Early Project-Management Performance and Project Outcomes Correlate

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Abstract

Using 128 capital projects and a longitudinal design, this study finds a correlation between performance variables in the project-initiating and planning phases and project outcomes in the closing phase. Specifically, this study's structural model suggests that team and risk performance prior to project execution have a direct positive effect on project outcomes in the closing phase. Subsequent analyses show that team and communication performance prior to project execution possess the largest and second-largest effects on project outcomes, respectively. Our findings extend the current state of knowledge concerning not only the relationships among performance variables prior to project execution, but how these performance variables affect project outcomes in the closing phase.

Keywords
Project management; Project performance; Decision analysis; Capital project construction; Structural analysis

1. Introduction

Successful project management largely depends on identifying the critical determinants of project performance (Chen, 2013), and extensive research examines and identifies a wide variety of measures that describe or affect performance (e.g., Hoang and Rothaermel, 2005; Keller, 1994; Schippers et al., 2014). Some studies focus on the importance of the execution phase on project-management performance and identify the critical factors associated with that phase (e.g., Hoegl and Parboteeah, 2007; Keller, 1994; Tabassi and Bakar, 2009). Others emphasize the overall project life cycle (e.g., El-Sayegh, 2008; Ling et al., 2009; Oke and Idiagbon-Oke, 2010, Scott-Young and Samson, 2008).

Despite the panoply of studies into which factors affect project performance (e.g., El-Sayegh, 2008; Oke and Idiagbon-Oke, 2010; Scott-Young and Samson, 2008), most studies (e.g., Haas, 2006; Keller, 1994; Ling et al., 2009; Schwab and Anne, 2008) focus on describing project performance and the input characteristics that affect the performance. Few investigate structrual causal relationships among performance variables and, hence, with project outcomes.

Therefore, the objective of this study is to develop a structural model that provides quantitative assessment of project-management performance' impacts on project outcomes. The rest of the paper is organized as follows. "Research background" reviews related studies, "Hypotheses" delineates the test hypotheses, "Research methodology" describes the sample collection and presents the research methodology, and "Research results" depicts the statistical tests and model building. "Discussions" discusses the implications of the research results. "Conclusion" presents the research summary and conclusions.

2. Research Background

A central task in the study of project management is to identify the critical determinants of project performance. Questions regarding how to manage critical issues scientifically and thus enhance project performance take center stage in the research (Chen, 2013). Not surprisingly, numerous scholars and practitioners (e.g., Calamel et al., 2012; Haas, 2006; Hoang and Rothaermel, 2005; Scott-Young and Samson, 2008; Schwab and Anne, 2008; Shepherd et al., 2011) conduct extensive studies to examine and identify the key determinants of project performance.

For example, Hoang and Rothaermel (2005) use binary logistic analysis to examine the performance of 158 joint research and development (R&D) projects in 43 pharmaceutical firms; they find that the general alliance experience of biotechnology partners, but not of pharmaceutical firms, positively affects joint project performance. Haas (2006), on the other hand, examines knowledge gathering, team capabilities, and project performance in work environments using logistic regression. Based on data from independent quality ratings of 96 projects and survey data from 485 project-team members collected during a multi method field study, he concludes that slack time, organizational experience, and decision-making autonomy moderate the relationship between knowledge gathering and project performance.

Furthermore, Ling et al. (2009) examine 33 capital projects in China and conclude, using Pearson's correlation analysis, that 24 project-management practices (such as effective communication and high customer satisfaction) are significantly correlated with project performance. Anand et al. (2010) analyzed 98 projects in five companies using hierarchical regression. They show that the inclusion of softer, people-oriented practices for capturing tacit knowledge explains a significant amount of variance in project outcomes.

More recently, using a qualitative field study of drug-development teams in a pharmaceutical firm, Bresman (2013) analyzes how project teams change their routines based on prior experience with other project teams. Bresman (2013) then incorporates four distinct subprocesses (identification, translation, adoption, and continuation) into a process model.

However, despite the panoply of studies that examine and identify the key determinants of project performance, most studies (e.g., Calamel et al., 2012; Haas, 2006; Keller, 1994; Ling et al., 2009; Schwab and Anne, 2008; Shepherd et al., 2011) focus on describing project performance and the input characteristics that affect the performance. Few investigate structural causal relationships among project-management performance variables, and thus with capital-project outcomes.

Although few studies (e.g., Chou and Yang, 2012; Doloi et al., 2011; Wallace et al., 2004) do explore structural relationships among project-performance variables, their experimental treatment, however, is comtemporaneously designed in nature. Limited studies examine project-performance variables using longitudinal data. As a result, there appears to be a lack of research using longitudinal experiments to determine not only how one construct affects another, but also to estimate quantitatively the marginal effects of each construct on project outcomes prior to project execution.

3. Hypotheses

A project involving a number of specialists performing related activities to achieve a goal requires communication among the specialists (Blankevoort, 1984). Not surprisingly, prior research (e.g., Bommer and Jalajas, 2004; Chiocchio, 2007; Doolen et al., 2003; Park and Lee, 2014) finds that communication quality significantly influences team and innovation performance. For example, Doolen et al. (2003), based on production project teams of a *Fortune* 50 high-technology company, find a significant positive relationship between team effectiveness and the organizational culture that supports communication and cooperation among teams.

Based on a study of 235 professional R&D workers in large and small technology-based firms, Bommer and Jalajas (2004) note that policies supportive of communications affect the extent to which engineers can obtain more valuable information from suppliers, customers, and employees in other departments, which in turn affect innovation performance. Chiocchio (2007) uses time-series analysis and a sample of 34 project teams to examine the impact of communication on team performance and finds a significant difference in communication flow between high and low team performance.

Sundström and Zika-Viktorsson (2009) conclude that enhanced communication and leadership skills positively affect project team performance based on the case study of a NPD project. Oke and Idiagbon-Oke (2010) examine 93 innovation projects using structural equation modeling and conclude that the richness of communication channels influences project team performance. Park and Lee (2014) examine

135 project teams in two large IT firms, using partial least square analyses, that communication frequency has a strong impact on knowledge sharing, which in term affects team performance. Thus, we propose the following hypotheses:

Hypothesis 1: Communication has a direct positive effect on Innovation performance prior to the execution phase of capital projects.

Hypothesis 2: Communication has a direct positive effect on Team performance prior to the execution phase of capital projects.

Studies have shown team quality as a critical factor in overall organizational performance (e.g., Bendoly and Swink, 2007; Ben-Hur et al., 2012; Keller, 1994). For example, using data from CEOs at 705 corporations in various industries, Alexiev et al. (2010) performs hierarchical regression analysis to examine how management teams employ advice to modify strategies and pursue exploratory innovation. Their tests show that both external and internal advice-seeking significantly affect a firm's exploratory innovation.

Ben-Hur et al. (2012) use systematic case research to examine published studies and conclude that the decision-making process of teams has a fundamental effect on the quality of risk-management performance. Buganza et al. (2013) use regression analysis and a sample of 562 program participants to examine the impacts of training programs on project management. They find a strong relationship between the degree of collaboration of the project team and its ability to handle project risk.

Subsequent work by Schippers et al. (2014) uses regression analysis to examine the relationships between team reflexivity and innovation performance. Based on a sample of 98 primary health care teams in the United Kingdom, they conclude that increases in work quality at the team level positively affect innovation performance. We therefore propose the following hypotheses:

Hypothesis 3: Team has a direct positive effect on Risk performance prior to the execution phase of capital projects.

Hypothesis 4: Team has a direct positive effect on Innovation performance prior to the execution phase of capital projects.

In particular, studies have long recognized team performance as a key factor in project success (e.g., Bendoly and Swink 2007; Keller 1994; Scott-Young and Samson 2008). For example, using data from 56 capital projects in 15 process-industry companies, Scott-Young and Samson (2008) examine the impact of team design, team leadership, and team process factors on project performance using factor analysis and regression analysis. Their results show that these factors are significant determinants of project outcomes.

Hsu et al. (2011) examine a sample of 194 information system developers, using partial least square analyses, that the ability to apply and share team knowledge effectively explains a significant amount of variance in project outcomes. Calamel et al. (2012) examine two collaborative R&D projects in a large global-innovation cluster in France using a longitudinal design based on in-depth case research. They conclude that team collaboration—a product of social construction fostered by managerial support—is an important factor in project outcomes.

Chen (2014) analyzes 121 capital projects, using robust regression analysis, and finds significant impacts of leadership and team performance on project outcomes. Thus, we propose the fifth hypothesis:

Hypothesis 5: Team performance prior to the execution phase of capital projects has a direct positive effect on capital-project outcomes.

Innovation often manifests itself in new products, services, processes, or methods (Brady and Söderlund, 2008). Several studies suggest that innovative responses and knowledge improve risk management (Koelling et al., 2010; Koschatzky and Stahlecker, 2010; Zipperer and Amori, 2011). For example, through monitoring 80 service innovators in Germany for one year, Koelling et al. (2010) recommend that managers create proactive organizational environments that encourage innovative responses to challenges and risk. Zipperer and Amori (2011) conclude from an analytical review of risk literature that innovative knowledge-sharing results in better risk management. Thus, we predict that risk performance is associated with innovation in the project early phase.

Hypothesis 6: Innovation has a direct positive effect on Risk performance prior to the execution phase of capital projects.

Further, though a recent study of the relationship between risk management and project success did not yield conclusive results (De Bakker et al., 2010), a general consensus is that effective risk management positively affects the success rate of any project or process in various industries (Holzmann and Spiegler, 2011, Hwang and Low, 2012). For example, using the data from 507 software project managers, Wallace et al. (2004) examine the impact of social subsystem risk, technical subsystem risk, and project-management risk on project performance using the structural-equations modeling technique. Their results show that social-subsystem risk significantly affects technical-subsystem risk, which, in turn, influences project-management risk, and ultimately, project outcomes.

Maytorena et al. (2007) use a combined method of the active information search (AIS) and the cognitive mapping (CM) approach to interview 51 project managers and conclude information search style, level of education, and risk management training play a significant role in project success. Bendoly et al. (2010) employ a laboratory experiment to investigate the impact of project manager task self-efficacy and perceptions of project work-planning risk on resource sharing behaviors. Their research results from the experiment involving 161 professional project managers suggest that risk in project work-planning has a significant impact on sharing behaviors, which significantly affects project performance.

In particular, the Project Management Institute (PMI) and the Association of Project Management (APM) include risk management as one of the key disciplines of project management. Hence, we predict that managing risk well in the early phase increases project success at completion.

Hypothesis 7: Risk assessment prior to the execution phase of capital projects has a direct positive effect on capital-project outcomes.

4. Research Methodology

4.1 Participants

The survey instrument was designed based on a detailed examination of literature in the project-management and organization-theory, fields, and consultation with several experienced researchers and practitioners. In particular, prior to the data collection, a panel of experts from Taiwan’s Chinese National Association of General Contractors (CNAGC) critiqued the questionnaire for structure, readability, clarity, and completeness. Based on the feedback from these experts, the survey instrument was then modified to strengthen its validity.

Data collection occurred in two stages and lasted two years. In the first stage, immediately after the end of a project's initiation and planning stages, participants respond to the portion of the questionnaire that excludes questions regarding project actual cost, project actual schedule, cost and schedule for project changes, and customer satisfaction. In the second stage, right after the close of the capital project, participants respond to the questions excluded in stage one.

Of the 600 members of Taiwan’s CNAGC that we randomly selected and invited to participate in this research, 128 companies participated—a 21.33 % response rate (CNAGC has over 6,000 members). Compared to other similar surveys of the industry, the response rate of 21.33% was considered good. Each of the 128 companies in the sample had assigned a project manager who had just completed the initiation and planning of a capital project scheduled to finish within the next two years.

4.2 Measures and Analysis

Communication (Cronbach's Alpha = 0.95) is measured according to a six-item scale based on the representative studies, including Bendoly and Swink (2007), Ling et al. (2009), and Oke and Idiagbon-Oke (2010). Sample items are "C1: The project team identifies all the key stakeholders of the project," and "C2: The project team meets the information needs of the stakeholders."

Team (Cronbach's Alpha = 0.97) is measured according to a 12-item scale based on the representative studies, including Anand et al. (2010), Bendoly and Swink (2007), Hoegl and Parboteeah (2007), Keller (1994), Ling et al. (2009), Song et al. (2007), and Tabassi and Bakar (2009). Sample items are "T1: Top management support for the project team is high," and "T2: Enthusiasm about project success is high."

Innovation (Cronbach's Alpha = 0.96) is measured according to a 10-item scale based on the representative studies, including Keegan and Turner (2002), Keller (1994), Kratzer et al. (2006), Prajogo and Ahmed (2006), and Song et al. (2007). Sample items are "I1: Management support for innovation is high," "I2: Project team applies latest technology to the project."

Risk (Cronbach's Alpha = 0.94) is measured according to a seven-item scale based on the representative studies, including El-Sayegh (2008), and Zou et al. (2007). Sample items include "R1: Project team handles customer design changes well," "R2: Project team handles lack of defined scope of work well."

Finally, *Project Outcomes* is measured on a three-item scale that includes *Cost*, *Time*, and *Customer Satisfaction*. *Customer Satisfaction* (Cronbach's Alpha = 0.95) is measured according to a 10-item scale based on the representative studies, including Chen (2014) and Ling *et al*. (2009). Sample items are " CS1: We complete and deliver all the project deliverables within the customer budget estimates", " CS2: We complete and deliver all the project deliverables within the customer scheduled time frame."

For comparison purpose with the *Communication*, *Team*, *Innovation*, *Risk*, and *Customer Satisfaction* of data collected using a 5-point Likert scale, percentile ranks categorize project time and cost performance based on the 128 sample projects. These values are based the following equations based on Anbari (2003) and Hartley and Watt (1981):

Time = Revised Estimated Duration/Actual Duration (1)

Cost = Revised Estimated Cost/Actual Cost (2)

Table 1 shows the percentile ranks of *Time* and *Cost* in the project-closing phase from the 128 sample projects.

Table 1. Percentile ranks of project time and cost in the closing phase

Percentile	Respective 5-Point Scale	Number of Observations	Mean Return (%)	Minimum Return (%)	Maximum Return (%)
Panel A. *Cost*					
1 to <=20	1	28	41.39	69	92
21 to <=40	2	25	30.88	93	100
41 to <=60	3	24	44.42	102	112
61 to <=80	4	26	91.77	113	138
81 to <=100	5	25	201.72	139	416
Panel B. *Time*					
1 to <=20	1	27	43.00	51	89
21 to <=40	2	33	25.76	90	100
41 to <=60	3	19	38.32	101	107
61 to <=80	4	24	42.00	108	116

81 to <=100	5	25	143.44	118	405

The methodology to test the hypotheses and, hence, to quantify the impact of change in a performance construct prior to the execution phase on capital-project outcomes is threefold. First, this study performs an isolated model analysis of each dimension of performance construct to evaluate the ability of the set of items to their associated dimension of project-management performance. Items with factor loadings smaller than 0.50 are primary candidates for deletion. Further deletion of a dimension's item scales for refining the initial measurement instrument is assessed through repeated model fittings based on an examination of standardized loadings, interpretability, and content validity along with a minimum standardized root mean square residual (RMSR) procedure (Wallace et al., 2004).

Second, this study develops the overall measurement model from the refined measurement instrument based on the confirmatory factor analysis (CFA) (Harrington, 2008). Third, this study uses structural equation modeling (SEM) (Kline, 2010; Lee, 2007) to test our hypotheses and, thus, quantifies the impact of change in a performance construct on capital-project outcomes.

5. Research Results

The measurement-theory model for project performance has the *Communication*, *Team*, *Innovation*, *Risk,* and *Project Outcomes* constructs that correlate with all other constructs. The analysis results of the measurement-theory model suggest an adequate fit with the data. The model chi-square (χ^2)/degrees of freedom = 1.786, which is smaller than the threshold value of 2.000 suggested by Kline (2010); CFI = 0.952 and TLI = 0.938 are both higher than the threshold value of 0.900 suggested by Fornell and Larcker (1981); and the RMSR = 0.040 and RMSEA = 0.079 are both smaller than the respective threshold values of 0.100 and 0.080 (Kline, 2010; Lee, 2007).

Based on the measurement model, we test our hypotheses using SEM (Kline, 2010; Lee, 2007). The model-fit indices suggest that the model fits the data adequately, where the model chi-square (χ^2)/degrees of freedom = 1.772, CFI = 0.952, TLI = 0.940, RMSR = 0.040, and RMSEA = 0.078. This insignificant difference in the relative χ^2 (1.786 versus 1.772) is strongly suggestive of model validity (Kline, 2010).

Figure 1 presents the results of the seven hypothesized relationships (Hypotheses 1 to 7) among the study constructs. Of the seven, five are significant at the 0.01 level, and two are significant at the 0.05 level. Hypotheses 1 to 2, which infer that communication performance has a direct positive impact on innovation and team performance of a project, are all highly significant at the 0.01 level. The coefficients of paths linking *Communication* to *Innovation* and *Team* are 0.48 and 0.93, respectively, which are direct effects.

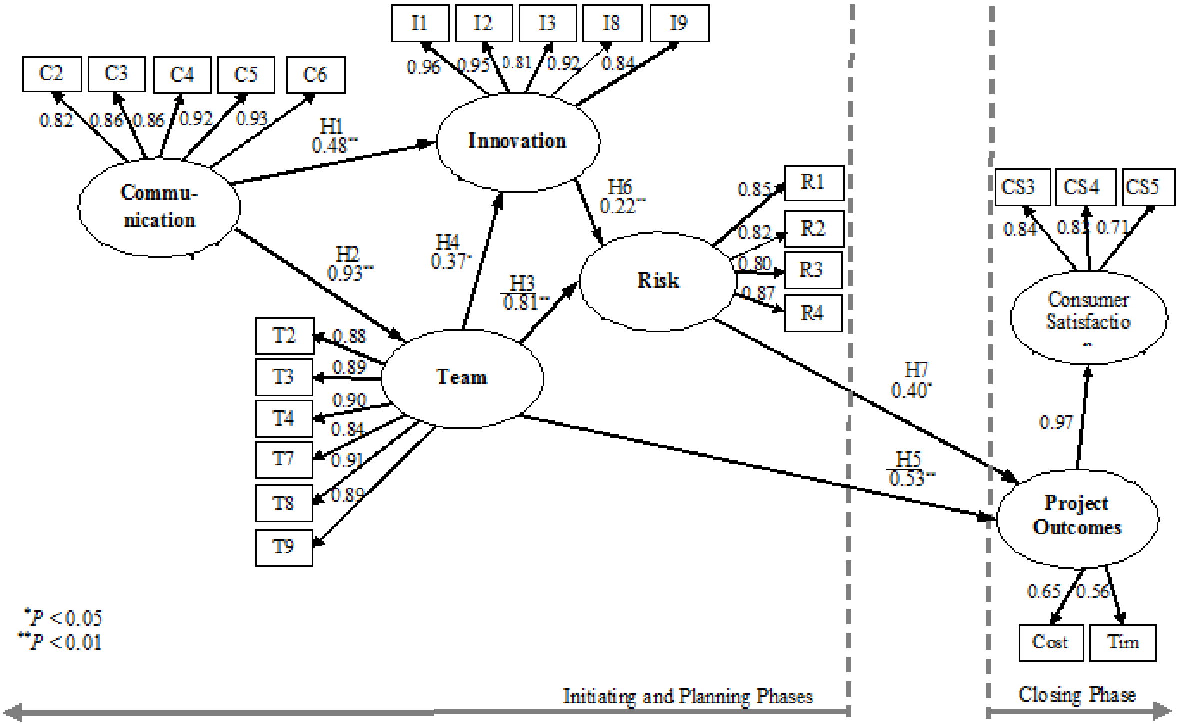

Figure 1. Capital project performance model

Specifically, *Communication* has direct positive effects of 0.48 and 0.93 on *Innovation* and *Team* performance prior to the execution phase of capital projects, respectively. Further, parameter estimates using the ML method find the indirect positive effects of *Communication* on *Innovation*, *Risk*, and *Project Outcomes* are 0.35, 0.94, and 0.93, respectively, as shown in Table 2. Collectively, the combined direct and indirect positive effects of *Communication* on *Team*, *Innovation*, *Risk*, and *Project Outcomes* (Table 2) are 0.93, 0.83, 0.94, and 0.93, respectively.

Table 2. Direct, indirect and total cause-effects

Variable	Communication			Team			Innovation			Risk		
	DE	IE	TE	DE	IE	TE	DE	IE	TE	DE	IE	TE
Team	0.93		0.93									
Innovation	0.48	0.35	0.83	0.37		0.37						
Risk		0.94	0.94	0.81	0.08	0.89	0.22		0.22			
Project Outcomes		0.93	0.93	0.59	0.36	0.95		0.09	0.09	0.40		0.40

Note: DE = Direct effect; IE = Indirect effect; and TE=Total effect.

Hypotheses 3 to 5 infer that team performance has a direct impact on the risk, innovation performance, and project outcomes. We find the connection highly significant at the 0.01 level (Hypotheses 3 and 5), and significant at the 0.05 level (Hypothesis 4). The respective coefficients of the paths linking *Team* to *Risk*, *Innovation*, and *Project Outcomes* are 0.81, 0.37, and 0.53. Specifically, *Team* has direct positive effects of 0.81 and 0.37 on *Risk* and *Innovation* performance prior to the execution phase of capital projects, respectively, and has a direct positive effect of 0.53 on *Project Outcomes* at completion.

Parameter estimates using the ML method (Table 2) find the respective indirect positive effects of *Team* on *Risk* and *Project Outcomes* are 0.08 and 0.36. Together, the combined direct and indirect positive effects of *Team* on *Risk*, *Innovation*, and *Project Outcomes* (Table 2) are 0.37, 0.89, and 0.95, respectively.

Test of hypotheses 6 and 7 finds that innovation affects risk (significant at the 0.0 level) and risk affect project outcomes (significant at the 0.05 level). The coefficients of paths linking *Innovation* to *Risk* and *Risk* to *Project Outcomes* are 0.22 and 0.40, respectively. Namely, *Innovation* has a direct positive effect of 0.22 on *Risk* prior to the execution phase of capital projects, whilst *Risk* prior to the project execution phase has a direct positive effect of 0.40 on *Project Outcomes* at completion. Parameter estimates using the ML method (Table 2) find that the indirect positive effect of *Innovation* on *Project Outcomes* is 0.09. Jointly, the combined direct and indirect positive effects of *Innovation* on *Risk* and *Project Outcomes* are 0.22 and 0.09, respectively.

We further tested an alternative model through a post hoc analysis (Oke et al., 2008; Oke and Idiagbon-Oke, 2010) to provide support for our hypothesized model. In the alternative model, we specified that communication performance prior to the execution phase of capital projects has a direct positive effect on capital-project outcomes, and likewise innovation performance. This model results in a poorer fit to the data than our hypothesized model (the model chi-square (χ^2)/degrees of freedom = 1.786, CFI = 0.952, TLI = 0.938, RMSR = 0.040, and RMSEA = 0.079). In addition, in the alternative model, the link from communication to capital-project outcomes and the link from innovation to capital-project outcomes are both insignificant, with p-values of 0.956 and 0.808, respectively. This test result supports our hypothesized model.

6. Discussion

The proposed model (Figure 1) not only provides structural relationships for the performance variables, but also helps managers estimate marginal project outcomes (MPOs) at the early stage of the project life cycle.

In the initiating and planning phases of a project, for example (see the Total Effect column in Table 2), a 1% performance increase in *Communication* results in a 0.93%, 0.83%, and 0.94% performance increase in *Team*, *Innovation*, *and Risk*, respectively. A 1% performance increase in *Team* results in 0.37% and 0.89% performance increase in *Innovation* and *Risk*, respectively. A 1% performance increase in *Innovation* results in 0.22% performance increase in *Risk*.

The respective MPOs of *Communication*, *Team*, *Innovation*, and *Risk* (see the Total Effect column of the Project Outcomes row in Table 2) are 0.93, 0.95, 0.09, and 0.40. This suggests that a 1% performance increase in *Communication* in the initiating and planning phases results in 0.93% performance increase in *Project Outcomes*; likewise, 1% increases in *Team*, *Innovation* and *Risk* create 0.95%, 0.09%, and 0.40% increases in *Project Outcomes*, respectively.

Further, we found that the links between *Communication* and *Innovation*, between *Team* and *Risk*, and between *Team* and *Project Outcomes* are partially mediated by *Team*, *Innovation*, and *Risk*, respectively. The findings confirm that the process by which the project-performance chain influences project outcomes is a complex one that depends team, innovation, and risk performance.

7. Conclusion

This study develops a project performance-model for capital projects by modeling structural causal relationships among project-performance variables using a longitudinal experiment. The model presented here not only provides a comprehensive picture of how performance variables affect one another, but also offers a way to estimate MPOs quantitatively in relation to time and cost performance prior to project execution. This research extends the knowledge of how performance variables in the initiating and planning phases affect project outcomes in the closing phase.

Extending the research to include new product development and R&D projects will provide additional information about how these variables change with different types of projects. Studying the relationships between improvements in *Communication*, *Team*, *Innovation,* and *Risk* and the *Project Outcomes* throughout the project-delivery process would also be beneficial in decision-making, management, and project control.

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