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Effect of Contractor Knowledge and Experience on Cost Estimation in Plant Infrastructure Projects in Kenya

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Abstract: ***Cost overruns on infrastructure development projects during implementation continue to pose great challenges to developing countries. Research has found that, there are many factors that impede on successful completion of projects on time, budget, and quality. This study seeked to investigate the effect of Contractor Knowledge and Experience on Cost Estimation in Plant infrastructure Projects in Kenya and analyse its impact. This study reviewed available literature and theories about project cost estimation thus theory of Learning Curve (LC), triple constraint theory, Complexity Theory and S-Curve theory. The descriptive research design was identified as the design of this study. The population of this study was 1000 REL employees and associates working in the area of projects operations and management. The study used a census sampling technique. Primary data was collected using interview and questionnaire and secondary data was collected by reviewing published materials. The data was presented in tables, charts and figures. It was established that contractor knowledge and experience has an adverse effect on cost estimation in plant infrastructure projects. The results should enable planners to take stock of past performance and incorporate lessons learned on future projects planning and implementation.***

Keywords: Plant infrastructure, Total estimate cost, Project, Project Scope Management

1. Introduction

Cost is one of the primary measures of a project success. This is true, especially for plant facility construction projects in developing countries, because construction projects in these countries are executed with scarce financial resources. As mentioned by Olawale, this industry contributes to the GDP and employment rate of many nations, and for this reason it is considered vital for the economic development of any nation (Olawale, 2010). Generally, a project is considered successful if the project is completed within a stated cost or budget. The role the plant infrastructure plays in socio-economic development is significant. It provides the basis upon which other sectors can grow by constructing the physical facilities required for the production and distribution of goods and services. The construction industry has a significant multiplier effect on the economy as a whole (Morris, 2006).

1.1 Statement of the Problem

The aftermath of the global financial crisis (GFC) has introduced stiff competition for jobs in the construction industry (Cong J., Mbachu J. and Domingo N., 2014). Tendering risks are at now at all-time highs, with the popular saying these days that projects are awarded to the bidders who make the biggest mistakes" (O Brien *et al*., 2014). This is mainly because of several risks which might not have been accounted for and these risks are compounded by the frequent use of fixed price lump sum contracts; with clients being eager to contest contractors' claims for the variations they ordered (Mbachu, 2011).

Inaccurate estimation of the contract price has resulted in the insolvency and liquidations of many contracting firms of all sizes. This is important because it could make or mar the ability of the tenderer to achieve expected profit margin and maintain credibility with the client, which is a condition for future invitations to tender (Cong and Domingo, 2014). Establishing and prioritizing the factors that may influence the final contract price when responding to a call for tenders is therefore crucial for proper risk analysis and reliable construction cost forecasting. In Kenyan plant infrastructure projects, these factors have not been researched; hence contractors rely only on judgement to guess-estimate in their price forecasting (Mbachu, 2011; O Brien *et al*., 2014).

Richfield Engineering Limited, a multifaceted projects execution & management company operating in Kenya and other East African countries, provides plant installation services in the engineering, infrastructure & process industries. Inaccurate cost estimates have been a major challenge and considered to be the biggest problem which hinders project's progress since it decreases the contractors profit margin, hence leading to huge losses, leaving the project in a big trouble or the contractor loses on the bid for not offering a competitive price. It is therefore important to contribute to filling the knowledge gap by examining the effect of contractor Knowledge and Experience on Cost Estimation in Plant infrastructure Projects in Kenya.

1.2 Objective of study

The purpose of this study was to evaluate the effect of contractor knowledge and experience on cost estimation in plant infrastructure projects in Kenya.

1.3 Research Questions

What is the effect of contractor knowledge and experience on cost estimation in plant infrastructure projects in Kenya?

2. Theoretical

The study will be grounded on four major theories namely: Theory of Learning Curve (TLC), Triple Constraint Theory (TCT), Complexity Theory (CT) and S-Curve Theory. A review of the theories will provide a clear link between contractor knowledge and experience on cost estimation in plant infrastructure projects.

2.1 Theory of Learning Curve (TLC)

The theory of Learning Curve (LC), sometimes also called experience curve or dynamic curve was first developed by T.P. Wright in 1936, while studying time required making airplane parts. He observed that, as the workers gained more experience, less time was required to manufacture these parts. This effect was not linear, but seemed to have a constant decrease. To be more precise, he observed that the labor required for producing doubled quantities, decreased by a constant factor in relation to the original quantity.

The rate of improvement is referred to as the learning rate and is expressed in terms of the slope of a curve. If it is a 70% curve, it represents a 30% reduction in effort with every doubling of experience. Similarly, an 80% curve corresponds to a 20% reduction in effort. This percentage varies with the type of industry, from 60% to 95%. Normally an 80% curve is used in construction. The effort required by the fourth unit will be 20% less than the second unit will; the hundredth unit will require 20% less effort compared to the fiftieth unit.

The basis for the learning curve theory has stemmed from the observation that experience makes repetitive tasks easier to perform. When a particular task or sequence of work is repeated without interruption, subsequent operations require reduced time and effort. The principle of learning curve, which has been used effectively in manufacturing, can also be used in construction as labor productivity and equipment operations affect the cost of many repetitive activities. Estimators can use this theory in cost estimating. Contractors can apply it in productivity studies and productivity improvement and for future bidding of similar activities. Owners may utilize this theory in evaluating bids or change orders and subsequently for negotiating prices (Sundaram, 2015).

Cost estimation requires that a project team comes up with a good cost estimation approach taking into consideration the fact that processes may change in due course thus calling for review of the cost budget. One of the cost elements that estimators should take into consideration is the additional incremental costs arising from project review. The adjusted amortization model (McNeill, 2003) serves as a good measure of estimating the Marginal Capacity Cost of developer charges when estimating developer charges in plant installation projects. From an economic point of view marginal cost of capital serves as a good measure of evaluating the existing plant infrastructure projects while looking into the prospects of future investments in such facilities.

This experience curve theory supports the variable contractor experience and knowledge effect on cost estimation by stating that experience makes repetitive tasks easier to perform and when a particular task or sequence of work is repeated without interruption, subsequent operations require reduced time and effort.

2.2.2 Triple Constraint Theory (TCT)

The triple constraint theory or project management triangle (pmt) formulated by Dr. Eliyahu M. Goldratt involves Scope, Time and Cost. Time refers to the actual time required to produce a deliverable, which in this case, would be the end result of the project. Naturally, the amount of time required to produce the deliverable will be directly related to the amount of requirements that are part of the end result (scope) along with the amount of resources allocated to the project (cost).Cost is the estimation of the amount of money that will be required to complete the project. Cost, in itself encompasses various things, such as: resources, labor rates for contractors, risk estimates, bills of materials, et cetera. All aspects of the project that have a monetary component are made part of the overall cost structure.

Scope is the functional elements that, when completed, make up the end deliverable for the project. The scope itself is generally identified up front so as to give the project the best chance of success. Although scope can potentially change during the project life-cycle, a concept known as ‘scope creep’, the common success measure for the scope aspect of a project is its inherent quality upon delivery.

The Triple Constraint, being a triangle, one cannot adjust or alter one side of it without in effect, altering the other sides. So for example, if there is a request for a scope change midway through the execution of the project, the other two attributes (cost and time) will be affected in some manner. How much or how little is dictated by the nature and complexity of the scope change. The limited information available at the early stages of a plant infrastructure project may mean the cost estimator must make assumptions about the scope of the project based on experience, which may not eventuate as project design, planning and construction evolve.

2.2.3 The Complexity Theory (CT)

The complexity theory where a prominent author in the field of complexity Terry Williams (2008), shares the view of other scholars on complexity, but extends it by one additional dimension of cost estimates. In addition to the two components of complexity, vis-àvis the number of factors and the interdependency of these factors, he introduces the third factor which is uncertainty. Since uncertainty adds to the complexity of a project, cost estimates therefore can be viewed as a constituent dimension of project complexity that can be as a result of various factors (Williams, 2008). Projects occasionally demand for more additional funds as there is an increasing desire to reduce time to market thus affecting the cost estimates of the project (Williams, 2008).

Kahane on the other hand puts a lot of emphasis on talking and listening to each other when solving tough problems when developing estimate costs. His approach to complexity is deeply rooted in a social environment. He distinguishes complexity in three ways. One of ways is Dynamic Complexity which means that the cause and effect are far apart and it is hard to grasp from firsthand experience. They usually unfold in unpredictable and unfamiliar ways emanating especially from cost related issues such as design variations (Kahane, 2004).

Companies undertaking plant infrastructure projects where complexities revolving around cost estimates arise, seek to explore transformation programs aimed at identifying a cost-benefit model that integrates unit costs in the cumulative costs.

2.2.4 S - Curve Theory

An S-Curve is a sigmoid function, that is a mathematical process or function that results in a S shaped curve also called a Sigmoid Curve by Everett Rogers(1962). The S-Curve is used in project management as a means of representing the various expenditures of resources over the projected time of the project or as a means of charting the real-time expenditure of resources. This is important to project management in that it can be used to monitor the project as is progresses and compare it to the projected S-Curve to determine whether or the project is being completed within the time and budget limitations. These resources might be the cumulative cost of the project, the number of man hours required at any given stage in the project, the expenditure of raw materials for construction or assembly, etc.

The term S-Curve can also be used to indicate an S shaped chart resulting from a cumulative likelihood distribution. In this function, an S-Curve is a tool of quantitative risk analysis which project management would use to determine the possible dangers of any given course of action.

S-curve modelling in early phases of construction projects, where the methodological procedure for forecasting cost distribution over time is given for the project realization phase using cost S-curves for three different types of structures: building, tunnel, and motorway. Three different approaches are used, and their results are correlated and presented in form of mathematical regression expressions and appropriate diagrams.

The proposed methodology can be used for cost estimation in plant infrastructure projects, especially in the earliest phase in which detailed information about the project is scarce.

2.5 Empirical Review

Cong *et al.,* (2014) conducted a study Factors influencing the accuracy of pre-contract stage estimation of final contract price in New Zealand aimed to fill the knowledge gap by investigating the priority factors. 150 responses from professional members of the New Zealand Institute of Quantity Surveyors were analyzed using multi-attribute method. Results showed thirty-seven factors which could influence the final contract price; the three most influential being poor tender documentation, complexity of design & construction, and completeness of project information. Other factors relating to project, client and contractor characteristics, design consultants and tendering conditions, estimating practice and external factors were reported. Concordance analysis indicated high level of agreement amongst survey participants in the rank-ordering of the relative importance of the identified factors.

Mahamid (2011) investigated the statistical relationship between actual and estimated cost of road construction activities based on a sample of 100 road construction projects awarded in the West Bank in Palestine. The findings revealed that the average cost deviation in the investigated activities was as follows; earthworks -15.7 percent, base works 12.9 percent, asphalt works 18.5 percent and furniture works 36.4 percent. His findings however fell short of investigating the cost drivers responsible for the deviation between actual and estimated cost.

Memon *et al.* (2010) investigated factors influencing construction cost in the projects of Malaysian government agencies. The questionnaire survey method was used as empirical source of data. The study revealed seven main factors; these included cash flow and financial difficulties faced by contractors, poor site management and supervision (contractors), shortage of contractor experience, insufficient site labour, and inadequate construction planning and scheduling. This study identified design changes as the lowest influential factor on the cost of construction.

A study by Tebin (2009) identified two critical determinants of tendering price: client responsibility and contractor responsibility. The study emphasised the importance of having comprehensive knowledge about the construction process by both the project client and contractor to accurately calculate the tender price.

Chan and Park (2005) measured and evaluated factors that influenced construction costs in Singapore, based on national construction project data. The projects were divided into three main groups based on project characteristics, contract type and type of owner/consultant. The findings indicated that special requirements influenced construction costs; these included level of technology, special skills of the contractor and publicly administered contracts. Technical expertise of contractors, financial factors and level of construction familiarity were also high level influence factors.

Bubshait and Al-Juwairah (2002) evaluated 42 factors that could affect construction costs in Saudi Arabia. These factors were divided into five main groups. Results indicated that material cost, incorrect planning, contractor experience, contract management and poor financial control had significant influence on costs.

Dissanayaka and Kumaraswamy (1999) investigated factors influencing construction cost, based on projects in Hong Kong. The study used multiple linear regressions and identified four main construction cost influential factors: level of client confidence in the construction team; payment

method; risk of client's quantity variation; and complexity of construction.

3. Methods

The study adopted a descriptive survey design as it aims at collecting information from respondents on factors affecting cost estimation in plant infrastructure construction projects at REL. Descriptive survey research design was used in preliminary and exploratory studies to allow the researchers gather information, summarize, present and interpret data for the purpose of clarification. The target population was 1000 REL employees and associates, the population targeted comprised of REL employees, Surveyors, Consultants and Sub Contractors in Kenya.

The study generated both qualitative and quantitative data which was collected using both likert scales and descriptive questionnaires which were later analyzed descriptively using Measure of Central Tendency and inferentially using Multiple Regression Model. Analyzed data was presented using tables, charts and graphs.

3.1 Sampling Techniques and Sample Size

Stratified sampling was used and it enabled the population to be divided into four segments called strata comprising the REL Employees, Surveyors, Sub Contractors and Consultants. The researcher then applied simple random sampling to draw sub-samples from each stratum. These sub-samples were added together to form complete stratified samples. Disproportional allocation was employed, where each stratum, the categories at REL contributed to the sample a number that was proportional to its size in the population. This enabled concentration of more weight to all categories that were deemed to have more relevant information in relation to the study by virtue of day to day encounter with cost estimation.

3.2 Measurement of the Variable

Multiple regression analysis was used to determine whether the independent variables predict the dependent variable in any way. Cost Estimation in Plant Infrastructure Projects in Kenya, as the dependent variable was regressed against the independent variable, contractor Knowledge and Experience.

3.3 Sample Description

The sample frame describes the list of all population units from which the sample will be selected (Cooper & Schindler, 2003). For this study the sampling frame came from the REL employees and associates. Mugenda & Mugenda (2003) argues that sampling is that part of the statistical practice concerned with the selection of individual or observations intended to yield some knowledge about a population of concern. They advise that a researcher sample size of 10% to be appropriate as long as the sample size is more than 30, (n > 30). Therefore the sample size was 100 derived from a population of 1000.

4. Findings

Contractor Knowledge and Experience

Respondent's opinion was sought on whether contractor knowledge and experience had an influence on cost estimation in plant infrastructure projects in Kenya. The majority (75%) of the respondents agreed that Contractor's knowledge and experience had an effect on cost estimation while 25% disagreed. On whether a big number of plant infrastructure projects done in the past had an effect on cost estimation in plant infrastructure projects 71 % agreed, 78 % agreed that High quality of company databases had an effect on cost estimation in plant infrastructure projects while an overwhelming 73% agreed that use of lessons learned influenced estimation in plant installation projects. The three-stage project lessons learned process for project management improvement is an important element in moving the organization toward delivering consistently successful projects which positively affects cost estimates. It also can contribute to developing consistently effective project managers. All stakeholders get better over time and do not repeatedly relive failures.

Contractors' experience is a variable that affects cost estimation. Previous studies have rated it as one of the highest benefactor that is experienced across the world. Contractors are selected on the basis of price, experience in undertaking particular types of construction project and their reputation or track record in producing high quality work within budget and on time (Nandurdikar, 2014).The results are in agreement with (Choge & Muturi 2014) who 's study revealed that experience is a significant factor to adherence to cost estimates. At pre-qualification stage, the study established that contractors past experience in similar assignments and environment coupled with the entire team is among the parameters used in qualifying the contractors invited to bid for works. .

4.1 Results of Correlation Analysis

Contractor knowledge and experience and cost estimation have a significant positive correlation of 0.895 at the 0.01 significant levels in plant infrastructure projects. The results are in agreement with (Choge & Muturi, 2014) who's study revealed that experience is a significant factor to adherence to cost estimates. At pre-qualification stage, the study established that contractors past experience in similar assignments and environment coupled with the entire team is among the parameters used in qualifying the contractors invited to bid for works.

4.2 Regression Analysis Results.

The coefficient of determination R square is 0.898 and R is 0.895 at 0.05 significance level .The Coefficient of determination indicates that 89.8% of the variation on cost estimation in plant installation is influenced by contractor's knowledge and experience. This implies that there exists a strong relationship between contractors knowledge and experience and cost estimation in plant infrastructure.

The Analysis of variance (ANOVA) results further confirms that the model fit is appropriate for this set of data since

Contractors knowledge and experience. Coefficient of 0.898 was found to be positive at significant level of 0.001 and this indicates that contractor's knowledge and experience has a positive influence on cost estimation. A unit increase in Contractor knowledge and experience leads to 0.898 increase in success of cost estimation. Inferences can therefore be made that scope assumption followed by contractor knowledge and experience, available time and cost model influences success of cost estimation in plant infrastructure projects in Kenya.

5. Conclusions

Based on the findings, it can be concluded that contractor's knowledge and experience has a direct and positive influence on cost estimation in plant infrastructure projects in Kenya. The greater the levels of contractor's knowledge and experience increases the confidence levels of estimators, consequently impacting positively on their ability to give a precise cost estimate. The number of similar projects done in the past was found to give the estimator an edge when carrying out cost estimation on current plant infrastructure projects based on past experience. High quality of past similar projects databases was observed to enhance the accuracy of the cost estimate given the data can easily be accessed and references made on costing.

The lessons learnt in previous plant infrastructure projects was observed to greatly enhance the accuracy of the cost estimate since it facilitates continuous improvement in the process by avoiding a repeat of the same mistakes done in the past on similar projects. Akintoye and Fitzgerald (2000) in their study about UK current cost estimation practices reported that the standard estimation procedure is a widely used method in construction companies, followed by comparison of similar project completed by the company and with the help of personnel experience on similar projects.
This is same as traditional method of estimating, where the cost of construction items prepared based on (labour, plant, material, subcontractor, and preliminary) on top of it overhead and profit added. Even though, Contractor always follows a systematic process for cost estimating for construction project, but the ratio of research for the cost estimating practice is very less within specialized Contractors (Al-Hasan *et al*, 2005).

6. Recommendations

The following recommendations were made based on the findings and conclusions of the study:
The following recommendations were made based on the findings and conclusions of the study:
Since the result showed that contractor's knowledge and experience, available time, scope assumption and cost model played a critical role on cost estimation in plant infrastructure projects in Kenya.

6.1 Contractors Knowledge and Experience

Contractor knowledge and experience was found to have an adverse effect on cost estimations in plant infra-structure projects thus the number of similar projects done in the past, quality of past projects databases and value of lessons learned. Therefore the contractor should specialize in plant infrastructure projects to have an edge in terms of experience on those types of projects, hence enhance the experience and knowledge in plant infrastructure projects. Having a good number of similar projects done in the past hence an area of specialization, the contractor should have a quality past projects database to make maximum use of data from past similar projects when carrying out cost estimations for current jobs.

The value of lessons learned from previous plant infrastructure projects is very cruisal in cost estimations. Mistakes done on cost estimations in previous plant infrastructure projects should be well documented and lessons learnt drawn not to be repeated. The contractor should put in place the kaizen policy thus continuous improvement thus making use of lessons learnt for improvement in cost estimation. Project managers and other stakeholders in the construction industry should consider the knowledge and experience an estimator has in the industry. Estimators' past work experience should also be considered during the hiring process.

6.2 Areas for further research

This study contributes to the body of knowledge both in methodology, theory and practice. From this study it is recommended that scholars and practitioners in project management should actively engage in joint research that will be used to assist contractors, stakeholders, engineers, surveyors, Sub contractors and Consultants

This study is a milestone for future research in this area, particularly in Kenya. This study was done in Richfield Engineering Limited; similar studies can be done in other sectors of the economy. The study also recommends the need for further research as a major line of inquiry on the reason cost estimation is not given the importance as a key contributor to successful project

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