The influence of early stage project performance: Some project performance and outcome correlate

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Abstract

Understanding how project-management performance in the early stage affects project outcomes is critical to project decision-making process. Our study contributes by revealing how different constructs of project performance are interrelated before the construction phase of a project, and how they will impact project outcomes. Drawing on theories of project and organization management, we develop a project performance-causality model. Our research results suggest that the outcomes of completed projects are significantly directly related to the performance of project innovation and quality in the early stage of project delivery process (i.e., before project construction). Succeeding analysis reveals that communication performance before project construction indirectly affects project performance, which has the largest effect on project outcomes. The research findings indicate that it is practical to estimate marginal project outcomes quantitatively prior to project construction.

Keywords
Project outcomes, early stage performance, Survey research, Longitudinal study

1. Introduction

Whilst the modern corporate business environments have been characterized by ever-increasing challenges and economy globalization, managers have been utilizing innovative technologies and strategies to accomplish and maintain competitive edges (Chan and Qi, 2003). While project management, a strategic competency for organizations, is to apply skills, knowledge, and techniques for performing projects effectively, successful project management that efficiently achieves the project on time, on budget, and within specifications to the project stakeholders' stratification is treated as key to developing a sustainable competitive edge (Project Management Institute, 2013). Naturally, a volume of researchers and practitioners have performed numerous studies to identify the influential factors of project success.

For instance, Song et al. (2007) concludes from analyzing two R&D projects that the initial planning conditions and the effective performance of front-end planning management impact how well R&D plans and the subsequent R&D processes perform. Schwab and Anne (2008) employ regression analysis to study 239 movie projects from 1931 to 1940 and conclude that project outcomes are contingent upon the perceived relevance of preceding performance and upon organizational control on project participants.

Furthermore, based on a sample of 56 capital projects executed by 15 Fortune 500 process-industry corporations in North America, Europe, and Asia-Pacific, Scott-Young and Samson (2008) investigate the effects of project team process, project team design, project team leadership, and organizational context variables on capital project outcomes using regression analysis. They discover that project incentive, project leadership, and cross-functional project team factors are the strongest predictors of project outcomes.

Shepherd et al. (2011) utilze regression analysis technique to investigate how negative emotions and affective commitments due to project failure affect the performance of subsequent projects. Using the data collected from 257 research scientists with respect to project teams in 12 different German research institutes, they find that emotions as outcomes may affect emotions as inputs for succeeding projects; in other words, the negative emotions of past project failures generate affective commitments to the organization.

Recently, Patanakul et al. (2016) employ regression analysis to examine the data collected from 144 project team members from four companies that conduct business in construction, manufacturing, and information technology in North America, their results demonstrate that project team support and learning opportunity are significant factors of the motivation to perform well in a multiple-project environment.

More recently, Chen and Lin (2018) study the complex relationships among leader-leader exchange, trust among team members, goal orientations, and project outcomes. They, by utilizing structural equation modeling (SEM) techniques to analyze 320 auditing project managers/leaders from 50 accounting service firms, find that trust and leader-leader exchange partially mediate the effects of team goal orientations on project outcomes. They also find that trust moderates the relationship between leader-leader exchange and project outcomes.

However, despite extensive research examining and identifying the key factors of project performance, they mostly (e.g., Hoegl and Gemuenden, 2001; Hoegl et al., 2003; Chen and Lin, 2018) concentrate on delineating project performance and the input attributes that influence the performance. Relative little reserach examines structural causal relationships among project-management performance variables, and thus with capital-project outcomes. (A capital project is a project where its cost is capitalized. The common examples of capital projects are commercial and institutional buildings, industrial facilities, and residential buildings.)

Although some research (e.g., Chen, 2014; Chen and Lin, 2018) does investigate structural causality among project-management performance variables, their research design is comtemporaneous. Consequently, there seems to be short of research employing longitudinal experiments to examine how one factor influences another and thus, estimate the marginal effects of each factor on project outcomes before project construction.

Modeling longitudinal causality for project performance is essential, as it enables managers to estimate marginal project outcomes (MPOs) early in the project life cycle, providing a comprehensive picture of how changes in a performance construct before project construction affect the outcomes of a capital project at closing. (We define marginal project outcome (MPO) as change in per percentage of a construct (determinant) resulting in change in project performance at completion.)

2. Hypotheses

Now the question is, how do we quantitatively estimate the impact of change in a construct on capital-project outcomes prior to the project construction phase?

To answer this question, we propose several hypotheses based on the ideal that project performance in the project-initiating and planning phases affects not only one another, but project outcomes in the closing phase. Specifically, executing a project involving many specialists to perform related tasks in order to accomplish the project objectives demands effective communication among the specialists (Blankevoort, 1984). Not surprisingly, prior research (e.g., Adenfelt, 2010) finds that communication quality influences project performance. The reason is apparent: communication boosts knowledge sharing and hence project performance. Therefore, our hypotheses are proposed as follows:

Hypothesis 1: The performance of innovation of capital projects is related directly to communication performance before the construction phase of the capital projects.

Hypothesis 2: The performance of team of capital projects is related directly to communication performance before the construction phase of capital projects.

Hypothesis 3: The performance of scope of capital projects is related directly to communication performance before the construction phase of the capital projects.

Research has long recognized that team quality is an influential variable in corporate business performance (Keller, 1994). For example, Schippers et al. (2012) employ regression analyses to investigate how team reflexivity influences innovation performance. Using 98 primary health care teams (PHCTs) across 19 health authorities in the English National Health Service, they find that innovation performance is enhanced as team's work quality improves.

Subsequent work by Aronson et al. (2013) examines 60 U.S. technology-driven projects and suggests, using regression analysis, that emphasizing equality, open communication, and cooperation among team members improves quality performance. Thus, our hypotheses are:

Hypothesis 4: The performance of innovation of capital projects is related directly to team performance before the construction phase of capital projects.

Hypothesis 5: The performance of risk of capital projects is related directly to team performance before the construction phase of capital projects.

Hypothesis 6: The performance of quality of capital projects is related directly to team performance before the construction phase of capital projects.

Hypothesis 7: The performance of scope of capital projects is related directly to team performance before the construction phase of capital projects.

Defining a project's scope is a process by which managers outline and prepare a project for construction (Chen, 2013; Dumont et al., 1997). Whilst a project scope is a detailed formulation of a continuous strategy throughout a project to accomplish the objectives of projects, defining the scope is one of the primary tasks at the early stage in the project life cycle. A deficiently defined project scope could trigger substantial changes and rework, resulting in lower productivity and work quality (Dumont et al. 1997). Hence, we propose that quality is related to project scope prior to construction phase.

Hypothesis 8: The performance of quality of capital projects is related directly to scope performance before the construction phase of capital projects.

Further, while the research work by De Bakker et al. (2010) shows an inconclusive result about the impact of project risk management on the quality of projects, a more widespread consensus among researchers and practitioners is that effect risk management meaningfully increases the quality of projects. Additionally, the Project Management Knowledge Areas and Project Management Processes (PMBOK) of the Project Management Institute (PMI) includes risk management as one of the critical knowledge areas of the management of projects. We therefore hypothesize that effective risk management directly enhances project quality prior to the construction phase of a project.

Hypothesis 9: The performance of quality of capital projects is related directly to risk performance before the construction phase of capital projects.

Recent research indicates that innovative behavior and knowledge increase the effectiveness of risk management (Chen, 2014; Koelling et al., 2010; Zipperer and Amori, 2011). For instance, based on a sample of 80 service innovators from Germany, Koelling et al. (2010) suggest that management should create proactive organizational environments to stimulate innovative behavior and responses for uncertainty and challenges. Based on a systematic review of literature in the field of risk management, Zipperer and Amori (2011) conclude that innovative knowledge-sharing improve the effectiveness of risk management. We therefore hypothesize that innovation directly enhances risk performance prior to the construction phase of a project.

Hypothesis 10: The performance of risk of capital projects is related directly to innovation performance before the construction phase of capital projects.

In particular, whilst extensive research has been performed to investigate the relations between innovation and temporary organizations (i.e., projects), some research has demonstrated that innovation enhances project performance (Chen, 2013, 2014). For instance, using regression analysis to examine the data collected from 80 surveys (with R&D project managers and leaders) and 18 interviews (with top managers), Biedenbach and Müller (2012) find that innovative capability enhances innovation, which results in better project performance in both short- and long-term perspective. We therefore predict that innovation prior to the construction phase of a project affects project outcomes.

Hypothesis 11: The outcomes of capital projects are directly related to innovation performance before the construction phase of a capital project.

Furthermore, whilst quality planning begins in the initiating phase of a project, effective management of quality assures that the project will be able to meet its contract requirements. As might be expected, effective quality management has become one of the most frequently studied project-performance variables (e.g., Chen, 2013; Ling et al., 2009). Therefore, we expect that quality performance prior to the construction phase of a project affects project outcomes.

Hypothesis 12: The outcomes of capital projects are directly related to quality performance before the construction phase of a capital project.

3. Research Methodology

3.1 Participants

The sampling frame was Taiwan's Chinese National Association of General Contractors. In total, 128 firms participated. There were two phases in the collection of data that lasted two years. The first phase took place right after the end of the initiating and planning phases of a capital project, participants (project managers and/or leaders) responded to all the survey questions except those regarding project actual costs, project actual durations, and costs and durations for project changes. The second phase occurred immediately subsequent to the termination of the capital project, participants answered to the questions that were excluded in the first phase.

The survey instrument is composed of two sections. Section one comprises open-ended questions that collect background information such as company revenues and project types. Section two is composed of multiple-choice questions where participants mark on a 5-point Likert scale in which one indicates "strongly disagree" and five indicates "strongly agree." High and low scores imply good and poor performance, respectively.

3.2 Measures and Analysis

Communication is measured by using a six-item scale that is based on the representative research, including Bendoly and Swink (2007), Chen (2013), and Oke and Idiagbon-Oke (2010). The sample items are "C1: Our team is able to identify the key stakeholders of the project," and "C3: Our team is able to meet the stakeholders' communications requirements."

Team is measured by using a twelve-item scale that is based on the representative research, including Bendoly and Swink (2007), Hoegl and Parboteeah (2007), Hoegl et al. (2003), Ling et al. (2009), Scott-Young and Samson (2008), Song et al. (2007), and Tabassi and Bakar (2009). The sample items are "T1: The support from top management of the organization to the project team is high," and "T3: We clearly define each team member's project role, responsibilities, and rights."

Scope is measured by using a four-item scale that is based on the representative studies, including Dumont et al. (1997), and Ling et al. (2009). The sample items are "S1: Quality of contract documents is good," and "S3: The extent of project scope is well verified by the project owner."

Innovation is measured by using a ten-item scale that is based on the representative studies, including Kazanjian et al. (2000), Keller (1994), Prajogo and Ahmed (2006), and Song et al. (2007). The sample items are "I1: The support for innovation from top management is high," and "I3: Our team members have diverse skills and knowledge."

Risk is measured by using a seven-item scale that is based on the representative studies, including Chen (2013), and El-Sayegh (2008). Sample items include "R1: Our project team is able to deal with customer design changes well," an "R3: Our project team is able to cope with lack of or departure of qualified staff well."

Quality is measured by using a four-item scale that is based on the representative studies, including Ling et al. (2009), and Chen (2014). The sample items include "Q1: Quality-management plan is able to clearly describe how quality assurance will be executed," and "Q3: Quality checklist is able to verify that a set of required steps is complete."

To compare with the *Communication*, *Team*, *Scope*, *Innovation, Risk*, and *Quality* of data collected using a 5-point Likert scale prior to the construction phase, we use percentile ranks to categorize project time performance and project cost performance in the closing phase. The data from the closing phase measures capital-project outcomes on a 5-point scale using the computed values of *Time* and *Cost* from the 128 sample projects. The computation formulas are as follows:

Time = Estimated Time/Actual Time (1)

Cost = Estimated Cost/Actual Cost (2)

where the estimated time and estimated cost include the additional estimated time, and additional estimated cost due to changes in project scope, respectively.

Our methodology to examine the hypotheses and estimate their quantitative impact on project performance involves two steps. In the first step, we will develop a project-management performance measurement model using the confirmatory factor analysis (Harrington, 2008). In the second step, based on the measurement model, we employ the structural equation modeling technique (Kline, 2010) to examine and the hypotheses and hence, quantify the impact of the project-management performance constructs on project performance.

4. Results

The performance-measurement model for projects includes the *Communication*, *Team*, *Scope*, *Innovation, Risk*, *Quality*, and *Project Outcomes* constructs, which correlate with all other constructs. Analysis of the overall measurement model suggests an adequate fit with the data. (Several constructs' item scales (measures) are deleted for the purpose of refining the measurement model.) The value of the model chi-square (χ^2)/degrees of freedom (DF) is 1.685 that is smaller than 2.000 suggested by Lee, 2007; the values of CFI and TLI are 0.965 and 950, respectively, which are both higher than 0.900 suggested by Bentler (1990); and the value of RMSR is 0.031 and the value of the root mean square error of approximation (RMSEA) is 0.073 that are both less than the respective values of 0.100 and 0.080 (Kline, 2010; Lee, 2007).

Since the overall measurement model suggests an adequate fit with the data, we therefore test the hypothesized model (Figure 1) using SEM (Kline, 2010; Lee, 2007). The model-fit indices suggest that the model fits the data adequately, where the value of the model χ^2/DF is 1.721, the CFI value is 0.961, the TLI value is 0.947, the RMSR value is 0.045, and the RMSEA value is 0.076. This non-significant increase in the relative χ^2 from 1.685 to 1.760 is strongly suggestive of model validity (Kline, 2010).

Figure 1 reports the test results of our 12 hypotheses and their structural relationships. Of these 12 hypotheses, six hypotheses are significant at the $P< .001$ level, four hypotheses are significant at the $P< .050$ level, and two hypotheses are mildly significant at the $P< .150$ level. Hypotheses 1 to 3 deduce that communication performance possesses a direct effect on project innovation, project team, and project scope performance, which are all significant at the $P< .001$ level. The respective path coefficients that connect *Communication* to *Innovation*, *Team*, and *Scope* are 0.68, 0.90, and 0.54.

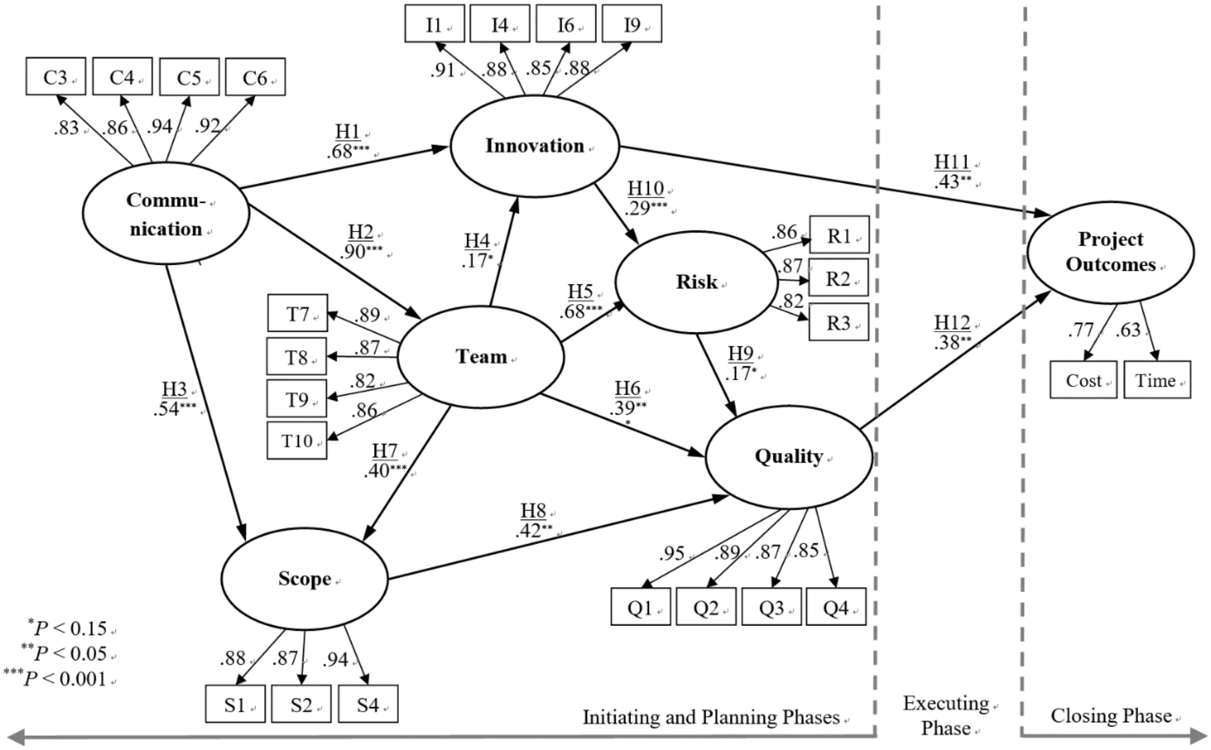

Figure 1. Capital project performance causality-model

Namely, *Communication* possesses a direct effect of 0.68 on *Innovation* performance before the construction phase of capital projects; it possesses a direct effect of 0.90 and 0.54 on *Team* and *Scope*, respectively. In addition, parameter estimates using the maximum likelihood estimation method find the indirect effects of *Communication* on *Innovation*, *Scope*, *Risk*, *Quality*, and *Project Outcomes* are 0.16, 0.36, 0.85, 0.88, and 0.70, respectively, as shown in Table 1, where the respective DE, IE, and TE denote direct effect, indirect effect, and total effect. Together, the total effects (i.e., combining direct and indirect effects) of *Communication* on *Team*, *Innovation*, *Scope*, *Risk*, *Quality*, and *Project Outcomes* (Table 4) are 0.90, 0.84, 0.90, 0.85, 0.88, and 0.70, respectively.

Table 1. Direct, indirect and total cause-effects

Variable	Communication			Team			Innovation			Scope			Risk			Quality		
	DE	IE	TE	DE	IE	TE	DE	IE	TE	DE	IE	TE	DE	IE	TE	DE	IE	TE
Team	0.90		0.90															
Innovation	0.68	0.16	0.84	0.17		0.17												
Scope	0.54	0.36	0.90	0.40		0.40												
Risk		0.85	0.85	0.68	0.05	0.73	0.29		0.29									
Quality		0.88	0.88	0.39	0.30	0.69		0.05	0.05	0.42		0.42	0.17		0.17			
Project Outcomes		0.70	0.70		0.34	0.34	0.43	0.02	0.45		0.16	0.16		0.07	0.07	0.38		0.38

Hypotheses 4 to 7 deduce that the performance of team possesses a direct effect on the project innovation, project risk, project quality, and project scope performance. We find the linkage mildly significant at the $P<.15$ level (Hypothesis 4), significant at the $P<.001$ (Hypotheses 5 and 7), and significant at the $P<.05$ level (Hypothesis 6). The path coefficients that connect *Team* to *Innovation*, *Risk*, *Quality*, and *Scope* are 0.17, 0.68, 0.39, and 0.40, respectively. Specifically, *Team* possesses a direct effect of 0.17 on

Innovation performance before the construction phase of projects, and a direct effect of 0.68, 0.39, and 0.40 on *Risk*, *Quality*, and *Scope* performance, respectively. Parameter estimates using the maximum likelihood estimation method (Table 4) reveal the indirect effects of *Team* on *Risk*, *Quality*, and *Project Outcomes* are 0.05, 0.30, and 0.34, respectively. Collectively, the total effects of *Team* on *Innovation*, *Scope*, *Risk*, *Quality*, and *Project Outcomes* (Table 4) are 0.17, 0.40, 0.73, 0.69, and 0.34, respectively.

Tests of hypotheses 8 to 10 find that scope affects quality (significant at the P<..05 level), risk affects quality (mildly significant at the P<.15 level), and innovation affects risk (significant at the P<.001 level). The corresponding path coefficients that link *Scope* to *Quality*, *Risk* to *Quality*, and *Innovation* to *Risk* are 0.42, 0.17, and 0.29. That is, *Scope* has a direct effect of 0.42 on *Quality* before the construction phase of capital projects. Likewise, *Risk* on *Quality* is 0.17, and *Innovation* on *Risk* is 0.29.

Parameter estimates using the maximum likelihood estimation method (Table 4) find that the corresponding indirect effects of *Scope* and *Risk* on *Project Outcomes* are 0.16 and 0.07, and the respective indirect effects of *Innovation* on *Quality* and *Project Outcomes* are 0.05 and 0.02. Jointly, the total effects of *Scope* on *Quality* and *Project Outcomes* are 0.42 and 0.16, respectively. Likewise, *Risk* on *Quality* and *Project Outcomes* are 0.17 and 0.07, respectively; *Innovation* on *Risk*, *Quality*, and *Project Outcomes* are 0.29, 0.05, and 0.45, respectively.

Tests of hypotheses 11 to 12 find that innovation and quality both influence project outcomes (both are significant at the P<.05 level). The respective path coefficients that connect *Innovation* to *Project Outcomes* and *Quality* to *Project Outcomes* are 0.43 and 0.38. Specifically, *Innovation* before the project construction phase possesses a direct effect of 0.43 on *Project Outcomes*, and likewise, *Quality* on *Project Outcomes* is 0.38. *Innovation* produces an indirect effect of 0.02 (Table 4) on *Project Outcomes*, *Quality* does not have any indirect effect on *Project Outcomes*. The total effects of *Innovation* and *Quality* on *Project Outcomes* are 0.45 and 0.38, respectively.

5. Discussion

The research findings with respect to the importance of the relationships among *Communication*, *Team*, *Scope*, *Innovation, Risk*, *Quality*, and *Project Outcomes* are consistent with prior studies of the project-construction phase and the overall project life cycle. For example, the test results for hypotheses 1 to 3 show that communication performance possesses a direct effect on a project's innovation, team, and scope performance prior to the construction phase. This is consistent with previous studies of the overall project life cycle (e.g., Adenfelt, 2010).

The test results for hypotheses 4 to 7 reveal that team performance possesses a direct effect on a project's innovation, risk, quality, and scope performance prior to the construction phase, which is consistent with previous studies of the project-construction phase (e.g., Hoegl and Parboteeah, 2007; Keller, 1994; Tabassi and Bakar, 2009) and the overall project life cycle (e.g., Bendoly and Swink 2007; Chen, 2014). The test results for hypothesis 8 show that scope performance also possesses a direct effect on the quality of the project prior to the construction phase, which is consistent with previous studies of the overall project life cycle (e.g., Chen, 2014; Dumont et al., 1997). Similarly, the results for hypothesis 9 are consistent with previous studies (e.g., Chen, 2013); the results for hypothesis 10 are consistent with previous studies, too (e.g., Koelling et al., 2010; Zipperer and Amori, 2011).

The test results for hypotheses 11 and 12 link innovation and quality performance prior to the construction phase to project outcomes in the closing phase. These test results are consistent with prior studies of the overall project life cycle, which conclude that better innovation management increases the chances of project success (e.g., Chen, 2014; Oke and Idiagbon-Oke, 2010) and that effective quality management enhances the chances of project success (e.g., Ling et al. 2009).

Further, previous studies (e.g., Calamel et al., 2012; Hoegl and Gemuenden, 2001; Hoegl et al., 2003; Keller, 1994) concentrating on dipicting project performance and the input attributes that would influence the performance. Few studies examine structural causality among performance variables using longitudinal data. The proposed research model shown in Figure 1 offers structural causality for the performance variables, helping management estimate MPOs in the early stage of the project delivery process.

For instance, during the initiation and planning phases of a project (please see the TE column in Table 4), a 1% performance increase in *Communication* produces respective 0.90%, 0.84%, 0.90%, 0.85%, and 0.88% performance increases in *Team*, *Innovation*, *Scope*, *Risk*, and *Quality*. A 1% performance increase in *Team* results in 0.17%, 0.40%, 0.73%, and 0.69% performance increase in *Innovation*, *Scope*, *Risk*, and *Quality*, respectively. A 1% performance increase in *Innovation* results in 0.29% and 0.05% performance increase in *Risk* and *Quality*, respectively; and a 1% performance increase in *Risk* results in 0.17% performance increase in *Quality*.

The MPOs of *Communication*, *Team*, *Innovation*, *Scope*, *Risk*, and *Quality* (please see the TE column of the Project Outcomes row in Table 4) are 0.70, 0.34, 0.45, 0.16, 0.07, and 0.38, respectively. This indicates that a 1% performance increase in *Communication* before the construction phase produces 0.70% performance increase in *Project Outcomes*. Similarly, 1% increases in *Team*, *Innovation*, *Scope*, *Risk*, and *Quality* create 0.34%, 0.45%, 0.16%, 0.07%, and 0.38% increases in *Project Outcomes*, respectively.

In particular, *Communication* possesses an MPO of 0.70, the highest among the variables, despite having no direct effect on *Project Outcomes*. This finding suggests that the project-performance chain may generate synergistic interaction effects that magnify the overall effects on the outcome variables.

Further, the proposed model gives managers a range of *Project Outcomes* measured by time and cost performance. By using the percentile ranks of *Project Outcomes* measured by completed time and cost performance (as shown Table 1), our causality model provides a way to estimate quantitative MPOs in relation to time and cost prior to project construction. As such, this study provides a direct benefit to both researchers and practitioners.

6. Conclusion

In sum, this research develops a capital project performance-causality model. The test results with respect to the importance of *Communication*, *Team*, *Scope*, *Innovation, Risk*, and *Quality* to *Project Outcomes* are consistent with prior studies of the project-construction phase (e.g., Chen, 2014; Chen and Lin, 2018; Hoegl and Parboteeah, 2007; Keller, 1994; Tabassi and Bakar, 2009) and overall project life cycle (e.g., Chen, 2014; Bendoly and Swink, 2007). The performance-causality model not only offers understandings of how project-management performance variables (such as scope, communication, risk and innovation) affect one another in the project delivery process's early stage , but also provides a method to compute MPOs before project construction. Namely, our research expands the comprehension of how project-management performance variables in the early stage of project delivery process influences project outcomes.

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