Role of Task Characteristics in the Relationship between Technological Innovation and Project Success

Li-Ren Yang

***Abstract*—Conceptualizing technological innovation in the project management context is still rudimentary. The primary objective of this study was to assess the moderating role of task characteristics in the relationship. This study empirically investigated a sample of projects in the Taiwanese construction industry. In testing the moderation effect, hierarchical regression analysis were used. The findings indicate that adopting technological innovation significantly contributes to project success. In addition, task characteristics have a moderating effect on the relationship between technological innovation and project success. Project managers can use the research results to help improve project success.**

***Index Terms*—Technological innovation, project success, task characteristics, project management.**

I. Introduction

Innovations in technology have changed the way project activities are performed. No previous studies have empirically analyzed the effects of technological innovation adoption on project success. Due to this deficiency, this study attempted to evaluate the association between the adoption of technological innovation on and project success. Previous studies suggested that technological innovation is an important factor influencing project performance [1]. This study sought to answer the research questions that focused on the role of technological innovation and its association with the outcomes of a project. First, does the adoption of technological innovation improve the outcomes of a project? Second, which part of the technological innovation is critical? Thus, the primary purpose of this study was to examine the role of task characteristics in the relationship between technological innovation and project success

II. Literature Review and Research Hypotheses

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

Previous studies indicated that technological innovation plays an important role in project outcomes. As such, project performance may derive from technological innovation. Several researchers have also stated that task characteristics play a moderating role in the relationship between practice use and project performance [6], [7]. O'Connor and Won [8], [9] developed several categories of task characteristics to classify tasks by their attributes. Overall, these factors influence coordination of efforts, resources, routines, and systems [10]. Thus, they may modify the form of the relationship between technological innovation and project success. In other words, technological innovation may have a positive effect on project performance, particularly when the project is associated with certain project characteristic variables. This leads to the following hypothesis:

Hypothesis (H): Task characteristics (including member diversity, process complexity, data and information complexity, and communication complexity) moderate the relationship between technological innovation and project success.

III. Methodology

A. Research Instrument

The survey instrument was developed to measure the adoption of technological innovation and capital facility 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) technological innovation, 2) task characteristics, 3) project success, and 4) project and personal information.

B. Sampling Method

Individuals interested in participating in the study were identified by a search from various industry associations. A survey of capital facility projects was conducted in the Taiwanese construction industry. The data collection tool was developed to collect project-based data. The targeted respondents were identified as the senior individuals who were familiar with technological innovation adoption and 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 approach helped the investigators select the right respondents who possess adequate knowledge to properly evaluate the subjective project and are capable of answering all of the survey questions. Project responses were collected via paper and

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online surveys. The projects were examined to ensure that no duplicate project information was collected. Ultimately, 160 survey responses were used in the analysis. Profile of respondents is shown in Table I.

TABLE I: PROFILE OF RESPONDENTS

Variable	Category	Number	Percent
Group involvement	Architect/Engineering (A/E)	28	17.7
Group involvement	Owner	62	39.2
Group involvement	General Contractor (GC)	68	43.0
Role in the project	Project superintendent	87	55.1
Role in the project	Project director	36	22.8
Role in the project	Project manager	22	13.9
Role in the project	Managers/deputy manager	5	3.2
Role in the project	President	8	5.1
Years of experience	<6	68	43.0
Years of experience	6-10	51	32.3
Years of experience	11-15	22	13.9
Years of experience	>15	17	10.7
Education	Associate's degree	55	34.8
Education	Bachelor's degree	77	48.7
Education	Master's degree	26	16.5
Number of project involvement	<6	94	59.5
Number of project involvement	6-10	47	29.7
Number of project involvement	>10	17	10.7

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 Yam *et al*. [11] were adapted to evaluate technological innovation. This study examined the three most important technological innovation in construction: research and development (R&D), resource allocation, and construction. In addition, items used to rate task characteristics were based on the studies developed by O'Connor and Won [8], [9]. They proposed several categories of task characteristics to classify tasks by their attributes. Four important categories associated with capital facility projects were considered: member diversity, process complexity, data and information complexity, and communication complexity. Finally, questions from Müller and Turner [7], Gelbard and Carmeli [12], and Westerveld [13] were adapted to measure capital facility project success. In this study, project success was measured by the four dimensions of schedule success, cost success, quality success, and safety success. The survey used these items because the literature and recommendations of six construction practitioners have shown that these items are closely linked to capital facility projects. Each item was rated on a 7-point scale, where 1 represented strongly disagree and 7 represented strongly agree.

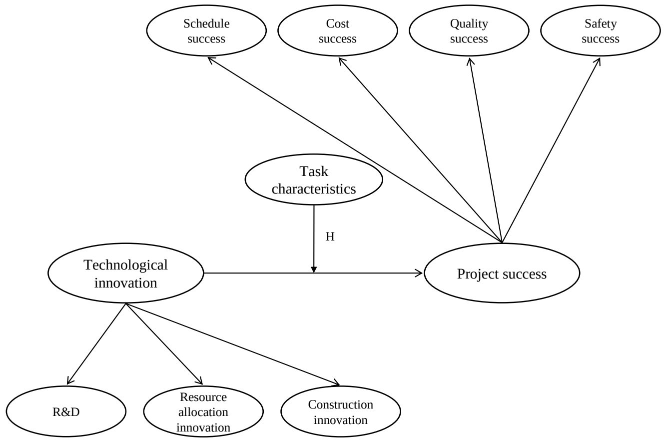

Fig. 1. Theoretical model.

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. The refined assessment items were included in the final survey. Finally, copies of a draft survey were also sent to three professors in the construction management discipline to pre-test for the clarity of questions. Their insights were also incorporated into the final version of the survey.

IV. RESULTS AND ANALYSIS

A. Measurement Model Test Results

Prior to estimating the structural model, a confirmatory factor analysis (CFA) was conducted to verify the measurement model. Multiple fit criteria were used to assess the overall fit of the model. In the proposed model, technological innovation and project success are a second order construct. The data were analyzed using the AMOS/SPSS statistical package. The model refinement was performed to improve the fit to its recommended levels. Based on several trials resulting in elimination of some of the items, all of the scales met the recommended levels (NFI=>0.9; CFI>0.9; GFI>0.9; AGFI>0.8; RMSEA<0.08) as shown in Fig. 2 and Fig. 3. Furthermore, the composite reliability for all constructs was above the 0.7 level suggested by Hair *et al*. [14], indicating adequate reliability for each construct. Thus, the results provide evidence that the scales are reliable.

All of the factor loadings are statistically significant at the five percent level and exceed the 0.5 standard. In addition, all constructs have an average variance extracted (AVE) greater than 0.5. Thus, these constructs demonstrate adequate convergent validity. Discriminant validity evaluates whether the constructs are measuring different concepts. The procedure requires comparing the set of models where each pair of latent constructs has a constrained correlation of one with the correspondent models where such pairs of constructs are freely estimated. The results show that the chi-square values are significantly lower for the unconstrained models at the five percent level, which suggests that the constructs exhibit discriminant validity.

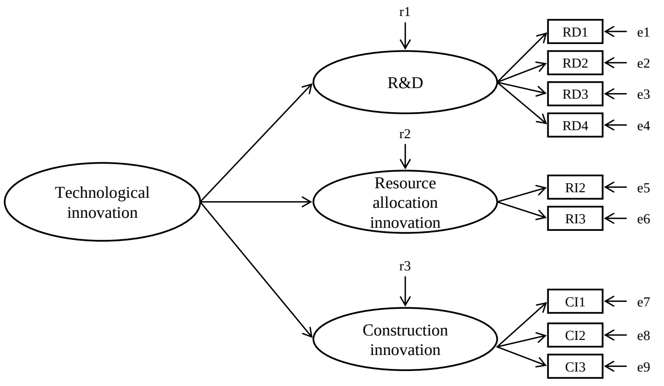

Fig. 2. CFA measurement model for technological innovation.

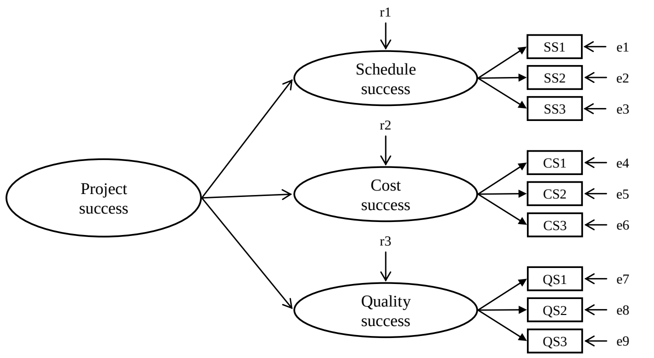

Fig. 3. CFA measurement model for project success.

B. *Testing the Moderating Effect of Task Characteristics*

The hypothesis was concerned with the moderating effects of the task characteristics (including member diversity, process complexity, data and information complexity, and communication complexity) on the relationship between technological innovation and project success. For example, hierarchical regression analysis was employed to examine whether member diversity has a moderator effect on the relationship between technological innovation and project success. In agreement with Aiken and West [15], this study centered any variable which was used as a component of an interaction term. Table II shows the regression results for schedule success. Particularly, at steps 1 through 4, this study entered the control variables, technological innovation, member diversity, and the interaction of technological innovation and member diversity. Step 4 indicates a significant interaction of R&D (RD) and member diversity (MD) for schedule success. Similarly, as shown in Table III, the results indicate a significant interaction of resource allocation innovation (RI) and data and information complexity (DI) for quality success. In addition, the results in Tables IV and V demonstrate that communication complexity (CO) and process complexity (PC) have a moderating effect on the relationship between technological innovation and project success. The findings suggest that the link between technological innovation capabilities and project success is moderated by task characteristics. Thus, it can be concluded that the hypothesis was confirmed and accepted.

TABLE II: MODERATING EFFECT OF MEMBER DIVERSITY FOR SCHEDULE SUCCESS

Variable	Schedule success			
	Model 1	Model 2	Model 3	Model 4
Control variable				
Owner regulation	0.118	-0.136	-0.097	-0.082
Industry sector	-0.094	0.033	-0.019	-0.039
Total installed cost	-0.127	-0.211*	-0.201*	-0.182
Project duration	-0.019	0.108	0.083	0.070
Team size	0.019	0.045	0.032	0.016
Independent variable				
R&D (RD)		0.336***	0.239*	0.222*
Resource allocation innovation (RI)		0.542***	0.451***	0.428***
Construction innovation (CI)		-0.157	-0.118	-0.063
Moderating variable				
Member diversity (MD)			0.219**	0.289**
Interaction				
RD x MD				0.273*
RI x MD				0.059
CI x MD				-0.266
F-test	0.753	11.711***	11.773***	9.572***
R-squared	0.024	0.389	0.421	0.445
R-squared increased	--	0.365	0.032	0.024

*significant at the 0.05 level; **significant at the 0.01 level; ***significant at the 0.001 level

TABLE III: MODERATING EFFECT OF DATA AND INFORMATION COMPLEXITY FOR QUALITY SUCCESS

Variable	Quality success			
	Model 1	Model 2	Model 3	Model 4
Control variable				
Owner regulation	0.158	-0.112	-0.081	-0.081
Industry sector	-0.204	-0.057	-0.047	-0.050
Total installed cost	-0.191	-0.171	-0.131	-0.135
Project duration	0.065	0.061	0.045	0.021
Team size	-0.149	-0.124	-0.118	-0.065
Independent variable				
R&D (RD)		0.410***	0.308**	0.298**
Resource allocation innovation (RI)		0.018	-0.015	0.012
Construction innovation (CI)		0.193	0.163	0.150
Moderating variable				
Data and information complexity (DI)			0.229**	0.173*
Interaction				
RD x DI				-0.190
RI x DI				0.291*
CI x DI				-0.177
F-test	2.195	8.779***	8.955***	7.504***
R-squared	0.068	0.323	0.356	0.386
R-squared increased	--	0.255	0.033	0.030

*significant at the 0.05 level; **significant at the 0.01 level; ***significant at the 0.001 level

V. CONCLUSION AND IMPLICATIONS

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

TABLE IV: MODERATING EFFECT OF COMMUNICATION COMPLEXITY FOR COST SUCCESS

Variable	Cost success			
	Model 1	Model 2	Model 3	Model 4
Control variable				
Owner regulation	0.207*	-0.044	-0.047	-0.038
Industry sector	-0.092	0.040	0.040	0.055
Total installed cost	-0.252*	-0.245*	-0.244*	-0.276**
Project duration	0.086	0.103	0.104	0.135
Team size	0.209*	0.229**	0.229**	0.210*
Independent variable				
R&D (RD)		0.408***	0.412***	0.422***
Resource allocation innovation (RI)		0.097	0.101	0.143
Construction innovation (CI)		0.059	0.062	0.029
Moderating variable				
Communication complexity (CO)			-0.018	-0.034
Interaction				
RD x CO				-0.016
RI x CO				-0.244
CI x CO				0.351*
F-test	3.476**	8.278***	7.316***	6.113***
R-squared	0.104	0.311	0.311	0.339
R-squared increased	--	0.207	0.000	0.028

*significant at the 0.05 level; **significant at the 0.01 level; ***significant at the 0.001 level

TABLE V: MODERATING EFFECT OF PROCESS COMPLEXITY FOR SCHEDULE SUCCESS

Variable	Schedule success			
	Model 1	Model 2	Model 3	Model 4
Control variable				
Owner regulation	0.118	-0.136	-0.151	-0.155
Industry sector	-0.094	0.033	-0.034	0.032
Total installed cost	-0.127	-0.211*	-0.217*	-0.229*
Project duration	-0.019	0.108	0.114	0.147
Team size	0.016	0.045	0.041	-0.010
Independent variable				
R&D (RD)		0.336***	0.368***	0.428***
Resource allocation innovation (RI)		0.542***	0.574***	0.620***
Construction innovation (CI)		-0.157	-0.163	-0.205
Moderating variable				
Process complexity (PC)			-0.077	-0.029
Interaction				
RD x PC				0.264*
RI x PC				0.148
CI x PC				-0.271
F-test	0.753	11.711***	10.498***	8.627***
R-squared	0.024	0.389	0.393	0.420
R-squared increased	--	0.365	0.004	0.027

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

The objective of the study was to evaluate the moderating role of task characteristics in the relationship between technological innovation and project success. The findings indicate that task characteristics (including member diversity, process complexity, data and information complexity, and communication complexity) have a moderating effect on the relationship between technological innovation and project success. Thus, the hypothesis is supported. It is clear that projects with high member diversity are more likely to be successful in schedule when they experience a high level of R&D than projects with low member diversity. The results also suggest that projects with high data and information complexity are more likely to be successful in quality when they experience a high level of resource allocation innovation than projects with low data and information complexity. In addition, it is evident that construction innovation has stronger effects on cost success for projects with high communication complexity compared to projects with low communication complexity. Finally, R&D has stronger effects on schedule success for projects with high process complexity compared to projects with low process complexity.

While this study offers important insights into the adoption of technological innovation, 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 reexamine the moderating relationship between technological innovation and project success for environmental factors such as salary, job satisfaction, working hours, information availability, time availability, team relationship, and project duration.

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