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Mapping the Influence of Project Management on Project Cost

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Abstract

This paper develops a framework to map the influence of Project Management (PM) attributes on project cost and then tests these relationships between PM attributes and project cost on industrial construction projects. PM attributes are identified and classified into five areas: Human Resource Management (HRM), function of PM, partnering and supply chain, design efficiency, and quality. The framework model is tested on survey data from member companies of the Construction Industry Institute (CII) using the Structural Equation Modeling method. The results reveal that quality, function of PM, and HRM can have a significant positive impact on project cost. Quality is found to have the most direct and greatest impact on project cost efficiency among PM attributes. The goal of this statistical study is to demonstrate the paths and strengths of the effects of PM attributes on project cost.

Keywords: *project management attributes, project cost, influence framework, structural equation modeling*

1. Introduction

Project cost control is one of the most important management techniques that contribute to project success. Cost overrun is so frequent that it is occurs on nearly all construction projects (Azhar *et al.*, 2008). History shows that significant cost overrun is endemic within the construction industry worldwide (Ameh, Soyingbe and Odusami, 2010) in both developing and developed countries (Angelo and Reina, 2002). It is widely acknowledged that the problem of cost overrun is critical and needs to be studied more to alleviate the issue.

Various studies have been conducted to address the factors affecting project cost. Some of the problems include unavailability of materials, inflation, price fluctuation in material, project complexity, excessive amendments of design and drawings, poor coordination among participants, ineffective monitoring and feedback, lack of project leadership skills, cash flow and financial difficulties, contractor's poor site management and supervision, inadequate contractor experience, shortage of site workers, incorrect planning and scheduling, and other factors (UNRWA, 2006; Memon, 2010; Okpala and Aniekwu, 1988; Chan and Park, 2005). Among these causes, many are related to project management; consequently, a deeper understanding of the attributes that influence project cost control is crucial to improving project outcomes (Avots, 1969; Nguyen *et al.*, 2004; Hasanzadeh *et al.*, 2011). PM maturity has a positive relationship with project success (Ibbs and Kwak, 2000) and good project management in construction is correlated with lower cost (Ibbs and Reginato 2002).

Many PM factors cause variations on cost performance. Mansfield *et al.* (1994) concluded that most of the problems from delay and cost overruns on construction projects can be attributed to human resources and management problems, such as financial arrangements, poor contract management, materials shortage, inaccurate estimating, and overall price fluctuations. Poor site management in the form of resource and schedule planning, supervision and control, and lack of experience are also causes of cost and time overruns, as stated by Chan and Kumaraswamy (2002), Kaming *et al.* (1997), and Ogunlana *et al.* (2003).

Chua *et al.* (1999) identified eight important project management attributes associated with achieving successful budget performance through an application of the neural network approach: (1) number of organizational levels between the project manager and craft workers, (2) amount of detailed design completed at the start of construction, (3) number of control meetings during the construction phase, (4) number of budget updates, (5) implementation of a constructability program, (6) team turnover, (7) amount of money expended on controlling the project, and (8) the project manager's technical experience.

The EFQM (European Foundation for Quality Management) model is a business excellence model used to measure and improve the overall quality of an organization (Westerveld, 2003). Using EFQM, studies developed the Project Management

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Performance Assessment (PMPA) model that includes enablers and results. Enablers include PM leadership, PM staff, PM policy and strategy, PM partnerships and resources, and project life cycle management processes. Results include key performance indicators such as cost and time (Bryde and David, 2003; Qureshi *et al*., 2009). A Structural Equation Modeling (SEM) perspective provides an extended understanding of the strength of the direct and indirect project management influencing factors on project performance (Zulu, 2007).

Nonetheless, the precise influence of PM factors on performance outcomes remains unclear (Brown and Adams, 2000). There is limited, quantifiable evidence of the effect of PM on cost performance (Thomas and Mullaly, 2007), yet an appropriate evaluation of the influence of project management factors upon project cost is timely and important. This paper aims to map the influence of project management attributes on project cost. To accomplish this goal, the paper is structured into three major parts. In the first section, the relationships of PM attributes and project cost are studied through a literature review and an influence framework is developed by building on the literature review and expert interview. In the second section, the influence framework is tested using the SEM method based on the data from industrial construction projects submitted by CII member companies and the influence coefficients of PM attributes on project cost are obtained. In the third section, the application of the tested framework and quantitative effects will be fully discussed.

2. Research Methodology

The influences of project management factors on project cost will be evaluated by a set of influence coefficients. To establish these coefficients, the following research process is carried out:

(1) Identify key PM factors through literature review
(2) Summarize and define PM attributes through literature review
(3) Establish a framework to map the influences of PM attributes on project cost to determine which of the variables influence outcomes
(4) Collect project data, perform reliability test, and data processing
(5) Select methods to test the influence framework model and calculate the influence coefficients
(6) Perform analysis and discuss results.

The research process and methods are shown below in Fig. 1.

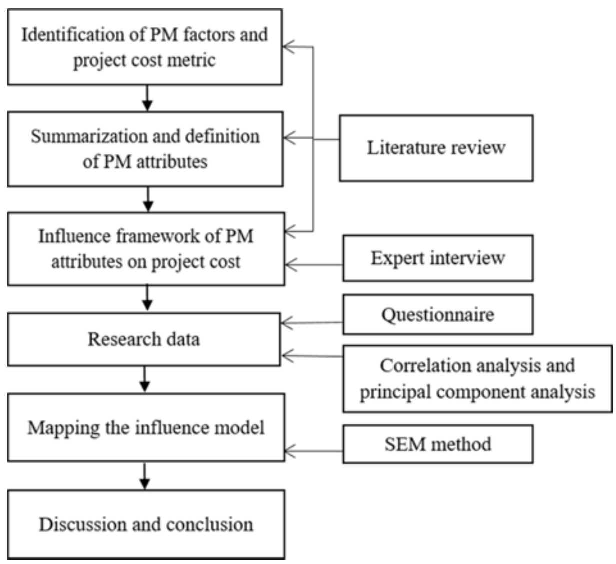

Fig. 1. Research Flowchart

2.1 Questionnaire Design

After a thorough review of the literature, PM factors affecting cost were identified, summarized, and classified into eight areas and cost efficiency was selected as a project cost metric. Data for PM factors and cost efficiency were collected from CII member companies who responded to CII's project level survey. CII members are leading engineering and construction owners, governmental agencies, contractors, and suppliers involved in the capital facilities process worldwide. At present CII members include 63 owners and 67 contractors. Project locations of member companies include North America, South America, Europe, Asia, Africa, and Australia.

In this study, only data from industrial construction projects was considered. The questionnaire consists of two parts. The first section captures descriptive and objective data about respondents and their projects. The next section deals with PM factors and asks the respondents to select from a range of responses e.g., strongly agree, agree, neutral, disagree, and strongly disagree, about statements related to PM practices. Responses are scored using a scale from -5 to +5, where -5 means "an extremely negative impact" compared to what was expected or planned and +5 means an "extremely positive impact" compared to what was expected or planned. The questionnaire can be found in the CII document: Benchmarking and Metrics: Project Level Survey (large project questionnaire and small project questionnaire) (CII, 2012; CII, 2011).

2.2 Pearson's Correlation Analysis and Principal Component Analysis

The relationships between PM factors and project cost were studied based on the review of the theoretical and empirical literature. Project management functions can be classified into four types of activities, planning, organizing, leading, and controlling. Using the collected industrial construction projects data, the relationships between the four types of activities were tested quantitatively using the Pearson correlation analysis method.

Statistical analysis of the data showed that these PM functions are significantly correlated with each other. Therefore a new, independent variable was created to replace the four activity types using principal component analysis.

2.3 Expert Interview

Based on the relationships of PM attributes and project cost, a relational framework was developed. In addition to the questionnaire survey, two experts from CII were interviewed to provide a deeper insight into the relationships between PM factors and project cost. The two experts are researchers and consultants in the field of benchmarking for capital projects and are program management experts. They are very familiar with project performance assessment. The author and the two CII experts discussed the relationships between the factors and the rationality for the framework. Each expert provided valuable perspective, insight, and expertise.

2.4 Structural Equation Modeling Method

It is important to assess the internal validity of the relational framework model from a statistical perspective. Structural Equation Modeling (SEM) is a statistical method designed to test a conceptual or theoretical model (Kline, 2010). SEM is defined as a statistical methodology that takes a confirmatory approach to the analysis of a structural theory bearing on some phenomenon and includes two components. First, the causal relationships under study must be represented by a series of structural equations and second, these structural relationships are then modeled pictorially to enable a clearer conceptualization of the theory under study. SEM provides a method for statistically testing hypothesized relationships between variables simultaneously to determine the extent to which the model is consistent with the data (Bryne, 2001; Schumacher *et al.*, 2004). SEM has been used in some studies to determine the influence of project management on project performance (Gowan and Mathieu, 2005; Sambo Zulu 2007), for example.

In this study, confirmation was needed to determine whether the data from the industrial construction projects fit the relational framework model. This can be examined using SEM, and so the validity of the framework model to determine how project management factors affect project cost and the proposed hypothesis were tested.

Another strength of the SEM method is that it accounts for both the direct relationships between variables and indirect relationships between PM attributes and project cost. Thus, the use of SEM improves the understanding of both direct and indirect influences of PM attributes on project cost.

3. Project Management Attributes

3.1 Literature Review of PM Attributes Affecting Project Cost

According to A Guide to the Project Management Body of Knowledge (PMI, 2004), project management is the application of knowledge, skills, tools, and techniques to a broad range of activities in order to meet the requirements of a particular project. Project management consists of nine knowledge areas: integration, scope, cost, time, quality, risk, human resources, communication, and procurement management. Having a cost target is one of the key project requirements. A comprehensive literature review was conducted to identify the major project management factors affecting project cost. Table 1 shows the major causes related to PM identified by the literature review.

Based on the literature review results, the relevant causes for cost overrun that were related to PM were classified under a number of PM attributes. The PM attributes were selected based on their definition and associated activities and their availability as input measures in the CII 10-10 project performance assessment

Table 1. Summary of Studies in the Field of PM Attributes Affecting Project Cost

No.	Causes related to PM	References	PM attributes
1	Planning and scheduling by contractors; Change in the scope of the project	Azhar *et al.* (2008); Ameh *et al.* (2010); Enshassi *et al.* (2009); UNRWA (2006); Memon *et al.* (2010)	Planning
2	Frequent design changes; Amount of detailed design at the start of construction; Design effectiveness	Enshassi *et al.* (2009); Ameh *et al.* (2010); Chua *et al.* (1999); Meeampol and Ogunlana (2006)	Design efficiency
3	Slow decision-making; Lack of project leadership skills	Enshassi *et al.* (2009); Sambasivan and Soon (2007); Iyer and Jha (2005); UNRWA (2006); Memon *et al.* (2010)	Leading
4	Contractor's poor site management and supervision; Number of control meetings during the construction phase; Number of budget updates	Hoai and Lee (2008); Chua *et al.* (1999); Azhar *et al.* (2008)	Controlling
5	Project manager's technical experience; Competence of project team; Labor productivity; Team turnover; Shortage of site workers; Lapses in the management of human resources	Chua *et al.* (1999); Abdullah *et al.* (2009); Memon *et al.* (2010); Okpala and Aniekwu (1988); Meeampol and Ogunlana (2006)	Human resource management
6	Conflict or coordination among project participants; Communication among partners	Iyer and Jha (2005); Meeampol and Ogunlana (2006)	Partnering and Supply chain management
7	Number of organizational levels between the project manager and craft workers; Poor contract management	Chua and Loh (1999); Mansfield *et al.* (1994)	Organizing
8	Mistakes during construction; Amount of rework	Palaneeswaran *et al.* (2008); Hoai and Lee (2008); Sambasivan and Soon (2007); Josephson *et al.* (2002)	Quality
9	Contractor experience; Contractor's financial management ability	Enshassi *et al.* (2009); Hoai and Lee (2008); Chan and Park (2005)	Contractor's competence
10	Change orders due to enhancements required by client	Nega (2008)	Owner

Table 2. Definitions of PM Attributes and Project Cost Efficiency

PM factors/output metric	Explanation
Human resource management	Examines if the project is staffed correctly, with a minimum amount of staff turnover and appropriate training. Measures if people are capable of achieving project goals.
Planning	The work a manager performs to predetermine a course of action. The function of planning includes the following activities: forecasting, objective setting, program development, scheduling, budgeting, and policies and procedures development.
Organizing	The work a manager performs to arrange and relate the work to be done so people can perform it most effectively. The function of organizing includes the following activities: development of organization structure, delegation of responsibility and authority, and establishment of relationships.
Leading	The work a manager performs to cause people to take effective action. The activities involved in the function of leading include: decision-making, communications, motivation, selection of people, and development of people.
Controlling	The work a manager performs to assess and regulate work in progress and completed. Management controls are achieved through the following activities: establishment of performance standards, measurement of performance, evaluation of performance, and correction of performance.
Design efficiency	Measures if the project team is exhausting all techniques to optimize the design in its use of material quantities to provide maximum capacity at minimum cost.
Partnering and supply chain management	Examines the strategies used by the project team to promote enhanced working relationships among all project stakeholders including those in the project supply chain.
Quality	Measures if the project team is strictly conforming to project requirements. Analyzes if programs are pursued to assure the delivery of material goods as intended.
Project cost efficiency	Forecasted total project cost / capacity

Note: Definitions of PM attributes and project cost efficiency are cited from CII document: The 10-10 Program (Kang *et al*., 2014).

program. In the following sections, each attribute is discussed in more detail.

Table 1 organizes the various PM-related causes for cost overrun found in the literature into ten categories including planning, design efficiency, leading, controlling, human resource management, partnering and supply chain management, organizing, quality, contractor's competence and owner. Contractor's competence and owner issues were excluded from this study because they are out of the project manager's control, although they do have an effect on cost. For simplicity, this study will refer to human resource management as HRM, partnering and supply chain management will be called supply chain, and project cost efficiency will simply be called cost efficiency. PM attributes and definitions will be presented in the next section.

3.2 The Definitions of PM Attributes

Ultimately, eight PM attributes were selected for inclusion in this study: human resource management, planning, organizing, leading, controlling, design efficiency, partnering and supply chain management, and quality. The CII 10-10 Program is based on the concept of anonymously surveying members of a project's management team regarding their project's performance, team dynamics, and organizational relationships. The objective and subjective questions contained in each questionnaire combine to create 10 input measures and 10 output measures. Ten input measures are surveyed during the project's development phases and are designed to warn senior management of impending problems. Ten outcome measures provide certainty that the project is proceeding on target, such as project cost efficiency (Kang *et al*., 2014). The questionnaire can be seen on CII's website (https://wikis.utexas.edu/display/CII1010/10-10 + Questionnaires). The definitions of eight PM attributes are shown in Table 2.

Total project cost is greatly affected by project size and project cost efficiency. Project cost efficiency is defined as the forecasted total project cost divided by capacity. Better cost efficiency indicates less money spent on unit production capacity (such as megawatts for an electrical project). Since units of cost efficiency are different for different types of projects, in order to reduce data diversity, project cost efficiency was processed by logarithms.

4. The Influence Framework of PM Attributes on Project Cost

The purpose of this research is to map the relationships between PM attributes and project cost. In order to perform such an analysis, a suitable framework model between PM attributes and project cost is needed.

4.1 Framework Structure

In this framework, PM attributes, including planning, organizing, leading, controlling, HRM, supply chain, design efficiency, and quality are utilized along with project cost efficiency. The relationships between the PM attributes and cost efficiency were analyzed and the results are presented in section 6.

The UK Association for Project Management (APM, 1995) stated that project management is developed as a leadership concept of interdisciplinary activities with the objective to solve a temporary problem (Litke, 1995). Through examination on the definition of PM, it can be appreciated that: (1) the purpose of PM is to achieve project objectives; and, (2) PM functions include leadership, organization, planning, monitoring, and coordinating. On the other hand, the definition of management has been interpreted in many ways. For example, management can be defined as the art of getting things done through people (Norman, 2013). According to Leonard (2012), management is defined as what managers do. People are key to the success or

Fig. 2. Influence Framework Structure of PM on Project Cost

failure of any management activity.

George (1982), identified four fundamental functions of management e.g., planning, organizing, actuating and controlling. According to Henry Fayol, to manage is to forecast and plan, to organize, to command, and to control. The major functions of management can be categorized into four different functions known as planning, organizing, leading, and controlling. For theoretical purposes, it may be convenient to separate the function of management but practically these functions are overlapping in nature. For example, they are highly inseparable. Each function blends into the other and affects the performance of others. The basic management functions which include planning, organizing, controlling and leading, are also required for the management of any project (Frigenti and Comninos, 2006; Stretton, 2015). Analytically, it may be convenient to distinguish the management functions separately but practically the functions overlap in nature and are inseparable. Each function blends into the other and affects the performance of others. The influence of PM attributes on project cost can be mapped in a preliminary framework, as shown in Fig. 2.

4.2 An Influence Framework

It can be seen from Fig. 2 that people are the driving force of PM, and through the functions of management, the objectives of transformation variables and project cost are achieved.

Human Resources (HR) is primarily concerned with the management of people within organizations. The Function of PM is a combination of planning, organizing, leading, and controlling and it leads to transformation variables such as supply chain, design efficiency and quality. In the study project cost refers to cost efficiency. The relationships between HR, supply chain, design efficiency, quality, and cost efficiency will be discussed below.

Human Resource Management (HRM) is a fundamental function of PM (Belout and Gauvreau, 2004). This area has experienced a renewal in many organizations and has been gradually affirming itself as a strategic role (Tsui, 1990; Belout, 1998). Many researchers agree that HRM is one of the most crucial elements that contribute to an organization's success (Fabi and Petersen, 1992; Ulrich, 1987; Schultz *et al.*, 1987).

The basis for quality is that in general, things should be "done right" the first time and "rework" should be avoided. Quality is regarded as one of the prime indicators of a successful construction project and Quality Management (QM) is an integral part of the project management process. It enables and contributes to a process-oriented and transparent project management approach across all project phases (ISO10006). The quality of the entire project is a function of the collective sum of many inputs including quality of design, construction, operations and maintenance, management participation, good design with sufficient experience, cooperation and coordination between parties in the design and construction phases, consistent design drawings and specifications, good communications with owner, and selection of appropriate designers and contractors (Wilson, 1999). One study showed that effective management of quality can be ensured from the conceptual-design stage of the project (Oyedele *et al.*, 2003).

QM in projects covers those activities to meet the project requirements in terms of functionality, costs, and deadline, therefore QM can lead to cost variation (ISO10006). The objective of QM in projects is to fulfill contractual obligations and obtain the appropriate level of customer satisfaction. Quality has traditionally been interpreted as the ability to satisfy needs, conformance to requirements, and fitness for purpose (Husin, 2008; ISO10006). Poor attention has been given however, to quality in relation to the cost of construction. Actual quality is cost-sensitive (Idiake, 2015).

Supply chain management describes the discipline of optimizing the delivery of goods, services and related information from supplier to customer (Cooper *et al.*, 1997). Efficiently and effectively managing the flow of material from supply sources to the ultimate customer involves proper design, planning and control of supply chains, and offers opportunities in terms of quality improvement, cost and lead time reduction (Persson, 2002), and rapid response to changes or new developments (Bowersox, 1996). Different supply chains link with the distinct result in quality and costs. (Persson, 2002).

Low costs can always be attributed to good decision-making during product design (Ehrlenspiel, 2007). Improving construction design through the application of the lean thinking paradigm could improve the designer's cost and program visibility when choosing between design options to increase the cost efficiency. (Morris, 1999). The quality of design is associated with cost efficiency.

Based on the above analysis between PM attributes and project cost, two experts from CII were interviewed to provide a deeper insight into relationships between PM attributes and project cost. The relationships between the factors and the rationality of the framework were discussed. The two experts both agreed that direct impacts of supply chain management and design efficiency on cost efficiency were not significant and that the two causal relationships could be cut out. A causal relationship framework was developed and shown in Fig. 3. The solid lines indicate causal relationships between factors and the two dotted lines indicate that the direct impacts of supply chain management and design efficiency on cost efficiency do not need to be considered according to the two experts' suggestion. The framework without the two dotted lines is named model A and the framework with the two dotted lines is named model B. The comparison of the

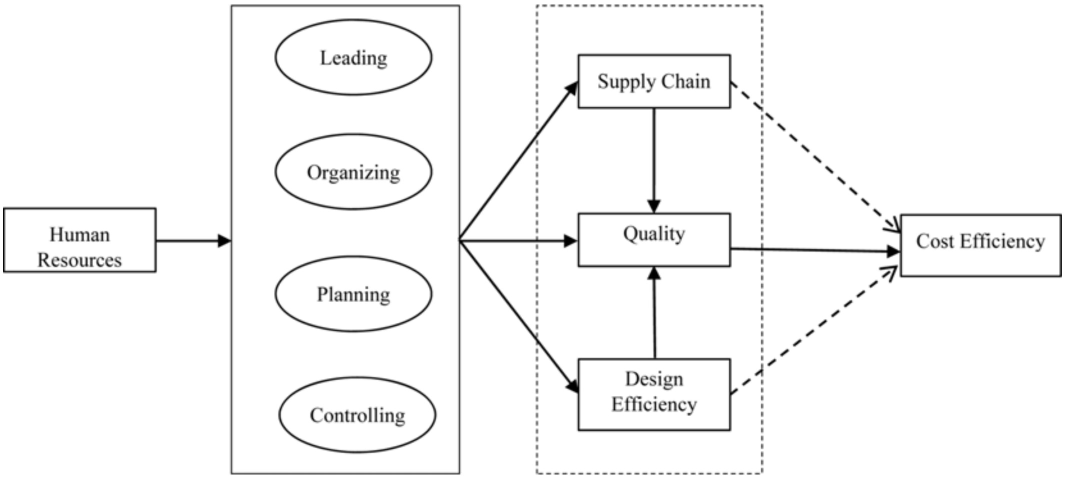

Fig. 3. The Influence Framework Indicating Relationships between PM Attributes and Project Cost

two models will be discussed in section 6.1.

4.3 Hypotheses

Based on the influence framework model A, seven proposed relationships between factors are hypothesized as follows:

H1. HRM is positively correlated with improved function of the PM effort.

H2. The PM function is positively correlated with improved supply chain.

H3. The PM function is positively correlated with improved quality.

H4. The PM function is positively correlated with improved design efficiency.

H5. Supply chain is positively correlated with improved quality.

H6. Design efficiency is positively correlated with improved quality.

H7. Quality is negatively correlated with cost efficiency.

5. Research Data

This section provides a description of the project data that were collected from CII member companies and a discussion of the statistical and reliability tests that were performed. Among the eight-selected PM factors, planning, leading, controlling, and organizing are related PM functions, and the correlation degree between the PM functions was expected to be high, from a theoretical perspective. Correlation analysis was used to get the correlation coefficients between planning, leading, controlling, and organizing, and if the correlation coefficients between PM attributes were found to be high then principal component analysis can be used to reduce the PM functions and make independent variables. The remaining PM attributes are evaluated in later sections.

5.1 Data Collection

Through the project-level survey, the data were gathered from 86 industrial construction projects executed mainly in North America from 2010-2014. The questionnaire collects responses on factors including HRM, leading, planning, controlling, organizing, design efficiency, supply chain, quality, and cost efficiency.

Although data from 86 industrial construction projects were provided, project cost efficiency of some of the projects was missing. Ultimately, data from 57 projects were used in the analysis and the remaining were discarded due to incomplete data. The Statistical Package for Social Science (SPSS) version 17.0 was used to analyze the data.

The project data set can be sorted according to project size, location, and type so the general nature of the 57 projects can be easily ascertained. From the perspective of project size, 38.6% of the projects had a value of between $10M and $100M US; 31.6% of the projects had a value of between $100M and $1000M US; 3.5% of the projects had a value of more than $1000M US, and 26.3% of the projects had a value of less than $10M US. If the total cost of a project is larger than $5MM, the project is considered a large project (CII, 2012). The majority of the projects have a value of greater than $10M US and therefore are large-scale projects.

According to the geographical distribution of project locations, 63.2% of the projects were located in the USA and 12.3% of the projects were in Canada, and 3.5%, 5.3%, and 5.2% of the projects were from South America, Asia and Africa respectively. In essence, 75.5% of the projects are from North America. In addition, region and time can influence project cost. In the study 75.5% of the projects are from North America, all projects were built from 2010 to 2014, therefore, the influence of region, and time was limited.

Industrial projects are the focus of this research and include manufacturing projects, oil and gas projects, electrical and environment projects, mining and metal refining projects, and so on. According to the distribution of projects by type, 17.5% of the projects were manufacturing projects, 8.8% were oil and gas projects, 29.8% were electrical and environment projects, 24.6% were mining and metal refining projects, and 19.3% were of unknown type.

Table 3. The Values of Cronbach α for Eight PM Attributes

	HRM	Planning	Organizing	Leading	Controlling	Quality	Design efficiency	Supply chain
Cronbach α	0.676	0.702	0.731	0.689	0.603	0.632	0.664	0.831

5.2 Reliability Test

Reliability testing depicts the degree of consistency of the data collected. The Cronbach α coefficient is a measure of inner consistency. Reliability is low when Cronbach α is less than 0.3 and it cannot be accepted. Reliability is high when Cronbach α is more than 0.7 where it indicates the inner consistency is at a high level and is therefore highly acceptable. The value of alpha is desirable with a range higher than 0.5 to 0.6 (Nunnally, 1978; Meeampol and Ogunlana, 2006).

The eight PM factors are related to attitude and are subjective, whereas cost efficiency is an objective variable, so the Cronbach α coefficient was done to test inner consistency for the eight subjective variables. The values of Cronbach α for the PM attributes are shown in Table 3, and from Table 3 it can be seen that all of the values of alpha are more than 0.6, which indicates that the inner consistency for the eight PM attributes is highly acceptable. The Cronbach α result for the whole index in this study is 0.936 and therefore it can be concluded that the questionnaire has reliability and stability.

5.3 Correlation Analysis

Correlation is a term that refers to the strength of a relationship between two variables. Correlation analysis is used to test the significance of the relationship between two variables. The Pearson correlation coefficient is a measure of the strength and direction of the linear relationship between two variables that is defined as the (sample) covariance of the variables divided by the product of their (sample) standard deviations. It is widely used in the sciences as a measure of the degree of linear dependence between two variables. Pearson's correlation coefficient is the covariance of the two variables divided by the product of their standard deviations (Karl Pearson, 1895; Gayen, 1951).

Planning, leading, controlling, and organizing are the main functions of PM, and from the theoretical perspective, the four factors are related with each other and highly inseparable. In order to make new independent variables, correlation analysis of the four PM functions was carried out. The result of correlation coefficients is shown in Table 4. The result shows that the correlation coefficient between organizing and leading is 0.768,

Table 4. Pearson Correlation Coefficients between Planning, Organizing, Leading and Controlling

	Planning	Organizing	Leading	Controlling
Planning	1	.686**	.727**	.672**
Organizing	.686**	1	.768**	.765**
Leading	.727**	.768**	1	.744**
Controlling	.672**	.765**	.744**	1

**Correlation is significant at the 0.01 level (2-tailed).

which is the highest, followed by the correlation coefficient between organizing and controlling at 0.765. The correlation coefficients between leading and controlling, leading and planning, planning and organizing were 0.744, 0.727, and 0.686, respectively. The smallest correlation coefficient was between planning and controlling, at 0.672. The results confirm that planning, leading, controlling, and organizing are significantly correlated with each other since the correlation coefficients are in the range of 0.6 to 0.8, are very high.

5.4 Principal Component Analysis

Since planning, organizing, leading and controlling were found to be significantly correlated with each other a new independent variable comes into being to replace the original four factors, using principal component analysis.

Principal Component Analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables (Jolliffe, 2002).

The results of the principal component analysis using data from 57 industrial projects are shown in Table 5. According to the Kaiser-Meyer-Olkin (KMO) and Bartlett's test, the measure of sampling adequacy is 0.851, which is greater than 0.7, showing that the effect of factor analysis is good. Bartlett's test of sphericity is 155.194 and the P = 0.000, which is less than 0.05 (Contreras, 2011), showing that the original hypothesis is rejected and factor analysis can be done. According to total variance as explained in Table 5, one common factor is extracted

Table 5. Total Variance Explained

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1 principal component	3.215	80.369	80.369	3.215	80.369	80.369
2 principal components	.350	8.762	89.131			
3 principal components	.232	5.802	94.933			
4 principal components	.203	5.067	100.000			

and the variance-contributed rate of the common factor is 80.369%, using principal component analysis and the cumulative contributed rate of the factors is greater than 80% (Ho, 2014), which shows that the principal component can explain 80% of the original four factors. The principal component is calculated through the component matrix and eigenvalue. So, the four variables, planning, organizing, leading, and controlling, are replaced by one principal component, called 'Function of PM.'

6. Mapping the Influence of PM Attributes on Project Cost Using SEM Method

With the influence framework set up, assessment of the internal validity of the framework model from the statistical perspective is the next step. The SEM method was selected to statistically test the hypotheses based on the influence framework model, upon which the quantitative map of the influence of PM attributes on project cost is founded.

SEM analysis includes two approaches: covariance based SEM (CB-SEM) and partial least squares based SEM (PLS-SEM). CB-SEM involves a maximum likelihood procedure whose goal is to minimize the difference between the observed and estimated covariance matrices, as opposed to maximizing explained variance. CB-SEM is more applicable to confirmatory factor analysis and PLS-SEM is more suitable for exploratory work in finding and evaluating causal relationships (Byrne, 2002; Hair *et al*., 2013). Therefore, CB-SEM was chosen to map the influence of PM attributes on project cost because the relational framework model is developed and the validity of the model needs to be confirmed. The significance was estimated by CB-SEM on Amos 17.0 software using 57 samples.

Recommendations for determining sample size, based on the number of parameters to be estimated (Deborah, 1997). The number of observations per parameter estimate was contrasted by the measured variable parameter estimates. The ratio of sample size to number of parameters (namely N: q) might be able to go as low as 5:1 under normal and elliptical theory (Bentler *et al*., 1987). Jackson suggested that in the context of confirmatory factor analysis, N:q values could be 10:1 or more (Jackson, 2003). The question of how large of a sample size is required is a deceptively difficult one to answer. Bentler considered that higher values of the observations per parameter ratio had a positive effect for some measures of fit. However, the overall effect was small relative to sample size (Bentler *et al.,* 1987). In the study, there are six variables and no latent variables, and according to the influence framework (in Fig. 4) there are seven parameters to be estimated. Based on the ratio of 5:1 the sample number should be greater than or equal to 35, or based on the ratio of 10:1, the sample number should be greater than or equal to 70. Consequently, the 57 samples in the study are acceptable.

The normality of the variables was tested because the significance probabilities are estimated by the maximum likelihood method (Tenenhaus *et al.*, 2005). One sample Kolmogorov-Smirnov test was performed and the result is shown in Table 6. From the result, the asymptotic significance for cost efficiency was found to be 0.000, which is less than 0.05, indicating that the cost efficiency data is not normally distributed. The asymptotic significance of all other variables were higher than 0.05, indicating that the other variables are normally distributed. Data for cost efficiency was transformed by the logarithm function and the transformed data is normally distributed. The data for HRM, function of PM, design efficiency, quality, supply chain, and the transformed data of cost efficiency were included in the SEM analysis.

6.1 Comparison of Two Framework Models

With the framework model A and B, assessment and comparison of the internal validity of the two models will be carried out using the SEM method. The values of χ^2/df for model A and model B are respectively 1.232 and 1.514 (if $1 < \chi^2/df < 2$, the model is acceptable), which shows that two model fits are both acceptable. AIC and ECVI for model A and model B are shown in Table 7. AIC, BCC, BIC, and CAIC of model A are smaller than those of model B. The ECVI and MECVI values of model A are also smaller than those of model B. Therefore, model A is more suitable for the data than model B (Minglong Wu, 2010), and the impacts of supply chain and design efficiency on cost efficiency are confirmed to not be significant. This result is consistent with two experts' suggestion that direct impacts of supply chain and design efficiency on project cost were not significant. Consequently,

Table 6. One Sample Kolmogorov-Smirnov Test of Variables

	Human resources	Function of PM	Design efficiency	Quality	Supply chain	Cost efficiency
Mean	.6253	1.3013	.5054	.6323	.6409	369468.55
Std deviation	.09450	.20260	.18079	.12541	.16597	848272.25
Kolmogorov-Smirnov Z	.670	.724	1.260	.710	.897	2.481
Asymp. Sig (2-tailed)	.761	.671	.084	.695	.397	.000

Table 7. AIC and ECVI for Model A and Model B

Model	AIC	BCC	BIC	CAIC	ECVI	LO 90	HI 90	MECVI
Model A	35.855	39.647	62.185	75.185	0.652	0.618	0.874	0.721
Model B	39.085	43.46	69.465	84.465	0.711	0.655	0.934	0.79

Table 8. Goodness of Fit Indices for the Measurement Model A

Fit index	Acceptable fit	Indices for data
Chi-square		9.855
df		16
P	>0.05	0.275
χ^2/df	≤2 to 5	1.232
RMR	<0.06	0.022
GFI	≥0.90	0.946
RMSEA	≤0.05 to 0.08	0.065
CFI	≥0.90	0.984
NFI (TLI)	≥0.90	0.924(0.97)
IFI	≥0.90	0.985

the two cuasal relationships can be cut out and model A is used for further study.

6.2 Goodness-of-fit Indices for the Framework Model A

The validity and reliability of the constructs in model A were estimated and a further examination in Table 8 of the goodness-of-fit indices for model A shows that the model is a relatively good fitting model. It is generally recommended to use a range of indices in order to assess a model (Schumacher and Lomax, 2004). An examination of the fit indices in Table 8 shows that model A fits the data fairly well. If the χ^2 has a p-value > 0.05 then the model is acceptable (Hair *et al.*, 1998). In this case the χ^2 value of 9.855 (p = 0.275) suggests that the model is acceptable. At the same time the values of RMR, GFI, CFI, NFI, RMSEA and IFI show that the model A fits well (Hair *et al.*, 1998) and the influence framework is acceptable.

6.3 Evaluation of Model A: Hypothesis Testing

Model A was tested on the Amos software with all the relationships shown in Fig. 3. The path coefficients represented by the regression weights are presented in Table 9. Based on the estimates it can be concluded that some relationships are confirmed. For example, the regression weight for HRM in the prediction of Function of PM is significantly different from zero at the .001 level (two-tailed), which means that HRM has a significant impact on the Function of PM.

Table 9 displays the findings of the structural equation model that tests the seven hypotheses. From the results of hypothesis tests, five of the seven hypotheses were confirmed. It was confirmed that HRM has a statistically significant influence on the Function of PM since the C.R. value exceeds the 1.96 threshold. The Function of PM was found to have a statistically significant influence on quality, design efficiency and supply chain. Quality was shown to have a statistically significant influence on cost efficiency. The other two relationships were not confirmed, however. The impacts of supply chain and design efficiency on quality were not found to be statistically significant.

The findings from the analysis summarized in Table 9 were mapped and are shown in Fig. 4 in the following section.

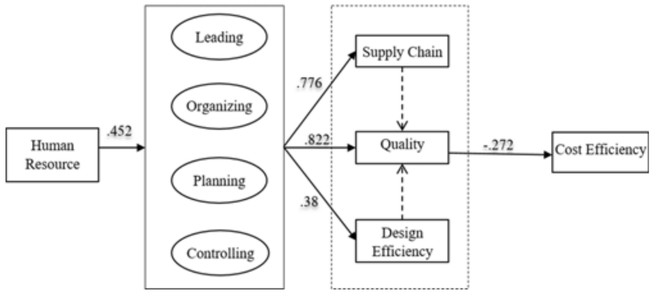

Figure note: solid arrows indicate statistically confirmed relationships and the numbers on the solid arrows indicate correlation coefficient values (standardized). Dotted arrows indicate statistically unconfirmed relationships.

Fig. 4. Significant Paths of the Influence Framework

7. Discussion

7.1 Results and Findings

The statistically negative relationship found between PM attributes and project cost was consistent with previous research, (Chua *et al.*, 1999; Azhar, Farooqui and Ahmed, 2008). SEM results show that the rational framework is accepted when χ^2 value of 9.855 (p = 0.275 > 0.05). This indicates that the chance of reduction of project cost can be significantly increased by improving the level of performance of PM attributes.

In the influence framework model A, among 7 causal relationships (or hypotheses) 5 causal relationships (or hypotheses) were statistically confirmed. Fig. 4 shows the influence framework with statistically confirmed relationships and their standardized correlation coefficient values. The correlation coefficient values indicate the strength and direction of the impact between variables, and the larger the correlation coefficient value, the

Table 9. Results of Hypothesis Tests

	Estimate (standardized)	S.E.	C.R.	P	Conclusion
Function of PM<---HRM	0.452	0.258	3.76	***	Confirmed
Design Efficiency<---Function of PM	0.38	0.111	3.043	**	Confirmed
Supply Chain<---Function of PM	0.776	0.07	9.125	***	Confirmed
Quality<---Function of PM	0.822	0.091	5.579	***	Confirmed
Quality<---Supply Chain	-0.132	0.108	-0.923	0.356	Not confirmed
Quality<---Design Efficiency	0.05	0.067	0.516	0.606	Not confirmed
Cost Efficiency<---Quality	-0.272	4.729	-2.095	*	confirmed

***Correlation is significant at the 0.001 level; **correlation is significant at the 0.01 level; *correlation is significant at the 0.05 level.

greater impact of the first variable upon the other one.

Cost efficiency, HRM, and quality are discussed in the following paragraphs.

(1) Impact paths of project cost

- Three paths were found where HRM affects cost efficiency: the first path is HRM-Function of PM-quality-cost efficiency, the second is HRM-Function of PM-supply chain-quality-cost efficiency, and the third path is HRM-Function of PM-design efficiency-quality-cost efficiency. The HRM-Function of PM-quality-cost efficiency path was statistically confirmed and the standardized path coefficient of HRM affecting cost efficiency is -0.101, which indicates that the improvement of HRM can indirectly explain 10.1% of a project's variation in cost efficiency.
- The paths where Function of PM affects cost efficiency are the same as HRM affecting cost efficiency. The Function of PM-quality-cost efficiency path was statistically confirmed and the standardized path coefficient of Function of PM affecting cost efficiency was -0.224, which indicates that PM function improvement can indirectly lead to better cost efficiency with Function of PM explaining 22.4% of the variation in cost efficiency.
- Quality was confirmed to directly affect cost efficiency. The path coefficient is -0.272 which indicates that improvement of quality can explain 27.2% of the variation in cost efficiency.
- Based on the statistically confirmed paths of the influence framework there were three PM attributes that directly and indirectly affected project cost, with quality as the most significant factor, Function of PM is the second most significant factor and HRM is the third.

(2) The impact of the Function of PM on transformation variables

- The impact of Function of PM on quality was found to be the largest, followed by the impact of Function of PM on supply chain, and then the impact of Function of PM on design efficiency.
- Through the improvement of Function of PM, the level of supply chain and quality could be increased significantly. In contrast, improvement of Function of PM was found to increase the level of design efficiency, but not significantly.

(3) The Quality Factor

- Quality is at the core of the influence framework. Quality is related to PM functions as well as project cost. The impact of quality on cost efficiency was negative and not found to be significant however.

7.2 Implications

Companies spend significant resources on project management (PMI, 2009) and executives seek evidence that their organizational efforts have borne fruit. Researchers agree that effective project management during the construction phase is important for project performance. In the study it is proved that PM attributes have significant impact on project cost and this result is consistent with previous research (Memon *et al.*, 2010; Belout and Gauvreau, 2004). The Function of PM explained 22.4% of the variation in cost efficiency, quality explained 27.2% and HRM explained 10.1%. This demonstrate that quality, Function of PM and HRM are major contributors to project cost efficiency. There are several important implications that project managers and contractors should take into advisement from this research. It suggests that cost efficiency can be improved by implementing management measures to improve the performance of HRM, PM functions and quality, with perhaps more focus directly on quality.

This study also arrives at the conclusion that HRM is a driving force that moves the functions of PM and some other outcomes, and confirms that HRM is a crucial element to an organization's success (Hasanzadeh *et al*., 2011; Saba, 2002). Therefore, another implication is that HRM can directly and indirectly affect all the PM factors and project cost.

Planning, leading, controlling, and organizing are major functions of PM and were combined in this study into Function of PM variable. It was clearly established that the Function of PM directly drives transformation variables and indirectly drives project cost. The improvement of each of the four functions of PM not only reduces project cost indirectly but also enhances quality, supply chain and design efficiency.

Quality was found to be a key factor on the impact of Function of PM, supply chain and design efficiency on project cost can be accomplished through quality (Wilson, 1999; Oyedele *et al*., 2003). Accordingly, it is found from the results that the most efficient way to reduce PM cost is improving quality. With project teams more strictly conforming to project requirements, the reduction in project cost is significant.

Although supply chain and design efficiency were selected as transformation variables they had no significant effect on cost efficiency, however, it is necessary to focus on them for other reasons. The improvement of PM functions can significantly influence supply chain effectiveness and design efficiency.

However, allocating too much cost on the improvement of quality, function of PM, or HRM will offset cost efficiency gains. Consequently, the cost on the improvement of quality, function of PM, and HRM is of important significance for total cost reduction. There are several situations:

(1) The most efficient way to reduce PM cost is improving quality, and the level of quality is gradually improved until the increased cost caused by the variation in Quality is greater than project cost reduction.
(2) The second efficient way to reduce PM cost is improving PM functions until the increased cost caused by the variation in PM functions is greater than project cost reduction.
(3) The third way to reduce PM cost is improving human resource management until the increased cost caused by the variation in HRM is greater than project cost reduction.
(4) Sometimes more than one methods (e.g., improving both quality and PM functions) may be used to reduce PM cost

until the increased cost caused by the variation in both Quality and PM functions is greater than project cost reduction.

8. Conclusions

It is widely acknowledged that the effectiveness of the Project Management (PM) effort is linked with project performance overall, however, this is the first statistical study using this approach to demonstrate the paths and strengths of effect of PM attributes on project cost. The paper was carried out in three phases. In the first phase, a review of the relationships of PM factors and project cost found in the literature review were discussed, and the influence framework was developed with seven proposed hypotheses. In the second phase, the influence framework was tested using the SEM method on industrial construction projects data collected from CII member companies. In the third phase, the application of the tested framework was fully discussed.

According to the results of the SEM and hypothesis tests, it was confirmed that there are significant relationships between PM attributes and project cost. Five hypotheses among the original seven were proved significantly. The HRM-Function of PM-quality-cost efficiency path was confirmed significantly, showing that HRM, the function of PM and quality can improve cost efficiency. The impact of quality on cost efficiency was the greatest, with quality explaining 27.2% of the variation in cost efficiency. Quality is proved to have the most direct and greatest impact on project cost efficiency among PM attributes. However, the increased cost caused by improving Quality, PM functions, or HRM will offset cost reduction, and so the level of quality, PM functions, and HRM cannot break through the critical points.

From the results, this research provides paths and strengths of the impact of PM attributes on project cost and enriches the project cost management body of knowledge. Specifically, the primary contribution of this research will be to help project managers and contractors reduce project cost by improving the levels of HRM, Function of PM, and quality in construction process. If the project is staffed correctly and if people are capable of achieving project goals, a project manager can improve planning, organizing, leading, and controlling. This supports the efforts of the project team to strictly conform to project requirements and to pursue programs to assure the delivery of material goods as intended. Such efforts will lead to reduction in project cost. The authors therefore recommend that project managers on cost-driven projects should give explicit attention to improving HRM, PM functions, and quality. Secondly, the results can help decision-makers to select whether to focus on HRM, Function of PM, or quality, according to the focus on cost objectives of each unique project. A decision-maker could select quality as the most efficient aspect to improve to revise current deviation from target in project cost. Finally, in the academic field, the results could provide a premise for further study on how deeply HRM, Function of PM, and quality influence project cost in order to find the specific measures to solve the project cost overrun.

In summary, the influence framework was confirmed statistically but further research is encouraged to determine the relationships between supply chain, design efficiency, and quality. Additional data from a broader range of project types could also enrich the model and expand its applicability to other sectors. Because the level of quality, PM functions, and HRM cannot break through the critical points, the critical points are worth further study.

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