# Relationship between Innovation Practice and Public Project Success: Project Type as a Moderating Variable

Ya-Ting Chang, Chung-Yuang Jan, and Li-Ren Yang

***Abstract*—Conceptualizing innovation practice in the public project context is still rudimentary. The first objective of this study was to assess the influence of innovation practice on public project success. The second objective was to evaluate the moderating role of project type in the relationship between innovation practice and public project success. This study empirically investigated a sample of public projects in the Taiwanese construction industry. Regression analysis was used to assess the influence of innovation practice on public project success. In testing the moderation effect, two-way analysis of variance (ANOVA) was used. The findings indicate that adopting innovation practice significantly contributes to public project success. In addition, project type has a moderating effect on the relationship between innovation practice and public project success. Owner and project managers can use the research results to help improve public project success.**

***Index Terms*—Innovation practice, project success, project type, public project.**

## I. Introduction

Innovation has changed the way project activities are performed. Previous studies suggested that innovation is an important factor influencing project performance [1]. However no previous studies have empirically analyzed the effects of innovation practice on public project success. Due to this deficiency, this study attempted to evaluate the impact of innovation practice on project success. This study sought to answer the research questions that focused on the role of innovation practice and its association with the outcomes of a public project. First, does the adoption of innovation practice improve the outcomes of a project? Second, what types of projects should pay more attention to the adoption of innovation practice? Thus, the first objective of this study was to assess the influence of innovation practice on public project success. The second objective was to evaluate the moderating role of project type in the relationship between innovation practice and public project success.

## II. Literature Review and Research Hypotheses

An innovation company has a sustainable competitive advantage [2]. While an innovation strategy is key to research and development [3]. The literature suggested that innovation provides benefits for the firm and helps improve performance outcomes [4]. Additionally, innovation has a substantial effect on project success [5]-[7].

Previous studies indicated that innovation plays an important role in project outcomes. In other words, project performance may derive from innovation. This leads to the following hypothesis:

H1: Innovation practice positively influences public project performance.

Several researchers have also argued that project type plays a moderating role in the relationship between practice use and project performance [8], [9]. Overall, this factor influences coordination of efforts, resources, routines, and systems [10]. Thus, it may modify the form of the relationship between innovation practice and project success. In other words, innovation practice may have a positive effect on project performance, particularly for certain types of projects. This leads to the following hypothesis:

H2: Project type moderates the relationship between innovation practice and public project success.

## III. Methodology

### A. Research Instrument

The survey instrument was developed to measure the adoption of innovation practice and public project success in the Taiwanese construction industry. Study participants were first asked to identify a recent project that they were familiar with for assessment. The survey was composed of four sections: 1) innovation practice, 2) project success, 3) project information (including project type: building, industrial, or infrastructure project), and 4) personal information.

### B. Sampling Method

Individuals interested in participating in the study included Taiwan Construction Research Institute, construction engineering and management program of the Universities, Public Works Department of Taipei City Government, New Taipei City Government, and Kaohsiung City Government. The data collection tool was developed to collect project-based data. The targeted respondents were identified as the senior individuals who were familiar with innovation practice adoption and public project success. In order to obtain a representative sample of the industry, a specified mix of project type was targeted.

All of the companies were contacted via phone or email to identify the person involved in projects by name and title. The investigators then contacted the respondents to confirm their participation in this study. This study also ensured that the investigators select the right respondents who are capable of answering all of the survey questions. Project responses

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were collected via paper and online surveys. Ultimately, 168 survey responses were used in the analysis. Characteristics of sampled projects are presented in Table I. Profile of respondents is shown in Table II.

TABLE I: CHARACTERISTICS OF SAMPLED PROJECTS

| Characteristic | Class | Number | Percent |
|---|---|---|---|
| Project type | Building | 98 | 58.3 |
| Project type | Industrial | 9 | 5.4 |
| Project type | Infrastructure | 58 | 34.5 |
| Geographic region | Northern Taiwan | 90 | 53.6 |
| Geographic region | Central Taiwan | 10 | 6.0 |
| Geographic region | Southern Taiwan | 63 | 37.5 |
| Geographic region | Other | 4 | 2.4 |
| Project duration | <1 year | 22 | 13.1 |
| Project duration | 1-2 years | 56 | 33.3 |
| Project duration | 2-3 years | 53 | 31.6 |
| Project duration | >3 years | 32 | 19.0 |
| Total installed cost | <5 million | 49 | 29.2 |
| Total installed cost | 5-20 million | 57 | 33.9 |
| Total installed cost | 20-50 million | 28 | 16.7 |
| Total installed cost | >50 million | 28 | 16.7 |
| Time availability | Unrealistic duration | 50 | 29.8 |
| Time availability | Realistic duration | 8 | 4.8 |
| Time availability | Medium | 106 | 63.1 |
| Number of team members | <6 | 46 | 27.4 |
| Number of team members | 6-10 | 64 | 38.1 |
| Number of team members | 11-20 | 36 | 21.4 |
| Number of team members | 21-30 | 7 | 4.2 |
| Number of team members | 31-40 | 3 | 1.8 |
| Number of team members | 41-50 | 1 | 0.6 |
| Number of team members | >50 | 8 | 4.8 |
| Information availability | Not enough | 13 | 7.7 |
| Information availability | Enough | 47 | 28.0 |
| Information availability | Medium | 104 | 61.9 |
| Environmental uncertainty | High | 41 | 24.4 |
| Environmental uncertainty | Medium | 90 | 53.6 |
| Environmental uncertainty | Low | 34 | 20.2 |
| International organization involved | Yes | 38 | 22.6 |
| International organization involved | No | 126 | 75.0 |
| Project complexity | High | 104 | 61.9 |
| Project complexity | Medium | 25 | 14.9 |
| Project complexity | Low | 36 | 21.4 |

TABLE II: PROFILE OF RESPONDENTS

| Variable | Category | Number | Percent |
|---|---|---|---|
| Age | <30 | 23 | 13.7 |
| Age | 31-35 | 31 | 18.5 |
| Age | 36-40 | 29 | 17.3 |
| Age | 41-45 | 47 | 28.0 |
| Age | >45 | 37 | 22.0 |
| Education | High school diploma | 1 | 0.6 |
| Education | Associate's degree | 27 | 16.1 |
| Education | Bachelor's degree | 66 | 39.3 |
| Education | Master's degree | 72 | 42.9 |
| Number of project involvement | <6 | 89 | 53.0 |
| Number of project involvement | 6-10 | 43 | 25.6 |
| Number of project involvement | 11-15 | 18 | 10.7 |
| Number of project involvement | 16-20 | 5 | 3.0 |
| Number of project involvement | >20 | 12 | 7.1 |
| Years of experience | <6 | 45 | 26.8 |
| Years of experience | 6-10 | 44 | 26.2 |
| Years of experience | 11-15 | 31 | 18.5 |
| Years of experience | 16-20 | 20 | 11.9 |
| Years of experience | >20 | 27 | 16.1 |
| Group involvement | Architect/Engineering (A/E) | 62 | 36.9 |
| Group involvement | Owner | 56 | 33.3 |
| Group involvement | General Contractor (GC) | 49 | 29.2 |

### C. Survey Design and Measurement

Multi-item scales were developed for each of the variables included in the theoretical model (see Fig. 1). The scales developed by Lin *et al.* [11] were adapted to evaluate innovation practice. In addition, questions from Müller and Turner [9], Gelbard and Carmeli [12], and Westerveld [13] Wang *et al.* [14], and Shenhar *et al.* [15] were adapted to measure public project success. Each item was rated on a 6-point scale, where 1 represented strongly disagree and 6 represented strongly agree.

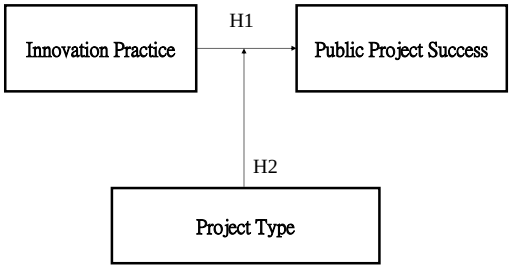

Fig. 1. Theoretical model.

### D. Content Validity

Content validity refers to the extent to which a measure represents all facets of a given concept. The content validity of the survey used in this study was tested through a literature review and interviews with the six construction professionals from the Owner, Architect/Engineering (A/E), and General Contractor (GC) groups. All of these professionals have more than 10 years of experience in public project management. The refined assessment items were included in the final survey.

### E. Construct Validity and Reliability

The construct validity was tested by factor analysis. Factors were extracted using Varimax rotation. As suggested by Hair et al. [16], an item is considered to load on a given factor if the factor loading from the rotated factor pattern is 0.50 or more for that factor. Thus, several items were dropped due to low factor loadings.

Cronbach's coefficient (α) was computed to test the reliability and internal consistency of the responses. The values of Cronbach's α above 0.7 are considered acceptable and those above 0.8 are considered meritorious [17].

## IV. Results and Analysis

### A. Constructs of Innovation Practice and Public Project Success

Factor analysis with Varimax rotation was used to decide the grouping of innovation practice construct. Only variables with a factor loading greater than 0.5 were extracted [16]. The 21 items of innovation practice construct are classified into four factors. They are management and service innovation, construction method innovation, facility function innovation, and environmental sustainability innovation. All of the factor loadings range from 0.518 to 0.834, indicating a high level of internal consistency among the innovation practice items. Additionally, the 21 items of public project success construct are classified into five factors. The five constructs categorized are safety success, quality success, schedule success, cost success, and owner satisfaction. The analysis shows factor loadings ranging from 0.502 to 0.829. Reliability was assessed for innovation practice at 0.938 and public project success at 0.949. All of the α values for constructs are above 0.7, indicating a high degree of internal consistency in the responses.

### B. Impacts of Innovation Practices on Public Project Success

Five regression models were developed using the four innovation practices as independent variables and each of the five public project success measures as a dependent variable in each model. The regression results of these models are presented in Table III. For safety success, the multiple coefficient of determination (R squared) was 0.243. The p-value (<0.001) indicates that there was a significant relationship between innovation practices and public project success. This suggests that management and service innovation and facility function innovation have a positive influence on public project success, as measured by safety success.

To further examine the relationship between innovation practices and public project success, another regression for quality success was conducted. "Management and service innovation" and "facility function innovation" emerged as two key independent variables in regression when the dependent variable used was quality success. The multiple coefficient of determination (R squared) was 0.309. In other words, the independent variables, "management and service innovation" and "facility function innovation", explained 30.9 percent of the variation in the dependent variable, quality success.

When "schedule success" was used as the dependent variable, two independent variables were identified to be significant: "management and service innovation" and "facility function innovation". The findings indicate that "management and service innovation" and "facility function innovation" are significantly related to public project success in terms of schedule success. The coefficient of determination (R squared) was found to be 0.322. This implies that 32.2% of the variations in schedule success can be explained by "management and service innovation" and "facility function innovation." In addition, no evidence of strong multicollinearity was found in any of the estimated models [i.e., variance-inflation factors $\leqq$10 [18].

TABLE III: Regression Analyses

| Variable | Public project success | | | | |
|---|---|---|---|---|---|
| | Safety | Quality | Schedule | Cost | Owner satisfaction |
| Independent variable | | | | | |
| Management and service | 0.247* | 0.304** | 0.408*** | 0.332** | 0.293** |
| Construction method | -0.016 | 0.095 | -0.002 | 0.005 | 0.058 |
| Facility function | 0.250** | 0.274** | 0.306** | 0.128 | 0.169 |
| Environmental sustainability | 0.102 | -0.058 | -0.182* | 0.060 | -0.093 |
| F-test | 13.068*** | 18.205*** | 19.371*** | 10.574*** | 8.677*** |
| R-squared | 0.243 | 0.309 | 0.322 | 0.207 | 0.176 |
| Adjusted R-squared | 0.224 | 0.292 | 0.306 | 0.187 | 0.155 |
| Durbin-Watson (DW) statistic | 1.926 | 2.264 | 2.176 | 2.102 | 2.074 |

[a]The number denotes the beta coefficient for the particular variable
*significant at the 0.05 level; **significant at the 0.01 level; ***significant at the 0.001 level

When "cost success" and "owner satisfaction" were used as the dependent variables, only one independent variable were identified to be significant: "management and service innovation." The findings indicate that "management and service innovation" is significantly related to public project success in terms of cost success and owner satisfaction.

### C. Testing the Moderating Effect of Project Type

Hypothesis 2 was concerned with the moderating effects of project type on the relationship between innovation practice and public project success. Cluster analysis was used in an exploratory mode to develop an objective classification of projects. In order to identify homogeneous projects clusters with the same levels of innovation practice, a K-means cluster analysis was performed on the basis of the four dimensions of innovation practice (i.e., management and service innovation, construction method innovation, facility function innovation, and environmental sustainability innovation). The cluster analysis has identified two clusters for information platform adoption, with the cluster mean values of discriminating variables given in Table IV. In addition, the independent-samples t tests shown in Table IV confirm that the variables of innovation practice do significantly differentiate across the two clusters. The first cluster was labeled projects with high levels of innovation practice adoption. The second cluster consists of projects with low levels of innovation practice adoption.

TABLE IV: CLUSTER MEANS OF DISCRIMINATING VARIABLES

| Variable | Projects with high level of innovation practice adoption | | Projects with low level of innovation practice adoption | | t-statistic |
|---|---|---|---|---|---|
| | Number | Mean | Number | Mean | |
| Management and service | 111 | 4.48 | 57 | 2.92 | 13.230*** |
| Construction method | 111 | 4.59 | 57 | 2.95 | 14.136*** |
| Facility function | 111 | 4.91 | 57 | 3.89 | 7.547*** |
| Environmental sustainability | 111 | 4.72 | 57 | 3.84 | 6.652*** |

***significant at the 0.001 level

The study revealed two segments for the two innovation practice dimensions. On the other hand, the subject projects were also categorized according to project type (i.e., building, industrial, or infrastructure project). Thus, to test for the moderating influence of project type on the association between innovation practice and public project success, 2 (innovation practice) x 3 (project type) analysis of variance (ANOVA) was performed. The two-way ANOVA was utilized to determine the joint effect of innovation practice and project type on public project success in terms of safety success, quality success, schedule success, cost success, and owner satisfaction. Table V summarizes the results of the ANOVAs. The results suggest a significant interaction of innovation practice (IP) and project type (PT) for public project success ($F = 3.177$, $p < 0.05$). The findings indicate that project type has a moderating effect on the relationship between innovation practice and public project success.

TABLE V: RESULTS OF TWO-WAY ANOVAS

| Variable | Degrees of freedom | Mean square | F |
|---|---|---|---|
| Innovation practice | 1 | 11.449 | 24.682*** |
| Project type | 3 | 1.524 | 3.285* |
| Innovation practice x Project type | 2 | 1.474 | 3.177* |

*significant at the 0.05 level; ***significant at the 0.001 level

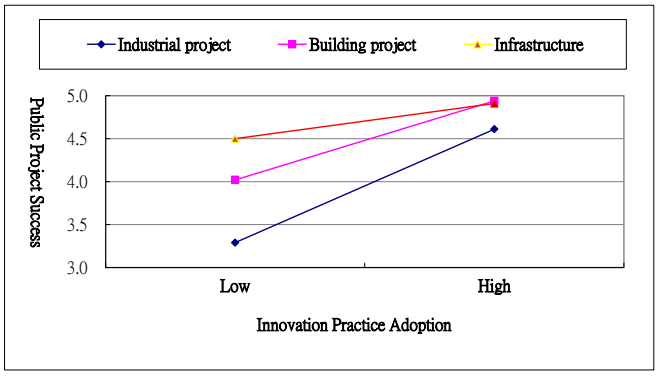


Fig. 2. Moderating effect of project type.

Since the interaction term was significant, the form of interaction was graphically represented to evaluate the direction of the differences within each of the conditions. Fig. 2 shows the relationship between innovation practice and public project success at different project type (building, industrial, and infrastructure project). The results in Fig. 4 demonstrate that building and industrial projects may achieve higher levels of project success when they experience high levels of innovation practice adoption than infrastructure projects. Thus, H2 is supported.

## V. CONCLUSION AND IMPLICATIONS

While the diverse benefits of innovation practice adoption have received substantial attention, the number of studies dealing with the influence of innovation practice adoption on public project success is rather scarce. Thus, developing such support will illustrate the relationships between innovation practice adoption and public project outcomes. This study attempts to fill the gap in the literature by identifying the relationship between innovation practice adoption and public project success.

The first objective of this study was to assess the influence of innovation practice on public project success. The findings indicate that management and service innovation and facility function innovation have a positive influence on public project success, as measured by safety, quality, and schedule success respectively. In addition, when "cost success" and "owner satisfaction" were used as the dependent variables, only one independent variable were identified to be significant: "management and service innovation." The findings indicate that "management and service innovation" is significantly related to public project success in terms of cost success and owner satisfaction.

The second objective was to evaluate the moderating role of project type in the relationship between innovation practice and public project success. The findings indicate that project type has a moderating effect on the relationship between innovation practice and public project success. Specifically, building and industrial projects may achieve higher levels of project success when they experience high levels of innovation practice adoption than infrastructure projects. Infrastructure projects involve simple construction activities when compared to building and industrial projects. These simple activities usually do not need innovation. This may be why the relationship between innovation practice adoption and project success is weaker for infrastructure projects.

While this study offers important insights into the adoption of innovation practice, there are some limitations. First, results are obtained from only one industry (i.e., construction industry). Thus, generalizations should be drawn with care. It would be helpful to conduct similar studies in other industries. Additionally, it would be interesting to examine the moderating relationship between innovation practice and project success for private projects.

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