Predictors of Project Performance and the Likelihood of Project Success

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ABSTRACT

Identifying the critical determinants of project performance is crucial, but few studies test how variables in projects' initiation and planning phases affect the outcomes of those projects. Results from this longitudinal study of 121 capital projects identifies key variables in the initiation and planning phases of capital projects that significantly affect the outcomes of completed cost, time, and profitability. Our Team variable provides the highest classification accuracy; the rest of the variables follow closely that range from 80.99% to 74.38%, indicating a class of stable predictors. Ultimately, our findings suggest that the variables reported in this study not only significantly affect project outcomes, but they identify successful projects early in the capital facility delivery process. Nonetheless, future research is still needed to develop the findings reported in this study into more sophisticated models for project success prediction.

Keywords: *Project Management, Project Success, Performance, Decision Making, Logit Analysis*

INTRODUCTION

A paramount problem for those who model project performance is identifying the critical factors of project success. Of course, extensive research in the project management field examines and identifies a wide variety of measures that describe project outcomes and the inputs that affect those outcomes (e.g., Aggarwal and Rezaee, 1996; Baiden et al., 2006; Barclay and Osei-Bryson, 2010; Chen et al., 2010; Duffy and Thomas, 1989; Emhjellen, 1997; Emmanuelides, 1993; Farris et al., 2006; Globerson, 1994; Grundy, 1998; Huesemann, 2006; Hoegl and Parboteeah, 2007; Ibbs et al., 2001; Ling et al., 2009; Moffat, 1998; Paul et al., 1999; Pheng and Chuan, 2006; Raiden et al., 2004; Robey et al., 1993; Roman, 1964; Schwab and Anne, 2008; Scott-Young and Samson, 2008; Sperpell, 1999; Tabassi and Bakar, 2009; Woodward, 1982; Zou et al., 2007). One recent finding, for example, is that the richness of communication channels influences project success (Oke and Idiagbon-Oke, 2010); another is that the ability to incorporate softer, people-oriented practices for capturing tacit knowledge explains a significant amount of variance in project success (Anand et al., 2010).

Yet, despite this panoply of research into which factors affect project outcomes, few test both the significance and predictability of variables in the project-initiation and planning phases on project outcomes using longitudinal data. The objective of this study, therefore, is to conduct a longitudinal experiment to examine how variables associated with project-initiation and planning affect project success.

The rest of the paper is organized as follows. Section 2 reviews related studies, Section 3 presents the research hypothesis and methodology, Section 4 describes the collection of the samples, Section 5 depicts the statistical tests, and Section 6 presents the research summary and conclusions.

RESEARCH BACKGROUND

Successful project management depends on identifying the critical determinants of success (Scott-Young and Samson, 2008) in order to engineer critical issues scientifically during execution (Chinowsky et al., 2010). Not surprisingly, researchers and professional associations (e.g., Anand et al., 2010; Arditi and Gunaydin, 1997; Bendoly and Swink, 2007; Brown et al., 1990; Cao and Hoffman, 2010; Chen and Lee, 2007; Dulaimi et al., 2005; El-Mashaleh et al., 2010; Hoang and Rothaermel, 2005; Hsu et al., 2010; Hwang et al., 2010; Ilan, 1989; Keller, 1986; Kratzer et al., 2006; Ling et al., 2009; Maytorena et al., 2007; Project Management Institute, 2008; Qureshi et al., 2009; Thamhain and Gemmill, 1974; Wang et al., 2005) conduct extensive studies to examine and identify these key determinants of project success.

For example, Hoegl et al. (2003) use regression analysis to examine the effects of teamwork quality on project performance. Based on data from 145 projects in four software development organizations, they conclude that teamwork quality is associated with the success of projects posing high task innovativeness.

Hoang and Rothaermel (2005) use binary logistic analysis to examine the success of 158 joint R&D projects in 43 pharmaceutical firms; they claim that the general alliance experience of biotechnology partners, but not of pharmaceutical firms, positively affects joint project success.

Song et al. (2007) conclude that initial planning conditions and the effectiveness of front-end planning management affect how well R&D plans and the later R&D process perform based on two R&D projects.

Recently, Schwab and Anne (2008) examine 239 U.S. movie projects from 1931 to 1940 and determine, using regression analysis, that project success depends on the perceived relevance of prior performance and on organizational control over project participants.

More recently, Anand et al. (2010) analyze 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 success.

Although a large number of studies use a wide variety of measures to describe project outcomes and the input characteristics that affect those outcomes, limited studies examine the potential predictors of project success using longitudinal data. As a result, there appears to be a lack of research that examines the potential impact of the project-initiation and planning phases on project success at completion.

Thus, the objective of this study is to conduct a longitudinal experiment that examines the impact of variables associated with the project-initiation and planning phases on project success. The second objective of this study is to assess how well the variables concluded from the longitudinal data differentiate between healthy and failing projects.

RESEARCH HYPOTHESIS AND METHODS

Cost, time, and performance are the typical measures of project success (Kloppenborg and Opfer, 2002). In other words, a project is often considered successful if it finishes within its budget estimate, finishes within its scheduled time frame, and performs as designed (Scott-Young and Samson, 2008). Whilst the research literature in project management engages in a fruitful debate over the nature of project success (Dvir et al., 1998), project success criteria have become multifaceted.

For example, Hackman (1987) assesses project success by measuring the client's or intended user's satisfaction, as well as employee development and satisfaction. Shenhar et al. (1997) evaluate project success by evaluating long-term business success and learning that prepares the organization for the future. Lim and Mohamed (1999) measure project success using the multidimensional set of time, cost, quality, performance, safety, and operational benefit.

Shenhar et al. (2001) use project efficiency, customer benefit, organizational success, and potential benefit to the organization to assess project success. Yu et al. (2005) develop a value-centered model based on net project execution cost and net project operation value to evaluate project success. The Project Management Institute (2008) assesses project success with cost, time, quality, and stakeholder satisfaction.

Therefore, this study chooses project time, cost, and profitability as the criteria for project success. This is principally due to that the cost, time, and profitability metrics are objective in nature, allowing a direct comparison of projects with different types, scopes, and sizes across different industries, especially when the metrics are binary measures (Scott-Young and Samson, 2008). Consequently, our dependent variable, *Project Success*, is binary, with 1 indicating that a project finishes within budget and scheduled time frame and makes a profit.

Criteria for our independent variables are based on an extensive review of literature in project management, group effectiveness, and organization theory; consultation with several experienced researchers; and consultation with a panel of experts from CNAGC. The process identifies six criteria that are similar to the project performance measures most project contracting organizations use internally. The criteria are scope, quality, team, communication, risk, and change.

Because our research is built on the proposition that what happens in the project-initiation and planning phases of the project delivery process predicts project success, we propose and test the following hypothesis:

Hypothesis: In the project-initiation and planning phases, the Scope, Quality, Team, Communication, Risk, and Change variables not only have positive effects on project success, but are significant predictors of project outcomes.

The methodology to estimate the likelihood of project success is twofold. First, for statistically verifying our hypothesis, this study uses the Kolmogorov-Smirnov (KS) test to verify normality, followed by Pearson's correlation test and Spearman's correlation test, respectively, when the data is normally and abnormally distributed. Second, this study conduct univariate logistic regression analysis to evaluate the predictive ability of the significant variables concluded from step one.

DATA SOURCES

Participants

Of the 500 members of Taiwan's Chinese National Association of General Contractors (CNAGC) that we randomly selected and invited to participate in this research, 121 companies participated—a 24.2 % response rate (CNAGC has over 1,000 members). Each of the 121 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. The 121 capital projects fall into three categories: buildings (69 projects), transportation facilities (22 projects), and industrial facilities (30 projects). Project managers average between one and 26 years of experience; 30 participants had fewer than five years of experience; 51 had between five and 10 years; 33 had between 10 and 20 years; and seven participants had over 20 years of experience.

Surveys collected the data. Prior to the data collection, several experienced researchers and a panel of experts from CNAGC critiqued the questionnaire for structure, readability, clarity, and completeness. These researchers and experts also appraised the extent to which the indicators sufficiently addressed the subject area (Dillman, 1978). Based on the feedback from these researchers and experts, the survey instrument was then modified to strengthen its validity.

The final version of the survey questionnaire comprises two sections. The first section, composed of open-ended questions, gathers detailed background information, such as annual revenue, project types, project cost including contract price, budget, contract price for project change, and actual cost, and the project schedule including the contract schedule, scheduled time, contract schedule for project change, and actual schedule.

The second section gathers data for the project variables and is measured by scales based on a synthesis of literature from the project management, group effectiveness, and organizational theory fields. Section two consists of multiple-choice questions in which respondents indicate on a 10-point scale the extent to which certain project variables likely affected the project outcome. Because of space limitations, complete survey questionnaires are not presented here but are available from the authors on request.

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

Measures

Scope ($\alpha = .97$) is measured according to a four-item scale based on Aggarwal and Rezaee (1996), Duffy and Thomas (1989), Dumont et al. (1997), Globerson (1994), Ling et al. (2009), Kwak and Ibbs (2002), and Roman (1964). The four-item scale includes quality of contract document, extent of scope definition, extent of scope verification, and extent of work breakdown structure (WBS).

Quality ($\alpha = .96$) is measured according to a four-item scale based on Globerson (1994), Ling et al. (2009), Paul et al. (1999), Roman (1964), and Sperpell (1999). The four-item scale includes quality management plan, quality metrics, quality checklist, and quality baseline.

Team ($\alpha = .98$) is measured according to a 12-item scale based on Anand et al. (2010), Baiden et al., (2006), Bendoly and Swink (2007), Brown et al. (1990), Chen et al. (2010), Chen and Lee (2007), Duffy and Thomas (1989), Hoegl and Parboteeah (2007), Hoegl et al. (2003), Hsu et al. (2010), Kats and Allen (1985), Keller (1986), Ling et al. (2009), Moffat (1998), Pheng and Chuan (2006), Raiden et al. (2004), Robey et al. (1993), Scott-Young and Samson (2008), Song et al. (2007), Tabassi and Bakar (2009), Thamhain (2004), Thamhain (2009), Thamhain and Gemmill (1974), Wang et al. (2005), Wanous and Youtz (1986), and Woodward (1982). They are the extent of top management support to the project team, clear definition of the role, responsibility, and rights of each team member, cohesiveness, motivation, degree of enthusiasm about the chances of the project being a success, cooperation, group participation in decision-making, quality of group decisions, team-building, team interpersonal relationship, degree of conflict resolution and problem solving, and degree of job skills and expertise.

Communication ($\alpha = .97$) is measured according to a six-item scale based on Barclay and Osei-Bryson (2010), Bendoly and Swink (2007), Chen et al. (2010), Emhjellen (1997), Grundy (1998), Huesemann (2006), Ling et al. (2009), Oke and Idiagbon-Oke (2010), and Thamhain and Gemmill (1974). They include identification of key stakeholders, information needs of the stakeholders, communications needs of the stakeholders, use of technology in information sharing, communication with the customer, and communication within project team members.

Risk (α = .94) is measured according to a four-item scale based on El-Sayegh (2008) and Zou et al. (2007). They include ability to handle change of design required by the customer, ability to handle the lack of scope of work definition by the customer, ability to handle to the lack or departure of qualified staff, and ability to handle delays in resolving contractual issues.

Change (α = .97) is measured according to a three-item scale based on Ibbs et al. (2001) and Luu et al. (2008). continually improving from lessons learned, bringing the appropriate parties into the discussion, and negotiating changes and communicate them to all affected parties. High scores suggest good performance; low scores indicate poor performance.

RESULTS

Hypothesis and Results

Table 1 presents means, standard deviations, and Spearman's correlation matrix of the estimation data of the variables, where only main effects of the variables appear. Correlation is significant when the probability value is smaller than the 0.05 threshold value. The Kolmogorov-Smirnov g value of the dependent variable *Project Success* is 0.41 with an associated *p*-value of <0.01, suggesting a significant distribution abnormality that justifies Spearman's correlation test.

Table 1: Descriptive Statistics and Spearman's Correlation Matrix for All Variables [a]

Variables	Kolmogorov -Smirnov Statistics	Mean	S.D.	1	2	3	4	5	6	7
1. Project Success [b]	0.41**	0.37	0.49	1.00						
2. Scope	0.07	6.94	1.67	0.64**	1.00					
3. Quality	0.12**	6.89	1.61	0.48**	0.85**	1.00				
4. Team	0.07	7.33	1.53	0.63**	0.86**	0.83**	1.00			
5. Communication	0.10**	6.81	1.65	0.57**	0.86**	0.87**	0.90**	1.00		
6. Risk	0.06	6.73	1.46	0.56**	0.84**	0.82**	0.91**	0.91**	1.00	
7. Change	0.10**	6.81	1.81	0.44**	0.74**	0.80**	0.81**	0.82**	0.85**	1.00

[a] N = 121.

[b] Project is a success (= 1), 1 when profitability = 1, cost = 1, and time = 1 exist; otherwise, it is a failure (= 0).

Notes: Profitability = (revised contract price – actual cost)/actual cost, where the revised contract price includes the cost of scope changes. When profitability is larger than 0, it is coded as 1; otherwise, it is 0.

Cost = revised estimated cost/actual cost, where the revised estimated cost includes the estimated cost of scope changes. When cost is smaller than 1, it is coded as 0; otherwise, it is 1.

Time = revised estimated duration/actual duration, where the revised estimated duration includes the estimated duration of scope change. When time is smaller than 1, it is coded as 0; otherwise, it is 1.

*p < 0.05 and ** p < 0.01

As the table shows, the Spearman correlation coefficients of *Scope*, *Quality*, *Team*, *Communication*, *Risk*, and *Change*, are 0.64, 0.48, 0.63, 0.57, 0.56, and 0.44 with *p*-values of <0.01, respectively. The test results imply that *Scope*, *Quality*, *Team*, *Communication*, *Risk*, and *Change* in the initiation and planning phases have a significant positive effect on project success, which supports the first part of our hypothesis. Specifically, the better *Scope* performs in the initiation and planning phases, the more likely a project will succeed at completion and likewise, *Quality*, *Team*, *Communication*, *Risk*, and *Change*.

To support the second part of our hypothesis, this study further performs a series of univariate logistic-regression analyses to evaluate how well these variables differentiate between project success and failure, as shown in Table 2.

The univariate logistic-regression coefficients of *Scope*, *Quality*, *Team*, *Communication*, *Risk*, and *Change* are 10.38, 0.86, 1.42, 1.06, 1.09, and 0.68 with *p*-values of <0.01, respectively. The results indicate that *Scope*, *Quality*, *Team*, *Communication*, *Risk*, and *Change* are significant univariate predictors of project success (failure) and demonstrate very high classification ability, ranging from 74.38% to 80.99% with Nagelkerke R-squared values from 0.26 to 0.53.

Table 2: Univariate Logistic Analysis Results

Variable	B[a]	Exp(B)	Nagelkerke R-squared	Actual Success / Actual Failure	Predicted Success / Predicted Failure	Percentage Correct	Overall Percentage Correct
Scope	10.38^{**}	3.87	0.53	76	64	84.21	
				45	30	66.67	77.67
Quality	0.86^{**}	2.37	0.32	76	62	81.58	
				45	28	62.22	74.38
Team	1.42^{**}	4.13	0.52	76	66	86.84	
				45	32	71.11	80.99
Communication	1.06^{**}	2.88	0.43	76	64	84.21	
				45	30	66.67	77.69
Risk	1.09^{**}	2.98	0.41	76	65	85.53	
				45	30	66.67	78.52
Change	0.68^{**}	1.97	0.26	76	64	84.21	
				45	29	64.44	76.86

[a] Coefficient.
Notes: $^{*}P < 0.05$.
$^{**}P < 0.01$.

Clearly, the Spearman correlation tests and the univariate logistic-regression analyses support our hypothesis. In the project-initiation and planning phases, *Scope*, *Quality*, *Team*, *Communication*, *Risk*, and *Change* are significantly positively related to project success, and more important to this study, these variables are significant predictors of project success and failure.

Analysis of Evidence

Although not all the variables forecast equally well, they follow closely that range from 80.99% to 74.38%, indicating a class of stable predictor of project success and failure. The *Team* variable provides the highest univariate classification accuracy. In particular, the ability to predict success is the strongest in the *Team* variable, providing a correct percentage of 86.84. The second best is the *Risk* variable that provides a correct percentage of 85.53. The *Scope* and *Change* variables predict next best, which provide a correct percentage of 84.21. The Quality variable performs least well that provides a correct percentage of 81.58.

In sum, the findings reported here show that *Scope*, *Quality*, *Team*, *Communication*, *Risk*, and *Change* not only significantly affect project success, but possess a strong, stable, discriminatory performance for differentiating between project success and failure. The findings also indicate that it is possible to discriminate between healthy and failing projects prior to failure before the project execution phase in the capital facility delivery process.

CONCLUSION

This study investigates the relationship between key determinants of project performance and project success at completion. Analysis of the longitudinal data of 121 capital projects in this study indicates that the scope, quality, team, communication, risk, and change variables not only significantly affect project success, but have a strong, stable, discriminatory power to predict project success and failure. The findings concerning the significance of *Scope*, *Quality*, *Team*, *Communication*, and *Change* are consistent with prior research (e.g.., Anand et al., 2010; Barclay and Osei-Bryson, 2010; Bendoly and Swink, 2007; Brown et al., 1990; Chen et al., 2010; Chen and Lee, 2007; Hoegl et al., 2003; Hsu et al., 2010; Huesemann, 2006; Ibbs et al., 2001; Kats and Allen, 1985; Keegan and Turner, 2002; Luu et al., 2008; Oke and Idiagbon-Oke, 2010; Raiden et al., 2004; Robey et al., 1993; Roman, 1964; Scott-Young and Samson, 2008; Song et al., 2007; Sperpell, 1999; Tabassi and Bakar, 2009; Thamhain, 2004; Wang et al., 2005; Woodward, 1982). Our study further extends the significance of these variables to the project-initiation and planning phases of the project delivery process. Such extension is especially importance because it makes early prediction of project outcomes possible. Nonetheless, future research is still needed to develop the findings reported here into more sophisticated models for predicting project success. Such development can be accomplished through more sophisticated model-building techniques, including but not limited to multivariate discriminant analysis (MDA), multivariate logit analysis (MLA), probit analysis (PA), and linear probability modeling (LPM).

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