\$2,365,000	\$2,368,714
C	18	\$191,771	\$128,565	\$151,700	\$157,180		
C	19	\$468,319	\$430,534	\$446,000	\$447,300	\$475,000	\$493,400
			\$498,817	\$592,400			
C	20	\$124,299	\$109,000	\$117,500	\$123,485	\$145,340	\$168,000
C	21	\$185,508	\$143,000	\$165,000	\$166,328	\$168,920	\$172,950
			\$255,000				
C	22	\$330,703	\$292,759	\$304,450	\$323,979	\$328,224	\$435,000
C	23	\$119,928	\$115,442	\$119,148	\$121,357	\$126,975	\$139,980
			\$149,709				
C	24	\$4,243,146	\$3,710,095	\$3,673,000	\$3,824,000	\$3,882,000	
C	25	\$220,434	\$195,000	\$207,346	\$224,550		
C	26	\$1,344,680	\$1,216,000	\$1,282,000	\$1,293,000	\$1,331,300	\$1,368,400
C	27	\$238,348	\$199,650	\$206,345	\$205,900	\$228,933	
C	28	\$204,070	\$189,600	\$227,410	\$215,640	\$218,900	
C	29	\$725,567	\$709,185	\$861,600	\$1,026,662		
C	30	\$270,635	\$247,207	\$249,700	\$263,900	\$301,900	\$302,000
			\$326,000	\$258,000			
C	31	\$85,400	\$169,000	\$104,000	\$96,160	\$86,888	
C	32	\$288,411	\$293,200	\$272,700	\$273,200	\$281,500	
C	33	\$74,376	\$128,400	\$90,365	\$119,776	\$165,000	
C	34	\$65,042	\$59,590	\$61,000	\$68,862	\$73,699	\$94,000
C	35	\$419,145	\$375,300	\$356,580	\$440,000	\$410,867	
C	36	\$101,829	\$131,980	\$108,700	\$99,530		
C	37	\$177,131	\$185,000	\$170,000	\$160,300	\$179,000	
C	38	\$3,196,327	\$2,763,000	\$3,010,000	\$2,999,000	\$2,984,300	\$2,857,000
C	39	\$3,159,185	\$2,736,735	\$2,776,000	\$2,873,300	\$3,313,500	
C	40	\$99,313	\$113,500	\$119,900	\$105,600	\$93,750	\$111,000
C	41	\$4,180,832	\$3,937,000	\$3,989,000	\$3,929,000	\$4,367,000	
C	42	\$1,658,508	\$1,561,184	\$1,593,400	\$1,685,974		
C	43	\$419,354	\$479,000	\$553,700	\$626,440	\$470,000	\$600,000
			\$496,682	\$399,766			
C	44	\$618,288	\$598,600	\$867,026	\$972,000	\$580,000	\$824,000
			\$600,000				
C	45	\$207,432	\$246,934	\$184,650	\$224,360	\$212,500	
C	46	\$237,050	\$208,374	\$189,750	\$187,950	\$186,000	\$179,365
C	47	\$648,399	\$619,244	\$549,424	\$569,246	\$540,000	
C	48	\$183,754	\$159,506	\$206,950	\$202,199	\$206,855	
C	49	\$127,522	\$155,960	\$127,590	\$161,227	\$167,152	
C	50	\$377,776	\$333,839	\$426,003	\$446,680		
C	51	\$1,076,417	\$821,440	\$938,610	\$1,084,080	\$888,936	\$1,000,000
C	52	\$402,753	\$496,000	\$420,900	\$438,300	\$384,100	\$369,000

			\$420,000				
C	53	\$218,774	\$172,740 \$200,500	\$202,000	\$202,400	\$224,000	\$233,300
C	54	\$650,180	\$733,250	\$673,577	\$680,000	\$595,000	\$588,000
C	55	\$77,430	\$73,163	\$74,840	\$75,825	\$78,235	\$91,600
C	56	\$1,930,133	\$1,405,000	\$1,405,057	\$1,600,000	\$1,626,490	\$1,857,000
C	57	\$102,095	\$197,000 \$131,100	\$191,000	\$87,880	\$219,000	\$126,000
C	58	\$121,662	\$134,640	\$149,000	\$126,000	\$127,758	
C	59	\$12,564,753	\$12,295,000 \$12,805,000	\$11,223,400	\$11,846,000	\$11,475,000	\$11,489,000
C	60	\$14,773,118	\$13,250,000 \$13,295,000	\$13,424,000	\$13,950,000	\$13,087,000	\$13,496,000
C	61	\$10,478,873	\$9,480,000	\$9,730,000	\$10,187,000	\$8,950,452	
C	62	\$11,180,335	\$10,070,000	\$9,775,000	\$9,817,000	\$9,762,000	\$9,482,000
C	63	\$1,676,064	\$1,055,000 \$1,149,000	\$988,000	\$1,265,313	\$1,093,000	\$1,103,300
C	64	\$150,822	\$3,516,000	\$3,765,000	\$3,830,000		
C	65	\$2,033,321	\$1,997,000	\$2,235,000	\$2,065,000	\$1,962,690	
C	66	\$20,346,090	\$19,372,630 \$18,666,183	\$20,534,000	\$19,500,000	\$20,408,000	\$19,186,000
C	67	\$24,575,061	\$21,615,000 \$20,410,000	\$21,856,000	\$21,749,000	\$22,465,000	\$21,459,000
C	68	\$389,141	\$335,996	\$459,000	\$530,000		
C	69	\$1,654,406	\$1,463,000	\$1,683,200	\$1,458,000	\$1,474,000	\$1,392,900
C	70	\$672,244	\$749,000 \$782,000	\$1,004,494	\$683,965	\$613,000	\$1,124,700