Original Paper

Cohesion between Cost, Time and Quality Performance of Civil Engineering Project: Evidence from Contractor Prequalification Criteria

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Abstract

Setting cost, time and quality targets for civil engineering project is motivated by the need to have an instrument that would dictate and control activities of the contractor towards delivery of product that meets client's expectations. This study, which examines the relationship between cost, time and quality performance of civil engineering project, is premised on the importance of showing whether cost, time and quality performance of civil engineering project demonstrates different correlation patterns on one part or exhibit different significance relative to contractor prequalification criteria on the other part. It uses questionnaire to obtain the needed data and analysis achieved through spearman's rank correlation and regression methods. It establishes the nature of the cohesion between these three parameters. Consequently, both strong and weak positive relationship exists between contractor prequalification criteria and cost, time and quality performance of civil engineering project at p≤1%. In spite of this, interconnectivity between these three variables is demonstrated by contractor prequalification criteria. Cohesion also exists between cost, time and quality performance of civil engineering project at p≤5%. Therefore, criteria for contractor prequalification firmly bind cost, time and quality performance of civil engineering project. Also, the firmness of cost time and quality performance of civil engineering project depends of contractor prequalification criteria. Hence, client and representatives should take the cohesiveness of cost, time and quality performance into consideration when determining the choice of contractor prequalification criteria for civil engineering project.

Keywords

Cost, time, quality, civil engineering project, prequalification criteria

1. Introduction

The construction industry is characterized by production of structures stemming from building, civil engineering and heavy/industrial engineering arms of the industry (Oforeh, 2006; Barbara, 2004). Each arm of the construction industry exhibits peculiar characteristics, parades projects with identifiable basic features, such as nature, type, magnitude and complexity. The construction industry, apart from meeting the demands of other industries, customarily satisfies the desire of clients through its products. However, every construction project's cost, time and quality receive attention of the consultants during project documentation with cost and time estimated while the conditions for achieving expected quality are predetermined. Before and during construction, activities of the consultants and contractor tend towards meeting cost, time and quality targets. Based on existing literatures, the price at which a construction project is awarded, its delivery period and expected quality standard are predominantly the three most essential criteria to be met by the project at completion. Hence, any construction project completed above budget is considered unsuccessful in spite of meeting time and quality targets. Therefore, delivery of construction project (civil engineering inclusive) within estimated cost and time without deviating from predetermined quality standard is usually a common goal of the stakeholders. According to Wenfa and Xinhua (2014), construction project's cost, time and quality are entirely different parameters, yet widely accepted as the three most important yardsticks to judge project performance in the construction industry. Similarly, Mallawaarachchi and Senaratne (2015) opine that no construction project is expected to favor any of these three variables at the expense of the other. Ironically, failure of construction project to meet one of these three variables implicationally indicates failure in others. Project's cost, time and quality frequently take the center stage among as many objectives that may form the interest of the project owner. This obviously suggest existence of interrelationship between cost, time and quality of construction project irrespective of whether it originates from building, civil engineering or heavy/industrial engineering sections of the construction industry. Consequently, efforts at affirming the inseparability of cost, time and quality performance of civil engineering project demands delving into determining the nature of the relationship between the three variables. Therefore, this study set to establish the cohesiveness of the cost, time and quality performance of civil engineering project using contractor prequalification criteria as basis. Depicts the manner of the relationship between cost, time and quality performance of civil engineering project. It also reflects the nature of the significance displayed by cost, time and quality performance relative to contractor prequalification criteria as far as civil engineering project is concerned. This shows whether significance difference exists in the relationship between cost, time and quality performance of civil engineering project relative to contractor prequalification criteria.

2. Method

2.1 Aim and Objectives

This study shows the cohesiveness of cost, time and quality performance of civil engineering project as indicated by contractor prequalification criteria with a view to establishing the inseparability of the three construction project performance measurement variables. In view of this, the objectives included:

i. to evaluate the relationship between cost, time and quality performance of civil engineering project as dictated by contractor prequalification criteria and;

ii. to determine the nature of the significance exhibited by cost, time and quality performance of civil engineering project relative to contractor prequalification criteria.

2.2 Review of Literature

2.2.1 Brief on the Concept of Cost, Time and Quality of Construction Project

Cost refers to the financial implication of the project thereby relieving the client of the fear of unknown in respect of how much to expend on the project from start to finish. Time, on the other hand, involves how long it will take the contractor to execute and complete the project, indicating the starting and completion dates, hence giving the client an idea about when the project would be delivered. However, quality deals with identifying and clearly stating the various requirements to be met by the project, thus, relieving the client of the fear of getting a product that would not stand the test of time. Therefore, construction project's cost, time and quality constitute major areas of interest for both the client and consultants in the construction industry. Since every construction project obviously need specific amount of money to be expended on it within estimated period and predetermined standard of requirements, attempts have been made by researchers to establish the imperativeness of ensuring that project meets these targets. Once established, consultants and contractor strive to make the client happy by delivering project within the cost, time and quality targets. Bojan S., Dragan, Bojan P., Dejan, and Slavica (2014) shows that quality issues on construction project manifest after completion irrespective of whether completed within cost and time targets. Literatures evidently reveal that cost, time and quality of project perform a number of roles. Apart from forming the determinants of project performance, the work of Jose (2009) stipulates that cost, time and quality of construction project are highly essential in the planning and controlling of projects. Consequently, construction cost, time and quality determination demand decision making after gathering relevant data and information by the consultants engaged on the project. Activities needed by these three major construction project performance measurement parameters may not be commensurate with one another since they demand entirely different data and information, length of time and activities for their determination. Furthermore, Wenfa and Xinhua (2014) opine that cost and time exhibit similar characteristics by being quantitative in nature differently to quality which has to do with compliance with predetermined standard.

2.2.2 Relevance of Cost, Time and Quality in Measuring Construction Project Performance

Construction project's client is always interested in the cost, time and quality of projects (Kathy, Paul, Keith, Peter, & Rob, 2007). According to Wenfa and Xinhua (2014), several research efforts stress the importance of cost, time and quality relative to their indispensability in measuring construction project performance. For instance, Shankar, Raju, Srikanth, and Bindu (2011) submit that cost, time and quality take center stage in project evaluation. Similarly, Kathy, Paul, Keith, Peter, and Rob (2007) opine that cost, time and quality constitute major construction project performance measurement criteria while noting their interdependency. In same vein, Bojan, Dragan, Bojan, Dejan, and Slavica (2014) support the research results which stipulate that construction project performance cannot be determined without measuring it against its cost, time and quality. Hence, minimizing construction project cost often leads to use of substandard material which eventually bring about poor quality in the long run. Despite the fact that cost is usually prioritized in the selection of contractors, it is often influenced by time. Construction project cost, time and quality constitute different variables, so they are difficult to balance in spite of being interdependent. This shows that construction project quality can be affected by adjusting the time and cost. Also, increasing construction project's cost and time brings about quality enhancement. Hence, reducing construction project time and cost leads to jeopardizing quality.

2.2.3 Relationship between Cost, Time and Quality Performance of Construction Project

According to Kathy, Paul, Keith, Peter, and Rob (2007) and Bojan S., Dragan, Bojan P., Dejan, and Slavica (2014), construction project's cost, time and quality are interdependent and not separable because one affects the other having established and described the degree of the relationship existing between them. Research result in Ifte, Mahiuddin, and Abdul (2002) indicate that positive relationship exists between cost, time and quality of construction project while noting that construction project time can be predicted if the cost is known. In like manner, Wikipedia (2017) agrees that relationship exists between cost, time and quality of construction project. It believes that project can be achieved faster by either reducing the scope or increasing the cost. However, expanding project's scope may demand corresponding increase in the cost and time while reducing the cost without equivalent reduction in the time or scope brings about lower quality. Similarly, Bojan S., Dragan, Bojan P., Dejan, and Slavica (2014) finds that adjusting one of these variables affect the other, thus cost, time and quality of construction project cannot be separated in spite of being adjustable. However, the nature of the relationship between cost, time and quality indicate that increased quality demand increased cost and time. On the other hand, reducing the time brings about quality reduction while cost increases. Hence, researchers suggest balancing the three variables because of their interdependency, inseparability and indispensability in ascertaining the status of construction project performance.

2.2.4 Relationship between Contractor Prequalification Criteria and Performance of Civil Engineering Project in Terms of Cost, Time and Quality

Construction industry is characterized by production of structures of various magnitudes irrespective of whether emanating from building, civil engineering or heavy/industrial engineering. Each product, which is generally known as project, usually has associated cost, time and quality standard. Achievement of construction project through contracting method demands involvement of a contractor who undertakes to construct and complete project to the satisfaction of both the client and consultants. Choosing such contractor depends on meeting predetermined prequalification criteria which can be determined by the client or consultants, who represents the client. According to Akinmusire (2015), a number of major contractor prequalification criteria are available in the construction industry. These include general/background, technical ability, financial ability, management capability, reputation, past performance, health and safety, relationship, and environmental and socio-political criteria. Efforts have been made to study the relationship between contractor prequalification criteria and civil engineering project performance in terms of cost, time and quality. Research results indicate that different kind of relationship exist between contractor prequalification criteria and cost, time and quality performance of civil engineering project. For instance, Adedokun, Akinmusire, and Aje (2016) and Ologunagba and Akinmusire (2016) respectively show that contractor prequalification criteria positively relates with cost and time performance of civil engineering project. Contrarily, contractor prequalification criteria show both positive and negative relationship with quality performance of civil engineering project Kothari (2004). In this case, financial ability displays negative relationship with quality performance of civil engineering project. This undoubtedly shows that cost, time and quality performance of civil engineering project is affected by contractor prequalification criteria. So, contractor selected on the basis of these prequalification criteria is saddled with the responsibility of completing project on schedule, without seeking extra fund and lowering the standard.

2.2.5 Data Collection, Analysis and Presentation

This study adopted questionnaire method of data collection. The questionnaire elicited information from 156 respondents engaging in civil engineering project in the six western states of Nigeria. In order to achieve the objectives of the study, respondents were requested to score the relationship between identified nine major contractor prequalification criteria (derived from literatures) and cost, time and quality performance of civil engineering project on a 5-point scale so as to obtain the needed ordinal data in this regard. However, data analysis was achieved through Spearman's rank correlation and regression methods. The contractor prequalification criteria were separately correlated with cost, time and quality to establish the degree of association between them using the formula below.

$$\text{Spearman's Coefficient of Correlation } (r) = 1 - \frac{6 \sum d_i 2}{n(n^2 - 1)} \qquad (1)$$

Where

di is the difference between ranks if ith pair of the two variables

n represents the number of pairs of data

Σ denotes the summation of the items indicated

The decision rule is as follows:

If the Rs value

Is -1, there is a perfect negative relationship

falls between -1 and -0.5, there is strong negative relationship

falls between -0.5 and 0, there is weak negative relationship

is 0, there is no relationship

falls between 0 and 0.5, there is weak positive relationship

falls between 0.5 and 1, there is strong positive relationship

is 1, there is a perfect positive relationship

The analysis tools, which allowed independent variables to be measured against dependent variables Kothari (2004), were adopted to show whether significance difference exist in the p-value of cost, time and quality performance of civil engineering project. Consequently, the needed correlation coefficients and p-values separately obtained for cost, time and quality performance of civil engineering project were extracted from the table generated by the analysis tools and presented accordingly.

3. Result

Consequent upon analyzing the data gathered in respect of this study, Table 1 reflected the nature of the relationship and significance value displayed by cost, time and quality performance of civil engineering project relative to contractor prequalification criteria. The correlation coefficient exhibited by cost, time and quality performance of civil engineering project in this regard slightly differed from one another. It ranged between 0 and 0.50 as well as 0.50 and 1 for cost, time and quality. Going by approximation and the decision rule earlier stated in this study, contractor's general/background criterion reflected weak positive relationship with cost, time and quality performance of civil engineering project since the correlation coefficient fell within 0 and 0.50 regions. On the other hand, the correlation coefficient of contractor's technical ability was less than 0.50 for cost but more than 0.50 for time and quality, signifying both weak and strong relationship. Past performance demonstrated contrary pattern of relationship by strongly correlated with cost but related weakly with time and quality performance of civil engineering project because their correlation coefficient ranged between 0.50 and 1. Contractor's financial ability, health and safety, and relationship strongly correlated with cost and time performance of civil engineering project while weakly correlated with quality performance. The correlation coefficient in this case fell between 0 and 0.50, and 0.50 and 1 respectively. However, contractor's reputation and environmental and socio-political criteria recorded strong relationship with cost performance of civil engineering project. The relationship between these contractor prequalification criteria and time and quality performance of civil engineering project was weak since their correlation coefficient fell between 0 and 0.50, and 0.50 and 1 respectively. Furthermore, correlation between

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contractor's management ability with cost, time and quality performance of civil engineering project with was also weak because the correlation coefficient fell between 0 and 0.50.

Table 1. Relationship between Contractor Prequalification Criteria and Performance of Civil Engineering Project in Terms of Cost, Time and Quality

Contractors' prequalification criteria	Correlation coefficient			p-value		
	Cost	Time	Quality	Cost	Time	Quality
General/Background	0.417**	0.388**	0.462**	0.000	0.000	0.000
Technical ability	0.497**	0.540**	0.532**	0.000	0.000	0.000
Financial ability	0.566**	0.532**	0.336**	0.000	0.000	0.000
Management ability	0.410**	0.399**	0.495**	0.000	0.000	0.000
Reputation	0.571**	0.441**	0.431**	0.000	0.000	0.000
Past performance	0.559**	0.479**	0.464**	0.000	0.000	0.000
Health and safety	0.618**	0.550**	0.383**	0.000	0.000	0.000
Relationship	0.602**	0.528**	0.368**	0.000	0.000	0.000
Environmental and socio-political	0.506**	0.350**	0.355**	0.000	0.000	0.000

**Correlation is significant at 1% ($p \leq 0.01$).

The p-value ($p \leq 0.01$) for cost, time and quality performance of civil engineering project as dictated by contractor prequalification criteria was 0.000. This means that cost, time and quality performance of civil engineering project demonstrated same significance value with contractor prequalification criteria. From Table 2, R^2=0.488, Adjusted R^2=0.456 and F-value=15.459 for cost. The R^2, adjusted R^2 and F-value for time were estimated at 0.488, 0.457 and 15.484 respectively. It also showed that R^2, adjusted R^2 and F-value for quality were 0.519, 0.489 and 17.502 respectively. A comparison indicated that there was extremely little difference in the R^2 value for the three variables (cost, time and quality). In spite of this, the R^2 values were approximately half (0.50) indicating that cohesion existed between cost, time and quality performance of civil engineering project. Similarly, at $p \leq 0.05$, the significance of the relationship between cost, time and quality performance of civil engineering project was 0.000. Hence, no difference in the significance values exhibited by cost, time and quality performance of civil engineering project. This further showed that cohesion existed between cost, time and quality performance of civil engineering project.

Table 2. Significance of the Cohesion between Cost, Time and Quality Performance of Civil Engineering Project

Variables	R^2	Adjusted R^2	F-Value	p-value
Cost	0.488	0.456	15.459	0.000
Time	0.488	0.457	15.484	0.000
Quality	0.519	0.489	17.502	0.000

P is significant at 5% ($p \leq 0.05$).

4. Discussion

Finding indicated that cost, time and quality performance of civil engineering project display same manner of relationship and significance value with contractor prequalification criteria. This infers that the three variables (cost, time and quality) and contractor prequalification criteria are interdependent. The result slightly differs to the opinion in Wenfa and Xinhua (2014), Shankar, Raju, Srikanth, and Bindu (2011) and Kathy, Paul, Keith, Peter, and Rob (2007) by clearly showing that interdependency in this regard is not limited to between cost, time and quality but extends to criteria for contractor prequalification as far as civil engineering project. Additionally, the correlation pattern indicates positive relationship between contractor prequalification criteria and cost, time and quality performance of civil engineering project. This shows that contractor prequalification criteria have positive effect on cost, time and quality performance of civil engineering project. Also, criteria for contractor prequalification criteria reflect same significance value with cost, time and quality performance of civil engineering project at $p \leq 0.01$ (p=0.000). The correlation pattern signifies an agreement that cohesion exist between cost, time and quality performance of civil engineering project. Going by the decision rule earlier stated in this study, both weak and strong positive relationship exist between cost, time and quality performance of civil engineering project and contractor prequalification criteria. This reveals that contractor prequalification criteria affect cost, time and quality performance of civil engineering project. This result therefore aligns with the report in Akinmusire (2015) which point out that contractor prequalification criterion affect the performance of civil engineering project. In spite of this, cost, time and quality performance of civil engineering project affect one another. This indicates that adjusting any of the three would lead to either increasing or reducing the other. This result agree with the opinion in Wikipedia (2017) which believed that construction project can be speedily delivered by increasing the cost. Therefore, reducing the cost and maintaining the delivery period would have negative effect on the quality of the project. However, cost, time and quality performance of civil engineering project related with one another. It infers that these three variables interact with one another, thus supports the result in Ifte, Mahiuddin, and Abdul (2002) by affirming that relationship existed between civil engineering project cost and time. Hence, civil engineering project's cost is a determinant of its delivery period and quality standard. This study, consequently, affirm that cohesion

exist between cost, time and quality performance of civil engineering project. It can be deduced that this study confirm the submission in Bojan S., Dragan, Bojan P., Dejan, and Slavica (2014) by agreeing that cost, time and quality of construction project are highly coherent.

However, it can be concluded that contractor prequalification criteria are capable of demonstrating the bond between cost, time and quality performance of civil engineering project. These variables are cohesive and exhibit both strong and weak positive relationship with contractor prequalification criteria at varying degrees. This suggests the likelihood of contractor prequalification criteria meeting cost, time and quality targets at different rate. In spite of this, civil engineering project's cost, time and quality are bonded by criteria for contractor prequalification. Thus, contractor prequalification criteria evidently contribute to the cohesiveness of cost, time and quality performance of civil engineering project. Cost, time and quality performance of civil engineering project depended on criteria for contractor prequalification criteria and vice versa. Hence, contractor prequalification criteria are not expected to be counterproductive on cost, time and quality performance but to support their achievement. Also, cost, time and quality performance of civil engineering project is coherent and affects one another. These three variables are consequently inseparable. However, client and consultants saddled with the responsibility of choosing a contractor to handle the delivery of civil engineering project should simultaneously balance the contractor prequalification criteria under consideration against cost, time and quality targets. So, choice of the contractor prequalification criteria to be adopted for civil engineering project should be based on the firmness of cost, time and quality performance. This will reduce the chances of project failure by alleviating the risk of adopting one-sided contractor prequalification criteria during contractor selection process.

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