JOURNAL OF CIVIL ENGINEERING AND MANAGEMENT
ISSN 1392-3730 / eISSN 1822-3605
2016 Volume 22(7): 936–943
doi:10.3846/13923730.2014.929023

INFORMATION PLATFORM TO IMPROVE TECHNOLOGICAL INNOVATION CAPABILITIES: ROLE OF CLOUD PLATFORM

Li-Ren YANG[a], Chung-Fah HUANG[b]

[a]*Department of Business Administration, Tamkang University, 151 Ying-chuan Rd., Tamsui, 251 Taipei, Taiwan*
[b]*Department of Civil Engineering, National Kaohsiung University of Applied Sciences, 415 Chien-Kung Rd., 807 Kaohsiung, Taiwan*

Received 25 Sep 2013; accepted 22 May 2014

Abstract. Conceptualizing technological innovation capabilities and cloud platform implementation in the construction management context is still rudimentary. The primary objective of this study was to validate a model for assessing the relationships among information platform usage, technological innovation capabilities, and capital facility project performance. This study also evaluated the moderating role of type of platform in the relationships. This study empirically investigated a sample of projects in the Taiwanese construction industry. The structural equation modeling (SEM) approach was used to validate the research model. In testing the moderation effect, two-way analysis of variance (ANOVA) was used. The findings indicate that implementation of information platform contrubutes significantly to technological innovation capabilities. In addition, these analyses suggest that technological innovation capabilities have a positive effect on project performance. The results also show that the relationship between information platform usage and technological innovation capabilities depends on type of platform (i.e., traditional or cloud-based information management platform). This indicates that the association between technological innovation capabilities and project performance is more strongly evident for projects that use cloud platform.

Keywords: information platform, cloud platform, technological innovation capabilities, project performance.

Introduction

Innovations in technology have changed the way project activities are performed. Cloud computing is one of the most popular trends in information technology (IT). It is the latest paradigm of information technology and substantially influences the IT landscape. In the wake of the economic slowdown, organizations are increasingly looking for ways to do more with the same resources; articulate differently – to make every penny, input and contribution count (Ouf, Nasr 2011). In such situations, cloud computing is becoming increasingly important in gaining and maintaining a competitive edge (Ouf, Nasr 2011). Thus, cloud-based information management platform is the new way to create new project processes, to enhance the base of knowledge available to a project team, and to improve coordination, communication, and cooperation among team members. Rather than implementing expensive and complex software on-site, the cloud-based information management platform runs in the cloud.

No previous studies have empirically analyzed the effects of cloud platform implementation on project performance. Due to this deficiency, this study attempted to evaluate the association between implementation of cloud platform and project performance. Previous studies suggested that IT adoption has a positive effect on technological innovation capabilities, which is an important factor influencing project performance (Pavlou, Sawy 2006). Thus, the primary purpose of this study was to examine the effects of implementation of information platform on technological innovation capabilities, and then on project performance. Moreover, previous studies implied that type of technology plays an important role in the relationship between technology usage and technological innovation capabilities. Thus, the second objective of the study was to assess the moderating role of type of platform (traditional vs. cloud-based information management platform) in the relationship between information platform usage and project performance. Based on previous studies (Zandhessami *et al.* 2012; Radujković *et al.* 2010; Hewage *et al.* 2008; Ouf, Nasr 2011), the following hypotheses are proposed:

H1: Information platform usage positively influences projects' levels of technological innovation capabilities.

Corresponding author: Li-Ren Yang
E-mail: *iry@mail.tku.edu.tw*

Copyright © 2016 Vilnius Gediminas Technical University (VGTU) Press
www.tandfonline.com/tcem
Taylor & Francis
Taylor & Francis Group

H2: Technological innovation capabilities positively influence capital facility project performance.
H3: Information platform usage has a positive effect on capital facility project performance.
H4: The association between information platform usage and technological innovation capabilities is more strongly evident for project that use cloud platform.

1. Methodology

1.1. Research instrument

The survey instrument was developed to measure implementation of information platform and capital facility project performance 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) information platform implementation; 2) technological innovation capabilities; 3) project performance; and 4) project and personal information. With respect to project information, the projects were classified according to four project characteristic related variables: type of platform, owner regulation, industry section, and number of core team members (team size). These variables are defined as follows (Müller, Turner 2007): 1) Type of platform – the survey investigated type of information platform used in the project: traditional or cloud-based information management platform; 2) Owner regulation – this variable allowed researchers to distinguish private projects from public projects; 3) Industry sector – building, industrial, or infrastructure; 4) Number of core team members – five optional responses were provided: <6, 6–10, 11–20, 21–30, and >30. In addition, this section also obtained information about total installed cost and project duration. Regarding personal information, the survey investigated the respondents' profile including group involvement (Architect/Engineering, Owner, or General Contractor), role in the project, years of experience, education, and number of project involvement.

1.2. Sampling method and sample description

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 between April 2013 and June 2013. The data collection tool was developed to collect project-based data. The targeted respondents were identified as the senior individuals who were familiar with implementation of information platform, technological innovation capabilities, and project performance. 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 online surveys. The projects were examined to ensure that no duplicate project information was collected. Ultimately, 158 survey responses were used in the analysis. Table 1 presents characteristics of sampled projects. In addition, profile of respondents is shown in Table 2.

1.3. Survey design and construct measurement

The items used to measure implementation of information platform were based on Cooper and Kleinschmidt (1993). This study evaluated implementation of information platform in three important project phases: project planning and evaluation, project design, and project

Table 1. Characteristics of sampled projects

Characteristic	Class	Number	Percent of projects
Type of platform	Cloud-based information platform	57	36.1
Type of platform	Traditional information platform	101	63.9
Owner regulation	Public	77	48.7
Owner regulation	Private	78	49.4
Owner regulation	Build–operate–transfer (BOT)	3	1.9
Industry sector	Infrastructure	47	29.7
Industry sector	Building	76	48.1
Industry sector	Industrial	35	22.2
Total installed cost	<1.67 million	79	50.0
Total installed cost	1.67–3.33 million	19	12.0
Total installed cost	3.33–10 million	34	21.5
Total installed cost	>10 million	24	15.2
Total installed cost	Not available	2	1.3
Project duration	<1 year	5	3.2
Project duration	1–3 years	118	74.7
Project duration	>3 years	35	22.2
Number of team members (team size)	<6	32	20.3
Number of team members (team size)	6–10	78	49.4
Number of team members (team size)	11–20	38	24.1
Number of team members (team size)	21–30	10	6.3

Table 2. Profile of respondents

Variable	Category	Number	Percentage
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

execution. On the other hand, the scales developed by Yam *et al*. (2011) were adapted to evaluate technological innovation capabilities. This study examined the three most important technological innovation capabilities in construction: research and development (R&D) capability, resource allocation capability, and construction capability. Finally, questions from Müller and Turner (2007) were adapted to measure capital facility project performance. The survey questions used to evaluate information platform implementation, technological innovation capabilities, and project performance are presented in Table 3. Each item was rated on a 7-point scale, where 1 represented strongly disagree and 7 represented strongly agree.

Project performance has been widely discussed in the project management literature. Traditional way of measuring project performance is the so-called golden triangle of time, budget, and required quality (Westerveld 2003). However, according to the PMBOK Guide published by the Project Management Institute (PMI), project perfor-

Table 3. Survey items and results of CFA

Construct and item	Standardized factor loading
Information platform usage – Project planning and evaluation (PP)	
PP1: The team used the platform to assist in evaluating the project.	0.793
PP2: The team used the platform to assist in understanding project requirements.	0.919
PP3: The team used the platform to assist in integrating project information.	0.910
Information platform usage – Project design (PD)	
PD1: The team used the platform to assist in designing the project with the owner.	0.774
PD2: The team used the platform to assist in creating project plan.	0.924
PD3: The team used the platform for project design.	0.832
Information platform usage – Project execution (PE)	
PE1: The team used the platform to assist in confirming project requirements with the owner.	Dropped in CFA
PE2: The team used the platform to store information about suppliers and subcontractors.	0.661
PE3: The team used the platform to store information about project schedule.	0.806
PE4: The team used the platform to coordinate construction operations.	Dropped in CFA
PE5: The team used the platform to keep the departments updated on project status.	0.647
Technological innovation capabilities – R&D capability (RD)	
RD1: The team had high quality and quick feedbacks from the owner and Architect/ Engineering.	0.656
RD2: The team had good mechanisms for transferring technology from research to construction.	0.847
RD3: The team had great extent of project feedback into technological innovation process.	0.910
RD4: The team generated innovative ideas for the project.	0.649
Technological innovation capabilities – Resource allocation capability (RA)	
RA1: The team attached importance to human resource.	Dropped in CFA
RA2: The team selected key personnel in each department into the innovation process.	0.678
RA3: The team provided steady capital supplement in innovation activities.	0.743

Continued of Table 3

Construct and item	Standardized factor loading
Technological innovation capabilities – Construction capability (CC)	
CC1: The team had ability in transforming R&D output into construction.	0.841
CC2: The team effectively applied advanced construction methods.	0.810
CC3: The team had capable construction personnel.	0.538
Project performance – Schedule performance (SP)	
SP1: The schedule for each phase of the project was essentially the same as planned.	0.777
SP2: All project assignments were proceeding as planned.	Dropped in CFA
SP3: The project was delivered ahead of schedule.	0.744
Project performance – Cost performance (CP)	
CP1: The cost objectives were met for the project.	Dropped in CFA
CP2: The budget for each phase of the project was essentially the same as planned.	0.947
CP3: The total installed cost of the project was significantly under authorized budget.	0.735
Project performance – Quality performance (QP)	
QP1: The quality objectives were achieved for the project.	Dropped in CFA
QP2: The project deliverables were of high quality.	0.881
QP3: The project's deliverables complied with the contractual requirements.	0.804
Project performance – Safety performance (SA)	
SA1: The project's construction and operation complied with all applicable environmental, health, and safety laws and regulations.	0.807
SA2: The recordable accident rate for this project was low.	Dropped in CFA
SA3: The recordable injury rate for this project was low.	0.731
Overall benefit (OB)	
OB1: The owner was satisfied with the project's deliverables and the project management process.	Dropped in CFA
OB2: The project's overall benefits exceeded owner's expectations.	Dropped in CFA
OB3: The project achieved a successful outcome.	0.982
OB4: The project enhanced the firm's reputation.	0.865

mance criteria shall include the golden triangle and overall benefit of the project (Project Management Institute 2004). Limitations of the traditional way of measuring performance are clearly known and researchers have started to talk about introducing new performance measures (Al-Tmeemy *et al*. 2011). Thus, many studies in the construction field have expanded project performance criteria into safety (Ling *et al*. 2009; Toor, Ogunlana 2010). In addition, Lim and Mohamed (1999) viewed project performance by the use of micro and macro criteria. Their micro criteria included time, cost, quality and safety, and their macro criteria included the micro criteria plus the project project's actual benefit. Thus, project performance was measured by the five dimensions of schedule performance, cost performance, quality performance, safety performance, and overall benefit in this study.

2. Results and analysis

2.1. 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, information platform usage, technological innovation capabilities, and project performance 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 as shown in Figure 1. Furthermore, the composite reliability for all constructs was above the 0.7 level suggested by Hair *et al.* (2006), 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, as shown in Table 3. 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 (Hair *et al.* 2006). 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 (Bagozzi, Phillips 1982). 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.

2.2. Structural model test results

Figure 2 presents results of the overall model fit in the structural model. A feasible model was selected based on the recommended Goodness-Of-Fit (GOF) measures and the model that satisfies both theoretical expectations and GOF was finally selected for structural equation modeling (SEM) analysis. Thus, the model refinement

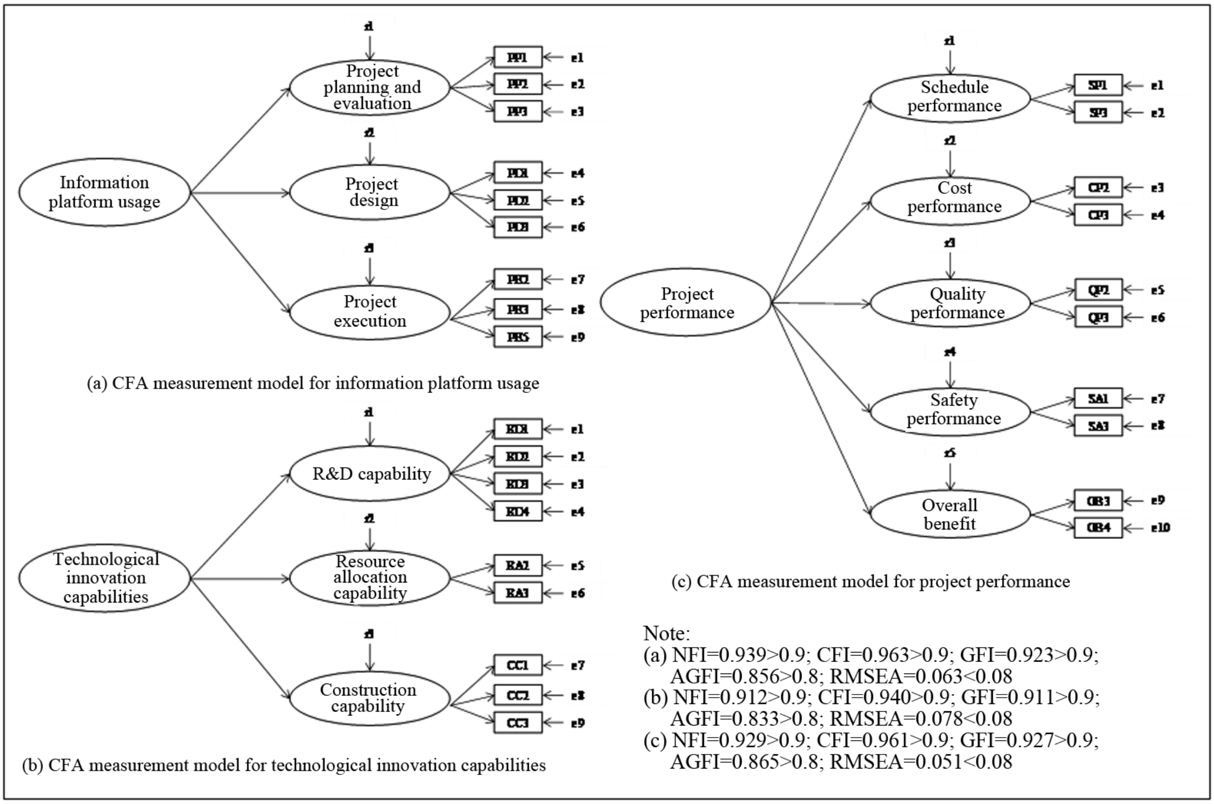

Fig. 1. CFA measurement models

was performed to improve the fit to its recommended levels. Based on several trials resulting in elimination of some of the items (including the items associated with schedule performance and safety performance variables), this model yielded a model fit of NFI = 0.906, CFI = 0.937, GFI = 0.922, AGFI = 0.853, and RMSEA = 0.073. The overall fit statistics indicated a very good fit for the model. Thus, the result supported the hypothesized relationship.

The test of H1, H2, and H3 was based on the direct effects (structural coefficients) among the constructs as shown in Figure 2. H1 proposed a positive relationship between information platform usage and technological innovation capabilities. This hypothesis was supported

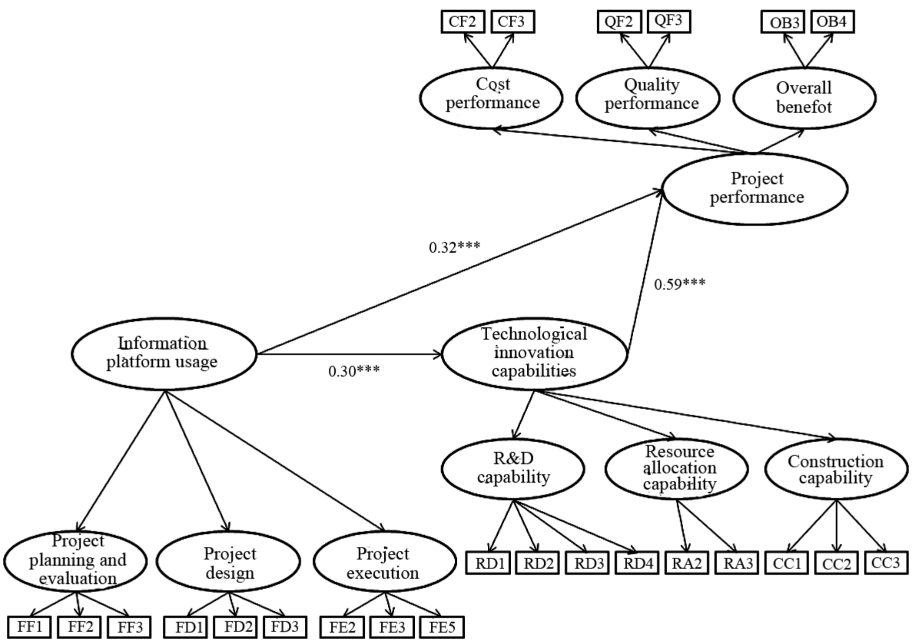

Fig. 2. Research model estimation results

since the standardized coefficient was 0.30 and statistically significant ($p < 0.001$). H2 proposed a positive relationship between technological innovation capabilities and project performance. This hypothesis was supported by a statistically significant structural coefficient of 0.59 ($p < 0.001$). In addition, the direct impact from information platform usage to project performance is significant (coefficient = 0.32; $p < 0.001$), and therefore H3 is supported.

2.3. Testing the moderating effect of type of platform

H4 was concerned with the moderating effects of type of flatform on the relationship between information platform usage and technological innovation capabilities. 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 information platform usage, a K-means cluster analysis was performed on the basis of the three dimensions of information platform usage (i.e. project planning and evaluation, project design, and project execution). The cluster analysis has identified two clusters for information platform adoption, with the cluster mean values of discriminating variables given in Table 4. In addition, the independent-samples *t* tests shown in Table 4 confirms that the variables of information platform usage do significantly differentiate across the two clusters. The first cluster was labeled projects with high levels of information platform usage. The second cluster consists of projects with low levels of information platform usage.

The study revealed two segments for the three information platform usage dimensions. On the other hand, the subject projects were also categorized according to type of platform (traditional or cloud-based information management platform). Thus, to test for the moderating influence of type of platform on the association between information platform usage and technological innovation capabilities, 2 (information platform usage) x 2 (type of platform) analysis of variance (ANOVA) was performed. The two-way ANOVA was utilized to determine the joint effect of information platform usage and type of platform on technological innovation capabilities in terms of R&D capability, resource allocation capability, and construction capability. Table 5 summarizes the results of the ANOVAs. The results suggest a significant interaction of information platform usage (IP) and type of platform (TP) for construction capability ($F = 4.048$, $p < 0.05$).

The findings indicate that type of platform has a moderating effect on the relationship between information platform usage and construction capability. 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. Figure 3 shows the relationship between information platform usage and construction capability for different types of platforms (traditional vs. cloud-based information management platform). The results in Figure 3 demonstrate that projects that use cloud-based information management platform may achieve higher levels of construction capability when they experience high levels of information platform usage than projects that use traditional information management platform. Thus, H4 is supported.

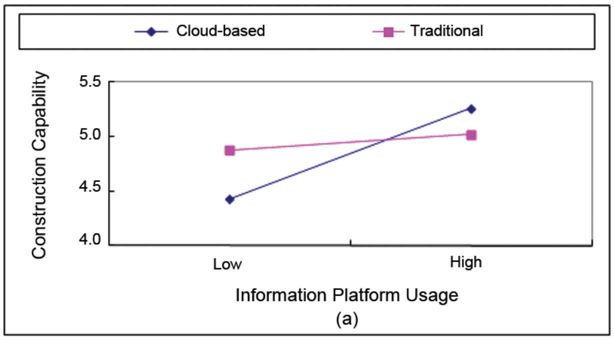

Fig. 3. Moderating effect of type of platform

Table 4. Cluster means of discriminating variables

Variable	Projects with high levels of information platform usage		Projects with low levels of information platform usage		t-statistic	*p*-value
	Number	Mean	Number	Mean		
Project planning and evaluation	116	5.82	42	4.20	10.252	0.000
Project design	116	5.75	42	3.98	11.141	0.000
Project execution	116	5.59	42	4.34	9.986	0.000

Table 5. Results of two-way ANOVAs

Dependent variable	Moderator: type of platform (TP)
R&D capability	1.142
Resource allocation capability	2.236
Construction capability	4.048*

*significant at the 0.05 level.

Conclusions and implications

While the diverse benefits of information technology utilization have received substantial attention, the number of studies dealing with the influence of information platform usage on technological innovation capabilities in construction is rather scarce. Additionally, empirical evidence that supports the benefits of cloud platform adoption is lacking. Thus, developing such support will illustrate the relationships among information platform usage (including traditional and cloud-based information management platform), technological innovation capabilities, and project outcomes. This study attempts to fill the gap in the literature by identifying the role of cloud platform and technological innovation capabilities in the relationship between information platform usage and project performance. On the other hand, this research reveals the importance of implementing cloud platform to enhance technological innovation capabilities. The results offer guides to improve project success and to gain a number of potential benefits to a project. Findings from this study are helpful to project managers in deciding how to adopt cloud platform in a project. Project managers can use the research results to modify their current project management effort and to effectively use IT tools to increase technological innovation capabilities.

The first objective of this study was to validate a model for assessing the relationships among information platform usage, technological innovation capabilities, and project performance. The research findings indicate that adoption of information platform is associated with technological innovation capabilities, which supports H1. The results are in line with previous research (Zandhessami *et al.* 2012), which has shown that information technology plays a crucial role in innovation capability. Additionally, the research findings imply that technological innovation capabilities can improve project performance in terms of cost performance, quality performance, and overall benefit, which supports H2. The positive relationship is in line with previous findings (Radujković *et al.* 2010), which suggested that innovation capability provides benefits for an organization and helps improve performance outcomes. The research results also show that implementation of information platform can enhance project performance, which supports H3. The results are in agreement with prior research (Hewage *et al.* 2008), which recognized technology adoption as a contributor to project performance. In summary, the findings of the research indicate that information platform usage in the project planning and evaluation, project design, and project execution phases can enhance technological innovation capabilities including R&D capability, resource allocation capability, and construction capability and improve project performance in terms of cost performance, quality performance, and overall benefit. Information platform is an effective IT tool that can be used to support project management in construction. In addition, information platform can be employed to incorporate technological innovation capabilities into project management processes. Thus, project managers should effectively use information platform to manage a project.

Moreover, the second objective was to evaluate the moderating role of type of platform in the relationship between information platform usage and technological innovation capabilities. According to the data analysis results, the influence of information platform usage on technological innovation capabilities increases in projects that adopt cloud-based information management platform, due to the moderating effect of type of platform (H4 is supported). In other words, the positive relationship between information platform usage and technological innovation capabilities depends on type of platform (i.e. traditional or cloud-based information management platform). This indicates that the influence of information platform usage on technological innovation capabilities for projects that adopt cloud-based information management platform is more than the same effect in the case of projects that adopt traditional information management platform. The moderating relationship is in line with previous findings (Ouf, Nasr 2011), which implied that the impact of technology on technological innovation capabilities becomes stronger for projects that use cloud platform. In addition, evidence suggests that cloud platform enables convenient and on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Achimugu *et al.* 2012).

This study has several implications for practitioners. This research confirms the importance of adopting cloud platform to improve project performance in terms of cost performance, quality performance, and overall benefit. It is also expected that implementation of cloud platform, particularly in the project planning and evaluation, project design, and project execution phases, contributes significantly to technological innovation capabilities. For project planning and evaluation, cloud platform can be used to assist in evaluating a project and understanding project requirements. It can also be used to assist in integrating project information. To improve project design, cloud platform can be used to assist in designing a project with the owner and creating project plan. In the project execution phase, project teams can use cloud platform to store information about suppliers, subcontractors, and project schedule. In addition, cloud platform can be used to keep different departments updated on project status. On the other hand, the results support that attention should be given to three important types of technological innovation capabilities: R&D capability, resource allocation capability, and construction capability. For enhancing R&D capability, project teams should have high quality and quick feedbacks from the owner and Architect/Engineering and good mechanisms for transferring technology from research to construction. They should also integrate great extent of project feedback into technological innovation process and generate innovative ideas for projects. With respect to improvement in resource allocation capability, project teams must select key personnel in each department into the innovation process and provide steady capital supplement in innovation activities. Regarding increasing construction capability, project teams should involve capable construction personnel and effectively apply advanced construction methods. They also need to develop ability to transform R&D output into construction.

References

Achimugu, P.; Oluwagbemi, O.; Gambo, I. 2012. Solving web-based applications architectural problems in the cloud: the way forward, *International Journal of Information Technology and Computer Science* 4(5): 8–15. http://dx.doi.org/10.5815/ijitcs.2012.05.02

Al-Tmeemy, S. M. H. M.; Abdul-Rahman, H.; Harun, Z. 2011. Future criteria for success of building projects in Malaysia, *International Journal of Project Management* 29(3): 337–348. http://dx.doi.org/10.1016/j.ijproman.2010.03.003

Bagozzi, R. P.; Phillips, L. W. 1982. Representing and testing organizational theories: a holistic construal, *Administrative Science Quarterly* 27(3): 459–489. http://dx.doi.org/10.2307/2392322

Cooper, R. G.; Kleinschmidt, E. J. 1993. Uncover the keys to new product success, *Engineering Management Review* 11(4): 5–18.

Hair, J. F.; Black, W. C.; Babin, B. J.; Anderson, R. E.; Tatham, R. L. 2006. *Multivariate data analysis*. 6th ed. Upper Saddle River, New Jersey: Prentice-Hall. 816 p.

Hewage, K. N.; Ruwanpura, J. Y.; Jergeas, G. F. 2008. IT usage in Alberta's building construction projects: current status and challenges, *Automation in Construction* 17(8): 940–947. http://dx.doi.org/10.1016/j.autcon.2008.03.002

Lim, C. S.; Mohamed, Z. M. 1999. Criteria of project success: an exploratory re-examination, *International Journal of Project Management* 17(4): 243–248. http://dx.doi.org/10.1016/S0263-7863(98)00040-4

Ling, F. Y. Y.; Low, S. P.; Wang, S. Q.; Lim, H. H. 2009. Key project management practices affecting Singaporean firms' project performance in China, *International Journal of Project management* 27(1): 59–71. http://dx.doi.org/10.1016/j.ijproman.2007.10.004

Müller, R.; Turner, J. R. 2007. Matching the project manager's leadership style to project type, *International Journal of Project Management* 25(1): 21–32. http://dx.doi.org/10.1016/j.ijproman.2006.04.003

Ouf, S.; Nasr, M. 2011. The cloud computing: the future of BI in the cloud, *International Journal of Computer Theory and Engineering* 3(6): 750–754. http://dx.doi.org/10.7763/IJCTE.2011.V3.404

Pavlou, P. A.; Sawy, O. E. 2006. From IT leveraging competence to competitive advantage in turbulent environments: the case of new product development, *Information Systems Research* 17(3): 198–227. http://dx.doi.org/10.1287/isre.1060.0094

Project Management Institute. 2004. *A guide to the Project Management Body of Knowledge (PMBOK Guide)*. 3rd ed. Newtown Square, Pennsylvania: Project Management Institute. 459 p.

Radujković, M.; Vukomanović, M.; Dunović, I. B. 2010. Application of key performance indicators in South-Eastern European construction, *Journal of Civil Engineering and Management* 16(4): 521–530. http://dx.doi.org/10.3846/jcem.2010.58

Toor, S.; Ogunlana, S. O. 2010. Beyond the 'iron triangle': stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects, *International Journal of Project Management* 28(3): 228–236. http://dx.doi.org/10.1016/j.ijproman.2009.05.005

Westerveld, E. 2003. The Project Excellence Model®: linking success criteria and critical success factors, *International Journal of Project Management* 21(6): 411–418. http://dx.doi.org/10.1016/S0263-7863(02)00112-6

Yam, R. C. M.; Lo, W.; Tang, E. P. Y.; Lau, A. K. W. 2011. Analysis of sources of innovation, technological innovation capabilities, and performance: an empirical study of Hong Kong manufacturing industries, *Research Policy* 40(3): 391–402. http://dx.doi.org/10.1016/j.respol.2010.10.013

Zandhessami, H.; Parvinchi, S.; Molaei, Z. 2012. Identification and prioritization of technology innovation capability on technology innovation performance, *International Journal of Economics and Management Sciences* 1(6): 13–20.

Li-Ren YANG. Professor of Business Administration at Tamkang University. He received his Doctoral degree from the University of Texas at Austin. His research interest is on project/construction management.

Chung-Fah HUANG. Associate Professor of Civil Engineering at National Kaohsiung University of Applied Sciences. He received his Doctoral degree from National Central University, Taiwan. His research interests include human resource management in construction, engineering ethics, and outsourcing management.