COST COMPARISON OF COLLABORATIVE AND IPD-LIKE PROJECT DELIVERY METHODS VERSUS COMPETITIVE NON-COLLABORATIVE PROJECT DELIVERY METHODS

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ABSTRACT

PURPOSE: Collaborative project delivery methods are believed to contribute to faster completion times, lower overall project costs and higher quality. Contracts are expected to influence the degree of collaboration on a given project since they allow or restrict certain lines of communication in the decision-making process. Various delivery systems rank differently on the spectrum of collaboration. The purpose of this study is to test if collaborative project delivery methods impart value. Ideally the most extreme forms of project delivery methods, that is, Integrated Project Delivery (IPD) and Design-Bid-Build (DBB), should be compared to test the effects of collaboration on benefits to the owner. Due to difficulty in obtaining data on IPD and similarly scaled DBB projects, for this study, their close cousins, CM-at-Risk (CMR) and Competitive Sealed Proposal (CSP) were compared.

METHODOLOGY: The study compared cost performance and reducible change orders of 17 CMR and 13 CSP projects by the same owner.

FINDINGS: The overall cost performance is more reliable for CMR than for CSP projects. The cost of reducible change orders for all three categories (errors, omissions and design modifications) are lower for CMR than for CSP projects

IMPLICATIONS: This study is expected to help boost confidence in the benefits of collaborative project delivery methods. It is also likely that the results will encourage acceptance of IPD for public projects.

KEYWORDS

Collaboration, Project Delivery, CM-at-Risk (CMR; CMAR), Competitive Sealed Proposal (CSP), Integrated Project Delivery (IPD), Design-Bid-Build (DBB), Cost Comparison

INTRODUCTION

One of the most widely accepted definitions of project delivery systems is "*allocation of relationships, roles and responsibilities of project team members and the sequence*

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of activities required for the deployment of a capital project" (Konchar and Sanvido 1998). Different delivery systems involve different degrees of collaboration and integration of key parties involved. This paper is focused on *collaboration* and its effect on benefits to the owner. There is no perfect project delivery system, but there is an expectation that collaborative projects are more cost beneficial than non-collaborative projects. The two extreme ends of the project delivery spectrum in terms of degree of collaboration are Design-Bid-Build (DBB) and Integrated Project Delivery (IPD). In the state of Texas, close cousins of these methods are Competitive Sealed Proposal (CSP) and CM-at-Risk (CMR) respectively. This study paper is an attempt to investigate these methods by comparing cost of change orders and cost performance.

BACKGROUND

Approximately 20-25% of total construction expenditure in the United States is comprised of public work (U.S. Census Bureau 2011). The long recession of the late 2000's, also called the Great Recession, started in December 2007. It has since become critical for public entities to justify public assets. Boyd Paulson (1976) theorized a relationship between level of influence and the cumulative cost of a project. He found that ability to influence cost is high during the early stages of construction and gradually reduces over the project life. A well-known modification of Paulson's curve was proposed by Patrick McLeamy, CEO of HOK, at the 2004 Construction User's Roundtable, to illustrate the advantages of IPD. Collaborative project delivery gives owners the benefit of having major role players of projects involved in the early stages of design and construction. Integrated processes reduce time delays, waste of motion, material and labor, and save money as they are driven by collaboration and teamwork (American Institute of Architects 2007, Ballard and Morris 2010, Lichtig 2005, Matthews and Howell 2005, Wilhelm 2007). In spite of the benefits observed, many public owners still consider the upfront costs associated with collaboration to be an important impediment. Hence, there lies a need for cost comparison analysis to be done on collaborative projects. This study tests only the following hypotheses:

(1) $\text{C. P.}_{\text{collaborative}} > \text{C.P.}_{\text{non-collaborative}}$
(2) $\text{C.O.}_{\text{collaborative}} < \text{C.O.}_{\text{/non-collaborative}}$

where,

$\text{C.P.}_{\text{collaborative}}$ is cost performance in collaborative projects (CMR)
$\text{C.P.}_{\text{collaborative}}$ is cost performance in non-collaborative projects (CSP)
$\text{C.O.}_{\text{collaborative}}$ is cost of reducible change orders in collaborative projects (CMR)
$\text{C.O.}_{\text{non-collaborative}}$ is cost of reducible change orders in non-collaborative projects (CSP)

Because of increased interest in Integrated Project Delivery, there is need for consensus on the cost performance advantages and disadvantages of collaborative project delivery methods. Based on the Construction State Law Matrix updated annually by the Associated General Contractors of America, 16 states still do not permit use of CMR delivery system for horizontal public works while 10 states permit it, within certain limitations (AGC 2010). One of the frequently asked questions about Integrated Project Delivery, posted on the AIA California website is:

"*Some professionals insist IPD is expensive to implement (especially in training costs associated with BIM and collaboration). What is the value proposition for Integration?"* Texas A&M University research about Texas elementary school projects states that CSP (a non-collaborative project delivery method) saved a tremendous $4000 per student over CMR (Reinisch 2011). There persists distrust regarding the benefits that are expected from collaborative project delivery systems like CMR. This clearly establishes a need to test a similar hypothesis on a different dataset with accurate costs for construction and benefits incurred.

Variations in project objectives gave birth to different project delivery systems. Construction researchers have since attempted to better understand the benefits of each system (Konchar and Sanvido 1998). Following are some examples of studies on various delivery systems. While successes and failures of various delivery systems have been studied by researchers. Some research has consisted of opinion surveys to investigate attitudes toward specific delivery methods by owners who frequently procure design and construction services (AIA 2007, Ballard and Morris 2010, Lichtig 2005, Matthews and Howell 2005, Songer and Molenaar 1996). Several case studies of industry builders and clients, such as the U.S. Postal Service, explain variations in the way project delivery systems are administered both privately and in the public sector (Bruns 1997). Three principal project delivery systems being used in the United States today are identified as Construction Manager-at-Risk (CMR), Design-Build (DB), and Design-Bid-Build (DBB) (Konchar and Sanvido 1998). A comparison between cost changes and delivery methods has been tested by researchers. Konchar and Sanvido (1998) found that DBB projects generally face 5.2% more change orders than DB projects.

CMR has many advantages such as: selection of contractor based upon qualifications, experience and team; design phase assistance by contractor in budget and planning; continuous budget control; screening of subcontractors; quality screening; faster schedule than traditional bid; and fast track construction, etc. A comparison of delivery systems completed by the Construction Industry Institute (CII) and Penn State University on construction in the United States states that CMR costs 1.5% less than DBB, completes 5% faster than DBB, and performs equal to or better than DBB on most quality measures (Konchar and Sanvido 1998). However, substantial efforts by owners to downsize in-house project management manpower, costly disputes between design and construction parties, and various levels of owner experience have forced several owners to adapt single source DB contracting (Dell'Isola 1987). Rojas and Kell (2008) studied completed construction projects and established that the degree of collaboration/integration has a significant relationship with the team practices imposed by the project procurement approach. The research was completely survey-based and made no comparisons to the cost benefits achieved on projects based on level of integration and type of delivery system. Pocock (1996) developed a method for assessing the control of project integration over the performance of public sector projects and used multivariate analysis techniques to compare the budget, duration and quality performance of 332 DB and DBB projects recently built in the United Kingdom.

METHODOLOGY

The source of data used for this study is a large US-based public institution. The source entity acts as a public owner and is currently gradually shifting to more collaborative project delivery methods like CMR and Design-Build. The data were collected over time through personal communication with the institution. After establishing a relationship of trust with the source, most data were gathered through email communication. Data were received in the form of project reports and change order logs. Due to a confidentiality request by the data source, the researcher cannot reveal any other details regarding the entity and their projects. The source is termed 'Company Z' throughout this paper for the sake of clarity. Figures 1 and 2 explain important underlying assumptions of this research. Figure 1 shows the similarity between DBB and CSP projects in general while figure 2 shows the similarity in terms of project phasing of CMR as followed by Company Z with the IPD phasing.

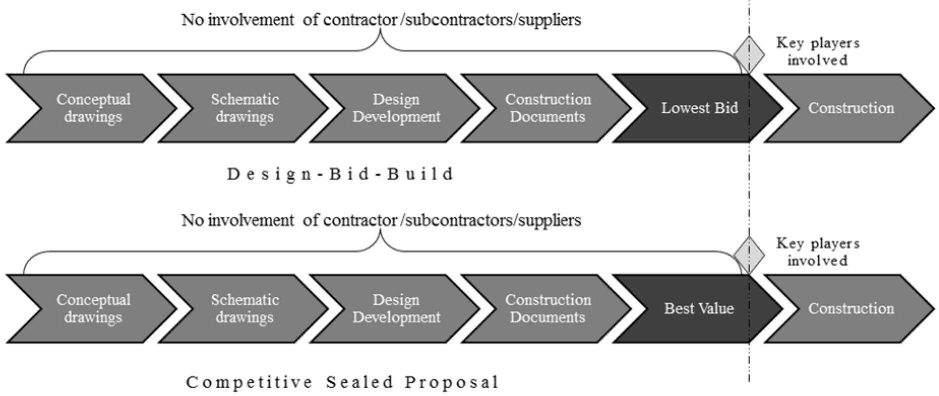

Figure 1: Typical project timelines for DBB and CSP (Illustration by authors)

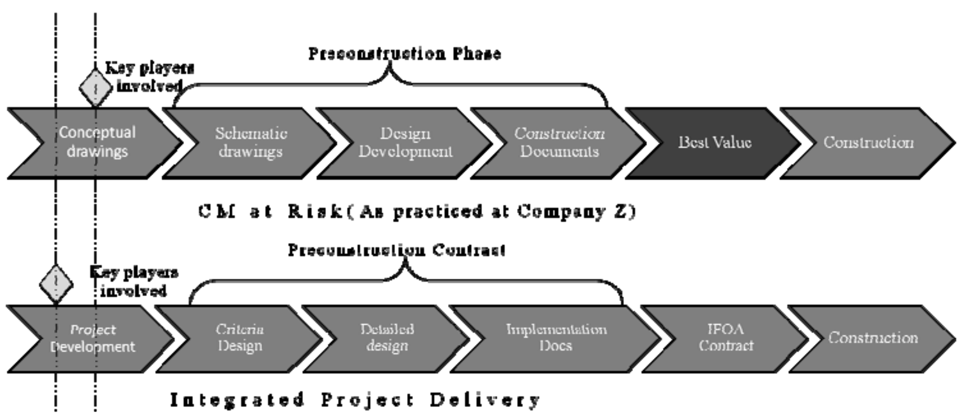

Figure 2: Typical project timelines for CMR and IPD (Illustration by authors)

Data for budgeted costs and actual construction costs were compiled and provided by Company Z itself while change order information for different projects was collected from Company Z's reports. Stratified random selection was used to collect the data. A dataset of 17 CMR projects & 13 CSP projects was considered for statistical testing.

RESEARCH METHOD

The study consisted of two parts. The first part involved comparing cost performance observed throughout the project cycle. Estimated budgets available for construction and corresponding actual construction costs were provided by Company Z. Cost savings were calculated to be the difference between the budgeted and actual costs on each project. To reduce the influence of size of projects, percent values of savings over the budgeted cost were calculated to represent cost performance as follows:

$$\text{Cost performance (\%)} = \frac{\text{(budgeted cost - actual cost)}}{\text{(budgeted project cost)}} * 100$$

The second part was to compare the costs incurred due to change orders in CSP and CMR projects. One of the benefits of collaboration between parties in the early stages of design is that it presumably eliminates unnecessary rework both before and during construction. Based on this logic, CMR, the collaborative system, should have significantly lower costs incurred due to change orders than CSP, the non-collaborative system. Change orders may negatively impact many aspects of construction leading to budget overruns, delays in completion, damaged relationships between parties due to potential disputes, and worsened labor efficiency. Hence reduction in change order costs can be seen as a major benefit of collaborative construction delivery systems. Company Z used a customized software tool to keep track of its projects. Change orders were categorized as follows:

1. Errors
2. Omissions
3. Design Modifications

Relevant to this study
(Reducible)

4. Changed Conditions
5. Unforeseen Conditions
6. Owner requirement
7. User Requirement
8. Weather Delays
9. Other

Irrelevant to this study
(Non-reducible)

It is postulated that reducible change orders such as Errors, Omissions and Design Modifications can be controlled by early involvement of key parties on a project while irreducible change orders caused by weather delays or change in owner/user requirements cannot be controlled by changing the delivery approach. Only Errors, Omissions and Design Modifications were included in this study as it is assumed that project delivery system had no impact on costs incurred due to the non-reducible items. The absolute values of change orders were normalized by taking their percentages over initial bid price. The percentages were calculated as follows:

$$\text{Reducible change order performance (\%)} = \frac{\text{(cost of reducible change orders)}}{\text{(initial bid price of project)}} * 100$$

We chose to use initial bid price in the denominator instead of budgeted cost because the initial price represented the cost at which the general contractor proposed to construct the project before the addition of change orders.

RESULTS

Data from the first part of this study, comparing distributions of % cost performance for CSP versus CMR projects, are represented in Figures 3, 4, and 5.

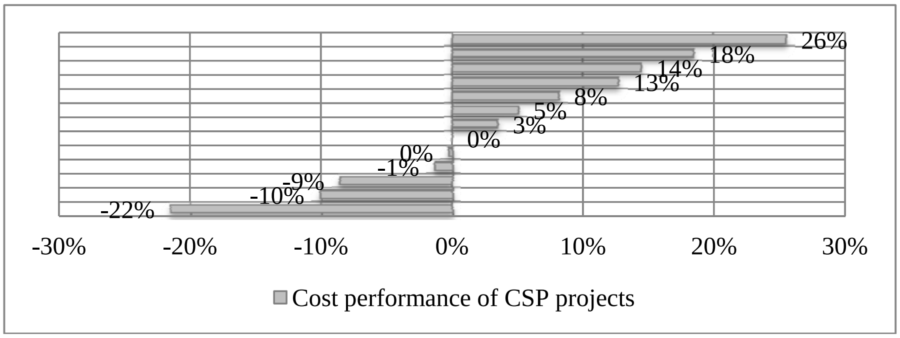

Figure 3: Cost performance for only CSP projects by Company Z. Each bar represents one project.

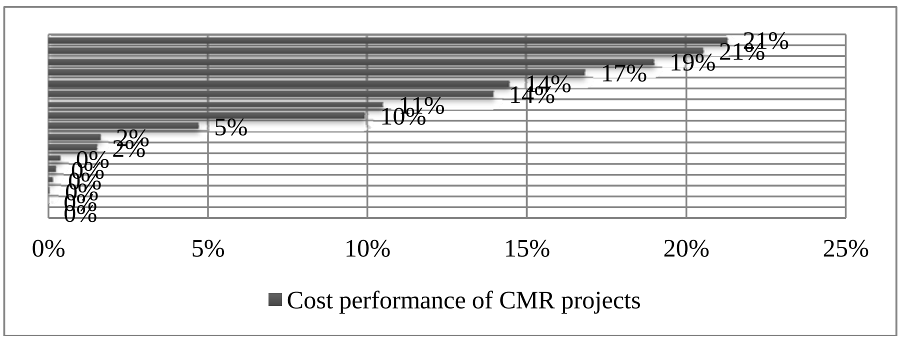

Figure 4: Cost performance for only CMR projects by Company Z

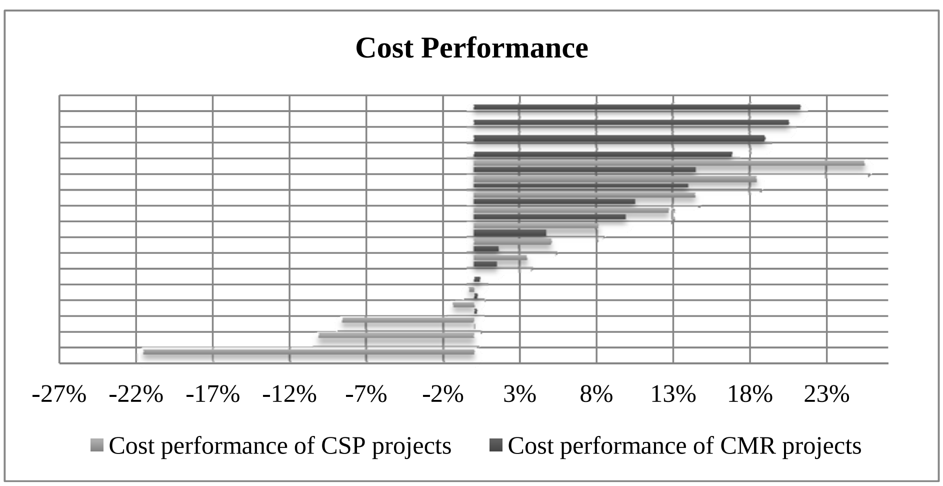

Figure 5: Cost performance for CMR and CSP projects by Company Z combined.

Data for the second part of this study, comparing reducible change order performance (%) for CMR versus CSP projects, are depicted as quartile box and whisker plots in Figures 6, 7, and 8.

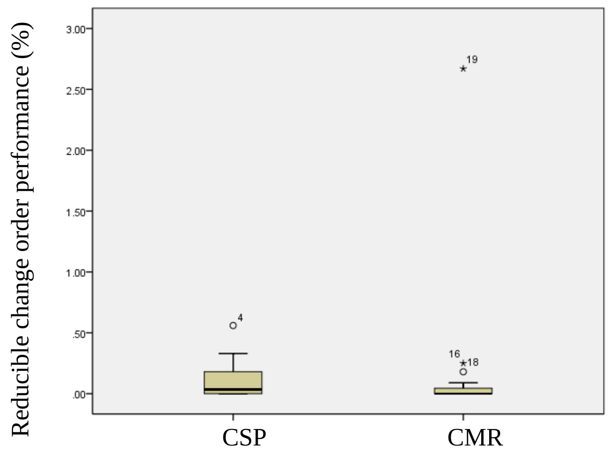

Figure 6: Reducible change order performance (%) categorized by project management as "errors" for CSP versus CMR projects. Outlier numbers represent project identification numbers from database but are not relevant to this discussion.

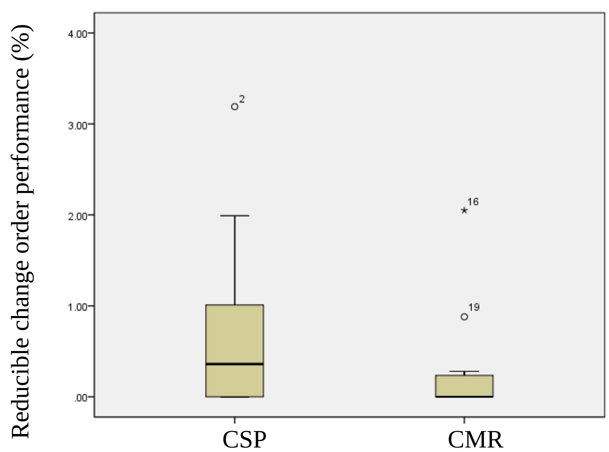

Figure 7: Reducible change order performance (%) categorized by project management as "omissions" for CSP versus CMR projects.

ANALYSIS & DISCUSSION

The data confirms the overall cost performance (%) of all CMR contracts was entirely positive (any variation between budgeted and actual cost represented savings; no projects were "in the red"). This is not surprising since the CMR contracts were governed by a guaranteed maximum price. By contrast, overall cost performance for CSP contracts were both positive and negative, confirming that CSP contracts may result in loss as well as savings.

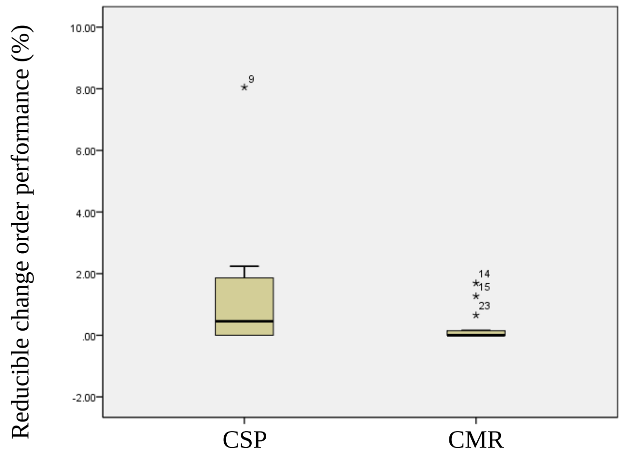

Figure 8: Reducible change order performance (%) categorized by project management as "design modifications" for CSP versus CMR projects.

Maximum cost savings was highest for a CSP project (26% for CSP versus 21% for CMR). However, the potential for loss was also considerable for CSP projects (-22% for CSP versus 0% for CMR). Note from Figures 3, 4, and 5 that the range of CSP data is approximately double of that of the range of CMR data (e.g. $\text{Range}_{(CSP)}\{X_{(+26\%)}, \ldots, X_{(-22\%)}\} = X_{(+26\%)} - X_{(-22\%)} = 48\%$; ($\text{Range}_{(CMR)}\{X_{(+21\%)}, \ldots, X_{(0\%)}\} = X_{(+21\%)} - X_{(0\%)} = 21\%$. In practical terms, this suggests that the cost prediction of a project is more reliable for CMR projects than for CSP projects.

Analysis of reducible change order performance (%), as shown in figures 6, 7, and 8, reveals that the cost of reducible change orders for all three categories (errors, omissions and design modifications) are lower for CMR than for CSP projects. This is consistent with the observation that overall cost performance is more reliable for CMR than for CSP projects.

This study was based on three assumptions. The first is that all the projects, irrespective of the change in contractor or architect/engineer, have similar degrees of collaboration since the owner is the same for all projects. The second assumption is that CMR is very closely related to IPD and CSP is very closely related to DBB. Therefore the results of this study might serve as a proxy for comparative cost analysis between the two extremes that are IPD and DBB. The data includes projects of varied typologies, ranging from research facilities, recreational facilities, laboratories, offices, and administration to health care. Finally, recognizing that the data includes projects of varied typologies ranging from research to recreational facilities, it is assumed that building typologies of the projects within data do not have any influence on the cost performance observed.

This study was limited in scope to include CSP and CMR projects by only one US-based owner. We understand that the most ideal cost comparison to solve the problems set at the center of this study is between IPD and DBB. But since there is a time as well as accessibility constraint on data available, we have tried to analyze the cost differences between only CMR and CSP projects. The owner ensured a certain degree of collaboration between important parties involved on projects within the dataset used for this study and was highly involved with the project developments throughout the phases of design and construction. As there are several levels of collaboration even within the CMR delivery approach (Jackson 2010, Thomsen 2008), the results of this study may not be representative of all CMR projects. In addition, since the data do not contain any IPD projects, the purest form of IPD with an integrated multi-party contract might not follow the findings of this study. It is expected that the study results will be used as a basis for triggering further research on cost analysis of IPD projects. Similarly, change in cost performance for projects using CSP delivery approach may be different from those using DBB, as CSP contractors are selected on a best-value basis. It is observed that in many CSP projects, value engineering on an accepted design can be facilitated to some extent by an owner;this might affect the cost performance of such CSP projects. Thus, the findings from this study cannot be expected to be replicated by all CSP projects.

CONCLUSION

The purpose of this study was to compare the relative costs associated with overall project cost performance and change orders for CMR and CSP projects by Company Z. It was hypothesized that under a collaborative method (CMR), cost performance would improve and change order costs would be reduced. Both of the above hypotheses have been supported by the shape and range of statistical graphs.

From the results, it is clear that collaborative project delivery systems produce a more reliable cost outcome for public owners. It was observed from the data that level of uncertainty is extremely high in the case of CSP projects, while CMR gives owners greater certainty over their budgets. The data shows a wide spread of percent changes on CSP projects. Thus, the study suggests that CMR is more reliable for more complex and risk prone projects. This warrants further attention in future research.

An informal poll on a professional networking site also indicated that CMR is considered more cost beneficial for public owners than other delivery systems. One of the respondents claimed, "*I did a lot of CMAR* work while I was with Nestle. It beats the daylights out of DB and DBB. The GC sends his lawyer home and he [the contractor] sits next to you at the table to work on getting the project built. A lot of the adversarial relationship stuff between the designer and the builder goes away*." Although this study does show that the cost performance is substantially superior in CMR delivery approach over CSP, there is need for additional empirical research which takes into account the level of collaboration on projects. Results of this study indicate that public owners like Company Z, which are moving from traditional delivery methods to more collaborative systems, are investing public funds in the right direction.

*CMAR is alternative acronym for CMR.

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