Identifying Moderation Effect
between Project Delivery Systems and Cost Performance

H. Moon, H.-S. Lee, M. Park, and B. Son

Department of Architecture and Architectural Engineering, Seoul National University, South Korea
Department of Architectural Engineering, Namseoul National University, South Korea
E-mail: axis1106@gmail.com

Abstract
This study was performed to identify the theoretical attribution of project type that moderates the impact of project delivery systems on cost performance. Previous studies have used direct relationship analysis to evaluate the project performance (e.g., the relationship between PDS and its cost performance, or the relationship between project type and cost performance). These analyses can cause inconsistent results and need to be analyzed in a single model. To combine the relationships between influential factors on cost performance, a causal model (i.e., moderation model) was suggested. The objective of this study is to develop a moderation model and test the statistical significance of moderation effect between PDS and cost performance. As a preliminary study, we established a simple moderation model and examine the moderation effect of project type. To test the model, 134 public sector projects completed between 1998 and 2013 in South Korea were utilized. The dataset consists of both Design-Build and Design-Bid-Build projects which are the most prevalent delivery systems. Even though the preliminary test results were not statistically significant, we can suggest the better way to understand the causal relationship moderated by project type between PDSs and their cost performance. This study is expected to provide the theoretical basis of the mechanism by which PDS impact cost performance, help project participants to select PDS by considering moderating effects in specific project types, and evaluate PDS appropriately in terms of cost performance.

Keywords— Cost management; Project delivery system; Design-build(DB); Design-bid-build(DBB); Cost performance; Change order; Project type; Moderation effect

1 Introduction
Evaluating project delivery system (PDS) in terms of cost performance has been conducted by comparing two prevalent methods: design–build (DB) and design–bid–build (DBB) [1-5]. Until the end of 1990s, most studies had concluded that DB outperforms the traditional DBB delivery systems in all aspects (e.g., cost, time, quality, safety and so on) [1-3]. However, adverse results have emerged in terms of cost performance since the early part of 2000s [4-7]. They found that DB is superior to DBB in terms of project schedule, however, cost performance is uncertain and debatable up to date. According to the previous studies, the reason why the comparison results are inconsistent depends on project type and dataset [7-8]. The explanation about the inconsistent results have been arbitrary without any theoretical basis.

To deal with this problem, causal model that explains the mechanism by which PDS cost effects operate should be needed. In research design, mediators and moderators are necessary to solve complex and unsettled problems in theory development [9]. Identifying and quantifying the mediators and moderators are useful in making contributions to the body of knowledge and both variables are the focus of research design in many situations [10]. Moderation is a causal model that postulates “when” or “for whom” an independent variable most strongly (or weakly) causes a dependent variable, while mediation is explains the process of “why” and “how” a cause-and-effect happens [10-12].

For the first step applying these theoretical basis, we identified and quantified a mediation effect between project delivery systems and cost performance through bidding characteristics (e.g., bid price, the number of bidders). The study suggests that the previous studies of evaluating PDS cost performance could be improved when the bidding characteristics are considered. As a second phase, we explored a moderation effect that affect the causal relationship
between PDSs and their cost performance.

The objective of this study is to develop a moderation model and test the statistical significance of moderation effect. As a preliminary study, we developed a simple moderation model and the test of the significance. The goal of this study is to identify the theoretical attribution of project type that moderates the impact of project delivery systems on cost performance. We use the same dataset as in the previous study [13], also the same cost performance metric (i.e., change order rate) is used. With the results, the current study can provide the theoretical basis on the reason why the cost performance comparison of PDSs is inconsistent.

2 Related Work

This section describes literature reviews related with the moderation effect and the influence of project type on the causal relationship between PDSs and their cost performance. Moderators is defined as a third variable that modifies a causal effect, an association between two variables X and Y is said to be moderated when its size or sign depends on a third variable of set of variables [14-15]. Moderation is also known as interaction. Moderation analysis is typically examined by testing for interaction between moderator and X in a model of Y [15]. In construction management discipline, studies on moderation effects have been rarely conducted [9, 16-17].

Yang et al [17] tested the moderating effect of project type by conducting a two-way ANOVA when examining the relationship between knowledge management and project performance. A number of studies indicate that project type affects cost performance [2, 7, 8, 18-21]. We assume that PDS cost performance varies depending on the project type.

3 Preliminary Moderation Model

As a preliminary model, we postulated a simple moderation model

Models were categorized to conceptual and statistical diagram. Conceptually, the moderation model is depicted in the form of a conceptual diagram in Figure 1. The diagram represents a process in which the effect of PDS on change orders is influenced or dependent on project type, as reflected by the arrow pointing from project type to the line from PDS to change order.

![Figure 1. Moderation Model as a Conceptual Diagram](image1)

Statistically, moderation effect is conducted by testing for interaction between project type(M) and PDS(X) in a model of change orders(Y). With evidence that X’s effect on Y is moderated by M, we then quantify and describe the contingent nature of the association or effect by estimating X’s effect on Y at various values of the moderator, an exercise known as probing an interaction. Equation (1) shows the standard multiple linear regression model. “ $b_3$ ” represents interaction role between PDS and project type.

$$Y = b_{01} + b_1X + b_2M + b_3XM + e_Y$$

(1)

The moderation effect is interpreted depending on both the statistical significance and the sign of $b_3$[22]. If the model result of $b_3$ is statistically significant. The association between PDS and change orders is various depending on project type (i.e., moderator).
4 Experiment and Results

The developed moderation model is being applied to the construction project of 134 samples from the same dataset of the previous work. Samples are categorized to three project types (i.e., residential building, non-residential building, and road civil work) where the sample sizes are evenly distributed. Table 1 shows the descriptive statistics of change orders according to project types. To examine the effect of moderator, two-way ANOVA was conducted. The results is shown in Table 2.

<table>
<thead>
<tr>
<th>Dependent var.</th>
<th>Project type (M)</th>
<th>N</th>
<th>Mean</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change order rate (Y)</td>
<td>Building(Residential)</td>
<td>41</td>
<td>13.936</td>
<td>2.753</td>
</tr>
<tr>
<td></td>
<td>Building(Non-Residential)</td>
<td>49</td>
<td>10.304</td>
<td>2.236</td>
</tr>
<tr>
<td></td>
<td>Civil(Road)</td>
<td>44</td>
<td>19.151</td>
<td>2.919</td>
</tr>
</tbody>
</table>

Table 2. Results of two-way ANOVA

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDS (X)</td>
<td>349.185</td>
<td>1</td>
<td>349.185</td>
<td>1.431</td>
<td>.234</td>
</tr>
<tr>
<td>Project type (M)</td>
<td>1415.473</td>
<td>2</td>
<td>707.736</td>
<td>2.901</td>
<td>.059</td>
</tr>
<tr>
<td>PDS*Project type (XM)</td>
<td>725.054</td>
<td>2</td>
<td>362.527</td>
<td>1.486</td>
<td>.230</td>
</tr>
<tr>
<td>Error</td>
<td>31231.363</td>
<td>128</td>
<td>243.995</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to the test results, the interaction effect (XM) of PDS and project type is not significant (p value > 0.05). Figure 3 shows the moderation effect (i.e., interaction effect) of PDS and project type on change orders.

![Figure 3. Moderation effect of PDS and project type on change orders](image)

The slopes of non-residential building and civil projects intersect each other in a cross, then the main effect of PDS appears wherever it is, and wherever it is...
reversed. That is, the main effect of the independent variable (i.e., PDS) does not consistently appear, and other results appear depending on mutual combinations with other variables. In this case, the model results show the dis-ordinal interaction.

5 Conclusions

A simple moderation model as a preliminary study was proposed to examine that project type moderates the impact of PDSs on their cost performance. This study is expected to provide a better understanding of the mechanism by which PDS impact cost performance, help project participants to select PDS by considering moderating effects in specific project types, and evaluate PDS appropriately in terms of cost performance. The academic contribution of the current study is to theoretically identify project type as a moderator using empirical data.

Regarding the limitations of this study, partial projects were selected from the original database, various combinations of project type should be applied to validate the moderation model. Also, value engineering costs for improvement were not considered because of data limitations.

For the further studies, conditional process model that integrates mediating effect and moderating effect in a single model could be developed. That is, moderated mediation and mediated moderation model considering project characteristics and bidding characteristics simultaneously need to be applied. Those models are to be expected to enhance the explanation the inconsistent evaluating results of PDS performance comparison.

Acknowledgement

This work was supported by the Technology Innovation Program (10077606, To Develop an Intelligent Integrated Management Support System for Engineering Project) funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea).

References


