Project Manager's Competency to Improve R&D Project Performance: Mediating Effect of Team Commitment and Moderating Effect of Project Type

Li-Ren Yang and Yueh-Hua Lee

***Abstract*—The primary purpose of this study was to examine the mediating effect of team commitment and moderating effect of project type on the relationship between leadership competency and research and development (R&D) project performance. To address the primary aim, a survey was used to measure the project manager's competency, team commitment, and the performance of R&D projects in the Taiwanese high-tech industry. These analyses suggest that team commitment may mediate the effect of leadership competency on R&D project performance. The findings also indicate that project complexity and team size have a moderating effect on the relationship between leadership competency and R&D project success.**

***Index Terms*—Project manager, leadership competence, team commitment, project performance, research and development.**

I. Introduction

Research and development (R&D) project is one of the most complex and difficult projects in various industries. Previous research identified the importance of project leaders and their impacts on the performance of projects [1]-[3]. However, the literature has largely ignored the impact of leadership on project success [4]. This lack of information regarding leadership benefits along with uncertain competitive advantage from team commitment has resulted in a manager's reluctance to develop different leadership abilities. This study attempts to fill this void of empirical evidence by identifying the associations among leadership competency, team commitment, and project performance. The primary purpose of this study was to determine whether team commitment plays a mediating role in the relationship between leadership competency and project performance. The second objective was to examine the moderating role of project type in the relationship between leadership competency and project performance. The analyses of the project manager's leadership competency and relationships with team commitment and project performance are based on an industry-wide survey. A data collection tool was developed to assess the project manager's leadership competency, levels of team commitment, and the performance of R&D projects in the Taiwanese high-tech industry.

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II. Literature Review and Research Hypotheses

Previous research conducted on leadership stresses the importance of leadership competency [5]-[7]. In addition to the literature on leadership competency, some focused on discussion of the relationships between leadership and team commitment. Team commitment is defined as the level of commitment members of teams feel towards the teams of which they are a part [8]. A review of the literature suggests that the adoption of leadership as a means to enhance team commitment has been supported [8]. As such, leadership is a highly influential factor in team commitment. As indicated by the review of literature, leadership competencies may be positively related to commitment in a team environment. The relationships between team commitment and job performance have also been studied. The results of previous studies indicated a correlation between team commitment and job performance [9].

Previous studies indicated a correlation between team commitment and successful job performance [10]-[12]. Thus, team commitment also plays an important role in performance of workers. Additionally, performance is considered to be affected indirectly through the effects of leadership on subordinates' affective commitment [12]. Yousef [13] also argued that commitment may play a mediating role in the relationship between leadership behavior and job performance. This study extends previous studies by addressing the impact of leadership competency and team commitment on project performance. Based on the relevant literature, the following hypothesis was postulated and tested:

H1: Team commitment may act as a mediator between leadership competency and R&D project performance.

Above previous studies indicated that leadership plays an important role in performance among subordinates. Teams can be made more successful by improving the project manager's leadership skills. Additionally, prior research has stated that project type may play a moderating role in the relationship between leadership behavior and project success [14]. Based on leadership theory and the previous research, the following research hypothesis was developed:

H2: Project type may act as a moderator between leadership competency and R&D project success.

III. Methodology

A. Data Collection Tool

A survey instrument was used to measure the project

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manager's leadership competency, team commitment, and the performance of R&D projects in the Taiwanese high-tech industry. The data collection tool was developed based on variables used in previous studies. The survey was composed of five sections: 1) the project manager's leadership competency, 2) team commitment, 3) project performance, 4) project type, and 5) personal information. These subject projects were categorized according to seven data class variables: project purpose, owner regulation, contract type, team size, complexity, project typicality, and international involvement. These variables are defined as follows [14]-[17]:

1. Project purpose – Two categories are presented: developing new products or systems and adding new functions to existing products or systems.

2. Owner regulation – This variable allowed researchers to distinguish private projects from public projects.

3. Contract type – Participants were provided with two optional responses: fixed-price contracts or cost-reimbursement contracts.

4. Team size (number of core team member) – Four categories are presented: small team (i.e., <16 members), medium team (i.e., 16-30 members), large team (i.e., 31-45 members), and extra large team (i.e., >45 members).

5. Complexity – Respondents were asked to compare the subject project to other company projects relative to complexity. Three optional responses were provided: high, medium, and low.

6. Project typicality – Respondents were asked to compare the subject project to other company projects relative to methods and approaches used. Two optional responses were provided: advanced or traditional.

7. International involvement – Respondents were asked to identify whether international organizations were involved in the subject project. Two optional responses were provided: international or local.

B. Sample Selection and Data Collection

TABLE I: CHARACTERISTICS OF SAMPLED PROJECTS

Characteristic	Class	Number	Percent
Project purpose	Developing new products	108	71.5
Project purpose	Adding new functions	43	28.5
Owner regulation	Private	130	86.1
Owner regulation	Public	17	11.3
Owner regulation	Not available	4	2.6
Contract type	Fixed-price contracts	83	55.0
Contract type	Cost-reimbursement contracts	68	45.0
Team size	<16	104	68.9
Team size	16-30	20	13.2
Team size	31-45	9	6.0
Team size	>45	18	11.9
Complexity	High	59	39.1
Complexity	Medium	83	55.0
Complexity	Low	9	6.0
Project typicality	Advanced	94	62.3
Project typicality	Traditional	55	36.4
Project typicality	Not available	2	1.3
International involvement	International	89	58.9
International involvement	Local	62	41.1

This research employed a mail survey methodology for data collection. The sample for this study focused on R&D projects in the Taiwanese high-tech industry. Individuals interested in participating in the study were identified by a search from various industry associations. The targeted respondents were identified as the senior individuals who were familiar with the project manager's leadership competencies, team commitment, and project performance. The survey questionnaire was sent to 200 practitioners of high-tech firms in Taiwan.

Of the 200 questionnaires sent, 153 were returned. The overall response rate was 76.5 percent. Among the returned surveys, 2 were discarded since they contained too many missing values. In addition, the responses were examined to ensure that no duplicate project information was collected. Ultimately, 151 survey responses were used in the analysis. Table I presents characteristics of sampled projects.

C. Measurement

The items used to measure leadership competency were based on the questionnaires developed by Dulewicz and Higgs [15]. On the other hand, the scales developed by Meyer *et al*. [18] were employed to evaluate team commitment. Finally, questions from Pinto and Mantel [19], Freeman and Beale [20], and Westerveld [21] were adapted to measure project performance. Each item was rated on a 7-point scale, where 1 represented strongly disagree and 7 represented strongly agree.

D. Dealing with Validity and Reliability

Two main types of validity, content and construct validity, were tested. The content validity of the survey used in this study was tested through a literature review and interviews with practitioners. The industry interviews encompassed five high-tech industry executives. Each of the professionals has over 20 years of senior management experience in the industry. The refined assessment items were included in the final survey. The construct validity was tested by factor analysis. Factors were extracted using Varimax rotation. As suggested by Hair *et al*. [22], an item is considered to load on a given factor if the factor loading from the rotated factor pattern is 0.50 or more for that factor. The factor loadings for the items used in the study are at lease 0.60. Thus, no items were dropped due to low factor loadings.

Cronbach's coefficient (α) was computed to test the reliability and internal consistency of the responses. Reliability was assessed for project manager's leadership competency at 0.959, team commitment at 0.934, and project performance at 0.958. The values of Cronbach's α above 0.7 are considered acceptable and those above 0.8 are considered meritorious [23]. All of the α values for constructs are above 0.8, indicating a high degree of internal consistency in the responses.

IV. RESULTS AND ANALYSIS

A. Constructs of Leadership Competency, Team Commitment, and Project Performance

Factor analysis with Varimax rotation was used to decide

the grouping of leadership competency constructs. Only variables with a factor loading greater than 0.5 were extracted [22]. The 15 items of leadership competency construct are classified into two factors. They are coordination skill and problem-solving skill. All of the factor loadings range from 0.617 to 0.923, indicating a high level of internal consistency among the leadership competency items. Similarly, factor analysis was also employed to group 11 items of team commitment construct. Only one factor was found to underlie team commitment. The factor loadings range from 0.675 to 0.878. Additionally, the 16 items of project performance construct are classified into two factors. The two constructs categorized are cost and schedule success and quality performance. The analysis shows factor loadings ranging from 0.601 to 0.862. Reliability was assessed for coordination skill at 0.950, problem-solving skill at 0.902, team commitment at 0.934, cost and schedule success at 0.950, and quality performance at 0.913.

B. Mediator between Leadership Competency and Project Performance

In this study, formal mediation testing was subsequently conducted to determine whether team commitment dimension mediates the relationships between leadership competency and project performance. The mediating role of team commitment dimension in the relationships between leadership competency and project performance was examined by investigating changes in beta coefficients and R-squared when entering team commitment variable in a series of regression models. In the relationship between leadership competency and project performance, the first three conditions for mediation specified by Baron and Kenny [24] were met by team commitment dimension. Thus, team commitment variable was subsequently tested to determine if it fulfilled the fourth condition for mediation.

The analysis assessed the effect of including team commitment in hierarchical linear regressions where individual subscales of leadership competency (i.e., coordination skill and problem-solving skill) were the independent variables and cost and schedule success was the dependent variable. Multiple regression models were developed with subscales of leadership competency, team commitment, and cost and schedule success in order to measure the mediating role of team commitment in the relationship between leadership competency and cost and schedule success. While cost and schedule success is the dependent variable, subscales of leadership competency were entered on the first step (Model 1) and team commitment was entered on the second step (Model 2). Table II presents summary of Hierarchical Regression Analysis for coordination skill. The first model (i.e. coordination skill) explained 30.5% of the variance in cost and schedule success ($p < .001$). Model 2 (i.e. "coordination skill" and "team commitment") explained 43.5% of the variance in cost and schedule success ($p < .001$). Both of "coordination skill" and "team commitment" are significant variables. In other words, an index of team commitment was added in the second model and this explained an additional 13.0% of the variance. However, with the addition of team commitment, standardized regression coefficients (β) for coordination skill decreased by 60.5% (from .522 to .206). The testing shows that the inclusion of team commitment yields significant reductions in the beta-coefficients for coordination skill. Although the coordination skill index continued to be a significant explanatory variable, its contribution was reduced. This is supportive of a mediatory role for team commitment. As such, the testing supports a role for team commitment as a partial mediator in the relationship between indices of "coordination skill" and "cost and schedule success." Additionally, as shown in Table II, team commitment partially mediates the effect of coordination skill and quality performance.

Table III presents summary of Hierarchical Regression Analysis for problem-solving skill. Similarly, the testing supports a role for team commitment as a partial mediator in the relationship between indices of problem-solving skill and cost and schedule success. For quality performance, the first model (i.e. problem-solving skill) explained 24.4% of the variance in project quality performance ($F = 48.067$, $p < .001$). The results indicate that higher levels of problem-solving skill are associated with higher levels of project quality performance. Model 2 (i.e. problem-solving skill and team commitment) explained 41.3% of the variance in project quality performance ($F = 51.994$, $p < .001$). With the addition of team commitment, problem-solving skill was no longer significant in explaining variance in project quality performance. However, the beta coefficient for team commitment is significant. This suggests that team commitment fully mediated the effects of problem-solving skill on project quality performance.

TABLE II: MEDIATORS BETWEEN COORDINATION SKILL AND PROJECT PERFORMANCE

Independent variable	Cost and schedule success		Quality performance	
	Model 1	Model 2	Model 1	Model 2
Coordination skill	0.552[a,*]	0.206[*]	0.533[*]	0.181[*]
Team commitment		0.500[*]		0.509[*]
R-Squared	0.305	0.435	0.284	0.419
F-Statistic	65.244[***]	56.929[***]	59.143[***]	53.440[***]

[a]The number denotes the beta coefficient for the particular variable

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

TABLE III: MEDIATORS BETWEEN PROBLEM-SOLVING SKILL AND PROJECT PERFORMANCE

Independent variable	Cost and schedule success		Quality performance	
	Model 1	Model 2	Model 1	Model 2
Problem-solving skill	0.516[a,*]	0.166[*]	0.494[*]	0.136
Team commitment		0.533[*]		0.545[*]
R-Squared	0.266	0.428	0.244	0.413
F-Statistic	54.123[***]	55.406[***]	48.067[***]	51.994[***]

[a]The number denotes the beta coefficient for the particular variable

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

C. Identification of Project Clusters with the Same Perceptions of Leadership Competency

In order to identify homogeneous projects clusters with the same kinds of perceptions of leadership competency, a K-means cluster analysis was performed on the basis of the

two dimensions of leadership competency (coordination skill and problem-solving skill). To validate the results of the cluster analysis, a discriminant analysis was also conducted. The cluster analysis has identified two clusters for leadership competency, with the cluster mean values of discriminating variables given in Table IV. The discriminant analysis classified 99.3 percent of the projects as the cluster analysis did, indicating extremely good differentiation and a correct classification. These results further suggest that the two clusters are distinctive. In addition, independent-samples t tests were undertaken to assess the internal validity of the cluster results. The independent-samples t tests shown in Table IV confirm that the two variables of coordination skill and problem-solving skill do significantly differentiate across the two clusters. The first cluster was labeled project with high leadership competency. The second cluster consists of projects with low leadership competency.

TABLE IV: CLUSTER MEANS OF DISCRIMINATING VARIABLES

Variable	High leadership competency projects		Low leadership competency projects		t-statistic
	Number	Mean	Number	Mean	
Coordination skill	89	5.61	62	4.08	16.85***
Problem-solving skill	89	5.62	62	4.12	14.81***

***significant at the 0.001 level

D. Moderating Effect of Project Type between Leadership Competency and Project Performance

These subject projects were categorized according to seven data class variables: project purpose, owner regulation, contract type, team size, complexity, project typicality, and international involvement. In other words, project type was assessed by using these attributes. As previously discussed, the projects were also examined by clustering them on the basis of differences in perceptions of the proposed leadership competency dimensions. The study reveals two segments for the leadership competency dimensions. Thus, to test for the moderating influence of complexity on the relationship between leadership competency and project cost and schedule success, 2 (leadership competency) x 3 (complexity) analysis of variance (ANOVA) were performed. The two-way ANOVAs were utilized to determine the joint effects of leadership competency and complexity on project cost and schedule success. Table V summarizes the results of the ANOVAs. The results indicate a significant interaction of leadership competency (LC) and complexity (C) for project cost and schedule success, $F = 3.326$, $p < 0.05$, and there was also a significant interaction of leadership competency and complexity for quality performance, $F = 3.081$, $p < 0.05$. These findings suggest that project complexity has a moderating effect on the relationship between leadership competency and cost and schedule success and between leadership competency and quality performance.

Fig. 1 and Fig. 2 show the relationship between leadership competency and project performance (cost and schedule success and quality performance) at different levels of project complexity. It is clear that projects with high and medium complexity were more likely to be successful when they experienced a high level of leadership competency than those with less complexity. The study also examined the correlations between leadership competency and project performance for each level of project complexity. The results of the correlation analysis are presented in Table VI. The results of this study indicate a significant positive correlation between leadership competency and project performance for projects with high and medium complexity. However, the relationships are low and not significant for projects with low complexity. These results further prove that the complexity may play a moderating role in the relationship between leadership competency and project success.

TABLE V: RESULTS OF ANOVA

Variable	Cost and schedule success		Quality performance	
	Complexity (C)	Team size (TS)	Complexity (C)	Team size (TS)
Leadership competency (LC)	3.326*	3.589*	3.081*	3.231*

*significant at the 0.05 level

TABLE VI: CORRELATION BETWEEN LEADERSHIP COMPETENCY AND PROJECT PERFORMANCE BY PROJECT TYPE

Project performance	Complexity			Team size			
	High	MED	Low	Extra large	Large	MED	Small
Cost and schedule success	0.37**	0.70**	-0.31	0.56**	0.82**	0.69**	0.44**
Quality performance	0.37**	0.67**	-0.57	0.51**	0.77**	0.70**	0.43**

**significant at the 0.01 level

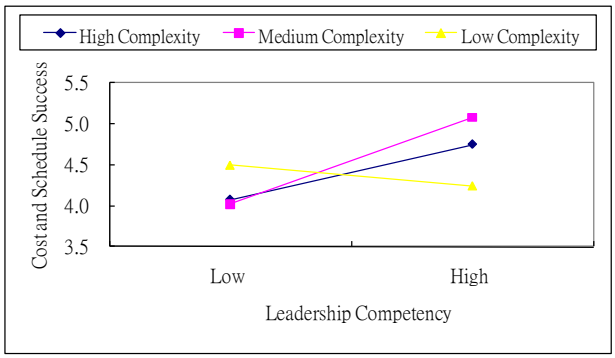

Fig. 1. Moderating effect of project complexity on the relationship between leadership competency and cost and schedule success.

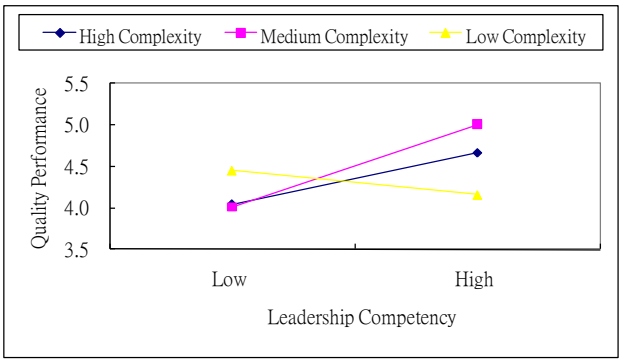

Fig. 2. Moderating effect of project complexity on the relationship between leadership competency and quality performance.

In order to test for the moderating influence of team size on the relationship between leadership competency and project cost and schedule success, 2 (leadership competency) x 4

(team size) ANOVAs were also performed. The results of the ANOVAs are also presented in Table V. The results indicate a significant interaction of leadership competency (LC) and team size (TS) for project cost and schedule success, $F = 3.589$, $p < 0.05$. As shown in Table V, a significant interaction of leadership competency and team size also exists for project quality performance, $F = 3.231$, $p < 0.05$. The findings suggest that team size has a moderating effect on the relationship between leadership competency and project cost and schedule success and between leadership competency and project quality performance. However, there was no significant interaction of leadership competency and project performance for the other data class variables. 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.

Fig. 3 and Fig. 4 graphically present the relationship between leadership competency and project performance (cost and schedule success and quality performance) for team size. Analyses suggest that large teams were more likely to be successful when they experienced a high level of leadership competency than the other types of teams. Results from the correlation analysis (see Table VI) indicate that there appears to be stronger positive correlations between leadership competency and cost and schedule success and between leadership competency and quality performance for large project teams. These results further prove that team size has a moderating effect on the relationship between leadership competency and project success. In summary, the findings suggest that project complexity and team size have a moderating effect on the relationship between the leadership competency and project success (cost and schedule success and quality performance).

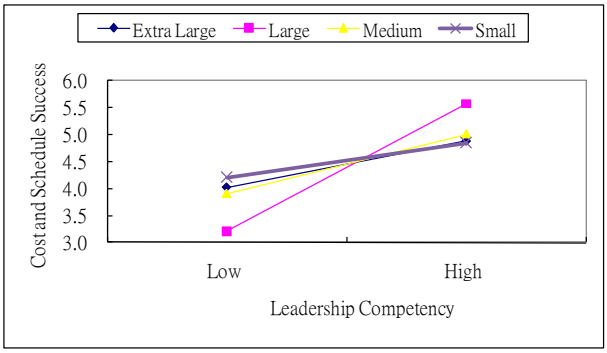

Fig. 3. Moderating effect of team size on the relationship between leadership competency and cost and schedule success.

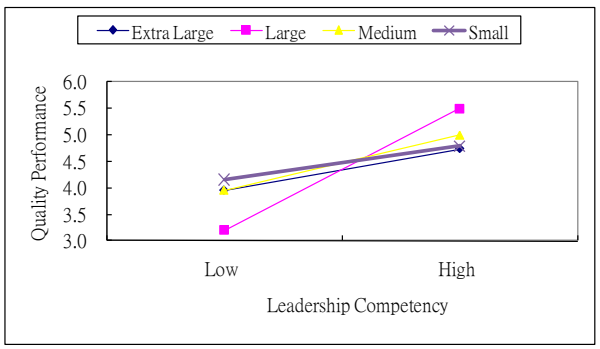

Fig. 4. Moderating effect of team size on the relationship between leadership competency and quality performance.

V. Conclusion and Recommendations

The study examined whether team commitment may act as a mediator between leadership competency and project performance. Formal mediation testing was subsequently conducted to determine whether team commitment mediates the relationships between leadership competency and project performance. The analysis assessed the effect of including team commitment in hierarchical linear regressions where individual subscales of leadership competency (i.e., coordination skill and problem-solving skill) were the independent variables and project success dimensions were the dependent variables. These analyses suggest that R&D project success can be achieved with better leadership competency as well as stronger team commitment. The findings also indicate that team commitment may mediate the effects of leadership competency in terms of coordination skill and problem-solving skill on R&D project performance (i.e., cost and schedule success and quality performance).

This research also attempts to determine whether project type may act as a moderator between leadership competency and project performance. The findings indicate that project complexity has a moderating effect on the relationship between leadership competency and R&D project success. The results also suggest that projects with high and medium complexity were more likely to be successful when they experienced a high level of leadership competency than those with less complexity. Additionally, team size has a moderating effect on the relationship between leadership competency and R&D project success. Analyses suggest that large project teams were more likely to be successful when they experienced a high level of leadership competency than the other types of teams.

This paper reports on the findings of empirical research and provides recommendations for improving R&D project performance. Findings from this study are helpful to project managers in deciding whether to develop certain leadership competency. The sample for this study focuses on R&D projects in the high-tech industry. Consideration should be given to investigate the associations in other industries. This could also lead to greater insights into the associations between leadership behaviors and project success.

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