Development of a Model for Determining Realistic Contract Period

Alex J Kalume, Stephen Diang'a

Abstract - The construction industry is very important to the economy in terms of employment and wealth but it is faced with numerous challenges which necessitate the need of taking measures to improve the management of construction projects. Building projects are normally realized by inputs from different experts in their areas of specialization. The many parties involved in the construction process shows how difficult it is to manage the process to a successful completion. Majority of projects are not completed within the agreed time due to unforeseen circumstances not included at the estimating stage.

The study focused on developing tools for effective management of building construction projects in Kenya, as a means of helping to bring about improvements in project executions. Specifically, this is realized by developing regression models for realistic estimate of contract period.

A survey of construction practitioners in Mombasa was conducted. The sample consists of architects, engineers, contractors and quantity surveyors. Information was obtained on past building projects performance in terms of time and determination of the degree of influence of various factors at every stage of a building project. Multiple regression technique was used in the analysis of data for the study.

Findings include regression models for realistic estimation of project time for residential houses, institutional buildings (education), industrial (factories), Hotel/motel and commercial (offices).

Key Words—Time, Cost, Construction, Project, Management

I. INTRODUCTION

The creation of new building structures is not an easy mission; many problems have to be solved between the initial ideas for a new asset, through its realization on site, to the client starting to exploit it. A large number of associated problems influence effective project management, namely: client's limited understanding of design, procurement and the construction process; inadequate design; poor quality management during design and construction; poor ground conditions; poor constructability, poor motivation of workers, non-participatory management style and adverse physical, economic, and socio-political factors.[12]. Construction projects have problems with construction process management as well as limitation of funds and time. The critical problems are inability to complete the project on schedule, low quality work, and cost overrun.

At various levels of building construction, there is the need and importance of taking measures to improve the management of the construction project during execution. This requires a deliberate process of continuously monitoring all the processes related to the realization of the project. Therefore, the complexity and uncertainty of the construction process require the application of significant management effort for project success [9].

In most cases professionals make contract estimates but the client may be disappointed by the extension of time and additional expenses. This occurs during project implementation due to unforeseen circumstances and design changes. It is therefore in the contractors' best interests to check if the contract costs are realistic to ensure liquidated damages will not incur after the original or extended contract period.

The study addresses the problem of inability of the project design and implementation teams to adequately predict time estimates of projects taking into account delays and other unforeseen circumstances. The time model from the study will be used as a standard for estimating or benchmarking the contract time of construction projects as the models incorporates all the delays and unforeseen circumstances not included at the estimating stage. This is because the models were developed from historical data of past projects.

The aim of setting up a time model is to enable the clients and contractors to estimate or benchmark the construction time. The models will be used to validate those obtained from critical path methods. A reliable estimation of project contract period and the management of the construction process are the major concerns of construction managers. This reliability is dependent upon the accuracy of estimating the effect of various time influencing factors in the project environment. The common practice is that the effect of these cost factors is considered intuitively depending upon the skill of the estimators or planners. The competitive nature of the industry places pressure on contractors to keep project costs as low as possible. At the same time, project durations, as determined by consultants, are kept to a minimum.

The problem of mismanagement of construction projects goes much deeper as not only does it affect the client but also it affects the parties involved in the construction process including the public. Delaying public projects leads to more serious repercussions given that there is a large number of interested parties. The actual construction time and cost of construction projects in many cases can be very different from the contract time and cost. The methods used for estimation of time do not consider contract variations which are inevitable in the construction process, leading to extension of time and additional expenses. The regression model developed in this study put into consideration contract variation and other unforeseen circumstances that lead to increase in time and cost, this is because the

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Alex John Kalume, Sustainable Materials Research and Technology Centre, Jomo Kenyatta University of Agriculture and Technology P.O. Box 62000-00100, Nairobi, Kenya.

Stephen Diang'a, School of Architecture and Building Sciences (SABS) Jomo Kenyatta University of Agriculture and Technology P.O. Box 62000-00100, Nairobi, Kenya.

model is based on past records of building projects.
Emphasis will be on avoidance of delays in projects by way of predicting realistic project implementation time. Statistical regression models were developed from past records of projects such that if the floor area, number of floors and type of facility are known, then the estimator can quickly determine realistic contract time. There are separate models for data from public and private sectors. This is due to the fact that the performance of government projects is different from private sector. The models will take into account delays and other unforeseen circumstances as they are developed from historical data of projects and will be used to validate those obtained from critical path methods.
The study was based on a survey of contractors, architects, engineers, project owners and quantity surveyors in Mombasa. Information on past projects performance in terms of time were obtained. Further, factors influencing effective management of the construction process were determined at every stage. The research is descriptive in nature and uses both qualitative and quantitative methods. The findings of this thesis will be used as a reference material by project owners, managers and consultants in developing their project management strategies.

OBJECTIVE

The aim of the research is to develop a model for effective management of building construction projects which ensures project delivery within stipulated period.

II. LITERATURE REVIEW

Any construction organization must have a strategic plan and vision that lead the way to achieving its goals. The key to achieving that is in successful management, by identifying needs and goals the company wants to achieve. To do that, project management must be planned on many levels, such as implementing, organizing, delegating, decision making and performing. The survival and the progress of any company depend upon how well project management is implemented and how experienced the company is in this field. The demands of clients, companies and employees differ from time to time, and thus the vision of the construction industry is always developing; to keep up, management must change too[3].
In order to clearly cover the review of the related literature on cost and time overruns as the key issue in question, the review mainly highlights on the following areas. These areas are:-

1. Contract performance
2. Management of the construction process
3. Project planning and control
4. Contract cash flow
5. Contract variations

A. Challenges of construction projects

According to reference [1], project management are a tool for project success; it is people who deliver projects and not processes and systems. Effective project management is a derivative of competency and authority levels. In addition to project management competence, there are other factors within the control of stakeholders that should be taken into account when estimating project delivery time. These could, if not properly managed, cause a delay in project delivery. For instance, project complexity has an appreciable influence on the time required for design and construction.
The construction process comprises many tasks. Task management, assumes that certainty prevails in production. However, it is widely observed that, due to the inherent variability of production in construction, the intended task management degenerates into mutual adjustment by teams on site [2]. Researchers, clients, contractors and professionals are concerned about this phenomenon, which results in inefficient production, and delayed projects. It is plausible that the phenomenon is a result of not considering the influence of the stakeholders on a contract, namely: the actions of clients, contractors and professionals as they impact on estimated contract duration and cost. Should the stakeholders to a contract promptly carry out duties, this will not happen.
Reference [8] identified 11 variables of time overruns and 7 variables of cost overruns. Out of which, materials cost increased by inflation, inaccurate quantity take-off and labour cost due to environmental restrictions are the first three causes of cost overruns; while design changes, poor labour productivity, inadequate planning, material shortage and inaccuracy of material estimates are first five causes of time overruns [8].

B. Construction management research work conducted in Kenya.

Reference [13] studied the management of public sector construction projects in Kenya and clearly puts it that most of the projects carried out in developing countries where Kenya is classified; have been either reasonably delayed, suffered uncontrolled cost escalation or precipitated poor functional qualities. He goes on to contribute this poor performance to lack of a fundamental framework of management relating to the construction industry and recommends that a project manager has to be responsible for the construction process; a project manager would go a long way in curbing some of these problems of time and cost escalations.
In Kenya, Reference [13] carried out a research on the performance of government building projects in the construction stage and found out that government projects overrun in terms of time and cost. Among the projects examined, 73 percent had time overruns as compared to 39 percent which had cost overruns coming to a conclusion that government projects are the poorest in performance. Reference [13] reckons that that clients have become more and more frustrated by the high costs, long design and construction times together with the functional shortcoming particularly as projects have become longer and more complicated during periods of inflation, labour problems and growing bureaucracy.
Reference [13] observed a very interesting phenomenon in the Kenyan construction industry whereby the new ideas in the construction industry are normally started by the public sector and end up being adopted by the private sector. This happens because, the private developers have remained fragmented and small, with very little to contribute to the national construction industry and leaving the public sector to have a clear rule of controlling 60 percent of all the construction projects in

Kenya. The government is forced to look and establish different means and methods in areas of research for new and improved methods in the construction process so as to come up with cost effective but efficient construction products. This is because the government as the main client suffers the most from the problem of cost and time overruns in its projects as the principle employer and could have far reaching effects.

Reference [13] studied the relationship between the size of the project in regard to the cost and time performance and found that its effect was only 12 percent and the other factors occupying the remaining 88 percent meaning that the size of a project of any nature has very little to do with performance. According to Reference [13], more than 50% of the procured construction projects in Kenya experience a cost overrun by up to 20% while 70% of these construction projects experience a time overruns of up to 50%. Reference [13], reckons that those projects that have got a higher contract value have got the best performance as compared to those projects with a less contract value which has a poor performance. Reference [13] suggests that this could be due to the reasons that the contractors:

- Are more experienced
- Are more organized
- Are more equipped
- Have more personnel experts

Even with these reasons by Reference [13], it still has a misleading effect as even some of the high value projects in Kenya have been worse hit by this problem of cost and time overruns.

C. Management techniques used for planning and control

Project controlling techniques indicate the direction of the project at each time and reveal progress. According to reference [3], there are various types of planning tools, namely:

- The Gantt (bar) chart
- Network diagrams
- The critical path methods (CPM)
- The programme Evaluation Review Technique (PERT)
- Line of balance

They are utilized in the construction industry for the planning and control of materials, labour, machinery and equipments. Two types of planning tools are generally used on any kind of project, namely the CPM and the bar chart. S-curve method is used for specific types of projects, such as heavy engineering projects.

- The bar chart

Bar charts are the oldest, most commonly used tools in nearly all projects and are presented in a bar chart form [14].

- Network diagrams

Network diagrams show the relationship between activities, tasks and sections of work more clearly. They also show sequence of time clearly and it's possible to identify critical schedules

It's also possible to computerize networks more effectively than bar charts.

D. Importance of time-cost analysis

The main objective of network planning is to complete the job within the stipulated time and at minimum overall cost. At times it becomes necessary to accelerate the completion of work. This can be made possible only by reducing the duration of critical activities. The duration of the critical activities can be reduced by the deployment of additional resources e.g. additional labour, shuttering, etc. while exploring the possibilities of accelerating the project completion by deploying additional resources on critical activities [3].

Project cost depends upon the time available for completing the work and the time in which a project may be completed depends upon the cost that the owner is prepared to bear. Cost and time being inter-related, a scientific analysis of project cost for different time periods of completion assumes paramount importance in project planning and implementation [3].

- Programme Evaluation Review Technique (PERT)

This system requires each contract to be networked. The values of work packages, which in essence are groups of activities, are assessed in advance. The time update of the network provides the value of work done as a 'byproduct' of the calculation. The value can be divided by the cost code, provided that the work package information is similarly divided. Thus, when incurred costs are recorded against the same codes, variances can be calculated for management information. The system cannot be applied directly where the work is valued by a bill of quantities which relates to the completed work rather than the operations. For this reason the system is seldom applied unless the work is the subject of an activity bill or operational bill. In practice, this confines its application to design/construct project. In such situations the contractor can readily provide a valuation document in a form which reflects the operations to be performed [3]

- **Line of balance**

Line of balance is a management control process for collecting, measuring and presenting facts relating to time, cost and accomplishments of a project, all measured against a specific plan [3]. It shows the process, status, background, timing and phasing of project activities, thus providing the management with measuring tools that help in:

- Comparing the actual progress with formal objective plan
- Examining the derivations from established plans, and gauging the degree of severity with respect to the remainder of the project.
- Receiving timely information concerning trouble areas; indicating where, what appropriate corrective action is required
- Forecasting future performance

Construction projects such as large housing estates, high-rise commercial buildings, high-ways, tunnels, pipelines, bridges and the like consist of numerous highly repetitive elements. Such projects are commonly referred to as repetitive or linear construction projects. Critical path method (CPM) techniques are less appropriate for scheduling repetitive projects

[3]. described techniques that may be used for scheduling repetitive projects:

- The critical path method (CPM)
- Optimization methods such as the dynamic programming model and the linear scheduling model

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- Graphic techniques such as the line of balance and linear scheduling method

Scheduling of repetitive tasks using CPM requires a large number of activities. Visualization and interpretation of CPM schedules with a large number of activities is often difficult. Optimization methods treat scheduling of repetitive projects as a dynamic process. They look for efficient solutions in terms of cost and time while maintaining the constraints related to the production rate and continuity of work of committed resources. Linear scheduling method is more applicable to truly linear construction projects where activities are repetitive for the entire project duration, such as pipeline or highway construction [3].

E. Multiple Regression

Multiple regression is not just one technique but a family of techniques that can be used to explore the relationship between one continuous dependent variable and a number of independent variables or predictor (usually continuous). Multiple regression is based on correlation but allows a more sophisticated exploration of the interrelations among a set of variables. This makes it ideal for the investigation of more complex real-life, rather than laboratory-based research questions [4]. Multiple regression can be used to address a variety of research questions. It can tell how well a set of variables is able to predict a particular outcome. Multiple regression will allow one to test whether adding a variable contributes to the predictive ability of the model, over and above those variables already included in the model. A multiple regression can also be used to statistically control for an additional variable when exploring the predictive ability of the model [4].

According to reference [5], some of the main types of research questions that multiple regression can be used to address are:-

- How well a set of variable is able to predict a particular outcome
- Which variable in a set of variables is the best predictor of an outcome
- Whether a particular predictor variable is still able to predict an outcome when the effects of another variable are controlled.

F. Major types of multiple regression

There are a number of different types of multiple regression analysis that one can use, depending on the nature the question to be addressed [5]. The three main types of multiple regression analysis are:-

i. Standard or simultaneous
ii. Hierarchial or sequential and
iii. Stepwise

i. Standard multiple regression

Reference [5], explains that in standard multiple regression, all the independent (or predictor) variable are entered into the equation simultaneously. Each independent variable is evaluated in terms of its predictive power, over and above that offered by all the other independent variable. This is the most commonly used multiple regression analysis. This approach is used with a set of variables and wanted to know how much variable in a dependent variable they were able to explain as a group or block. This approach would also tell how much unique variable in the dependent variable each of the independent variable explained.

ii. Hierarchial multiple regression

In hierarchial regression (also called sequential regression) the independent variable are entered into the equation in the order specified by the research based on theoretical grounds [4]. Variables or sets of variables are entered in steps (or blocks) with each independent variable being assessed in terms of what it adds to the predictor of the dependent variable.

iii. Stepwise multiple regression

In stepwise regression, the research provides SPSS with a list of independent variable and then allows the program to select which variable it will enter and in which order they go into the equation, based on a set of statistical criteria [4]. There are three different version of this approach: forward selection, backward selection and stepwise regression. There are a number of problems with these approaches and some controversy in the literature concerning their use.

G. Assumptions of multiple regression

Multiple regression is one of the fussier of the statistical technique. It makes a number of assumptions about the data, and it is not all that forgiving if they are violated. It is not a technique to use on small samples, where the distribution of scores is much skewed [4].

i) Sample size

The issue at stake here is generality. That is, with small samples one may obtain a result that does not generalize with other samples. If the results do not generalize to other samples, they are of little scientific value. Different authors tend to give different guidelines concerning the number of cases required for multiple regression. Stevens recommends that for social science research, about 15 subjects per predictor are needed for a reliable equation. Harper (1991), gives a formula for calculating sample size requirements, taking into account the number of independent variable that the researcher wishes to use: $N>50+8m$ (where m=number of independent variable). If the researcher has 5 independent variables, then 90 cases are needed. More cases are needed if the dependent variable is skewed. For stepwise regression there should be a ratio of 40 cases for every independent variable.

ii) Multicollinearity and singularity

This refers to the relationship among independent variables [4]. Multicollinearity exists when the independent variable are highly correlated ($r = 0.9$ and above). Singularity occurs when one independent variable is actually a combination of other independent variable (e.g. when both subscale scores and the total score of a scale are included). According to reference [4], multiple regression doesn't like multicollinearity or singularity as these certainly don't contribute to a good regression model, so always check for these problems before you start.

iii) Outliers

Multiple regression is very sensitive to outliers (very high or very low scores). Checking for extreme scores should be part of the initial data screening process. This should be done to all the variables both dependent and independent that will be used in the regression analysis. Outliers can either be deleted from the data set or, alternatively given a score for that variable that is high but not too different from the remaining cluster of scores[4]. Additional procedures for detecting outliers are also included in the multiple regression programs. Outliers on a dependent variable can be identified from the standardized residual plot that can be requested [4].

iv) Normality, linearity, homoscedasticity independence of residuals

These all refer to various aspects of the distribution of scores and the nature of the underlying relationship between variables [4]. These assumptions can be checked from the residuals scatter plots which are generated as part of the multiple regression procedure. Residuals are the differences between the obtained and the predicted dependent variable scores. Reference [4] further confirms that the residuals scatter plot allows the following to be checked:

- Normality: the residuals should be normally distributed about the predicted dependent variable scores
- Linearity: the residuals should have a straight line relationship with predicted dependent variable scores.
- Homoscedasticity: the variance of the residuals about predicted dependent variable score should be the same for all predicted scores.

H. Application of multiple regression

Reference [4] mentions the following areas of application of multiple regression:

1) Multiple regression requires a large number of observations. The number of cases (participants) must substantially exceed the number of predictor variables used in a regression. The absolute minimum is having five times as many participants as predictor variables.
2) The predictor variables selected should be measured on a ratio, interval, or ordinal scale. A nominal predictor variable is legitimate but only if it is dichotomous, i.e. there are no more than two categories.
3) The criterion variable the researcher is seeking to predict should be measured on a continuous scale (such as interval or ratio scale)
4) This statistical technique is used when exploring linear relationships between the predictor and criterion variables – that is, when the relationship follows a straight line. (To examine non-linear relationships, special techniques can be used).

I. The project management triangle

The project management triangle (also called triple constraint) is a model the constraints of project management. It is a graphic aid where the three attributes show on the corners of the triangle to show opposition. It is useful to help with intentionally choosing project biases, or analyzing the goals of your project. It is often used to illustrate that project management success is measured by the project team's ability to manage the project, so that the expected results are produced while managing time and cost [7].

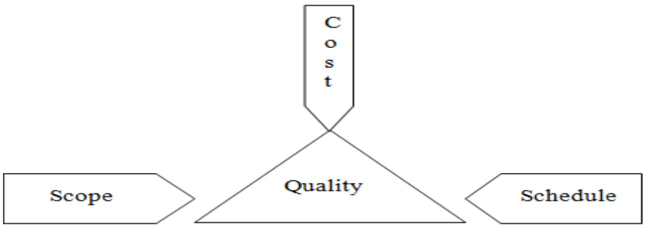

Figure: The project management triangle

One side the triangle cannot be changed without affecting the others. A further refinement of the constraints separates product "quality" or "performance" from scope, and turns quality into a fourth constraint.

J. Project management triangle elements

i. Time

The time constraint refers to the amount of time available to complete a project. The cost constraint refers to the budgeted amount available for the project. The scope constraint refers to what must be done to produce the project's end result. For analytical purposes, the time required to produce a deliverable is estimated using several techniques. One method is to identify tasks needed to produce the deliverables documented in a work breakdown structure. The work effort for each task is estimated and those estimates are rolled up into the final deliverable estimate [3]. The tasks are prioritized, dependencies between tasks are identified, and this information is documented in a project schedule. The dependencies between the tasks can affect the length of the overall project (dependency constrained), as can the availability of resources (resource constrained). Time is different from all other resources and cost categories. Actual cost of previous, similar projects can be used as a basis for estimating the cost of current project. According to reference [7] the project time management processes include:

1) Activity definition
2) Activity sequencing
3) Activity resource estimating
4) Activity duration estimating
5) Schedule development
6) Schedule control

ii. Cost

Reference [6] points out that to develop an approximation of a project cost depend on several variables including:

- Resources
- Work packages
- Mitigating or controlling influencing factors that create cost variances.

According to Reference [6], tools used in cost are, risk management, cost contingency, cost escalation, and indirect costs. But beyond this basic accounting approach to fixed and variable costs, the economic cost that must be considered includes worker skills and productivity which is calculated using various project cost estimate tools. This is important when companies hire temporary or contract employees. Cost process areas:

- Cost estimating is an approximation of the cost of all resources needed to complete activities.
- Cost budgeting aggregating the estimated costs of resources, work packages and activities to establish a cost baseline.
- Cost control – factors that create cost fluctuation and variance can be influenced and controlled using various cost management tools

iii. Scope

Reference [14] defines scope as requirements specified to achieve the end result. The overall definition of what the project is supposed to accomplish and a specific description of what the end result should be. A major component of scope is the quality of the final product. The amount of time put into individual tasks determines the overall quality of the project. Some tasks may require a given amount of time to complete adequately, but given more time could be completed exceptionally. Over the cause of a large project, quality can have a significant impact on time and cost (or vice versa).

iv. Project quality

Sometimes the project management triangle is described with the three constraints time, cost and quality rather than scope, as higher quality in a project can easily lead to higher cost and sometimes more time. However, quality can also be seen as part of the scope of a project, as well defined deliverables will include a statement of the desired quality [10].

III. METHODOLOGY

The primary data used was collected from the review of literature regarding the management of building projects. From the review of literature, a questionnaire was developed for collecting data. Secondary data was obtained from journals, articles and books.

Data collection Technique

This study adopted field survey methodology to obtain data on past building projects. Two methods were used to conduct the survey:

- qualitative method and
- Quantitative method

The purpose of the study is to predict construction cost, therefore, the data involved is numeric and the quantitative approach is adopted for the study. Furthermore the quantitative approach was chosen as appropriate since the data was analyzed statistically and findings communicated in numbers.

In qualitative research, open ended questions are used and the data format is textual [11]. The qualitative approach was chosen appropriate for the study when developing the project management tool.

The study used a questionnaire for data gathering. In designing the questionnaire, the objective of the study was considered. This helped in determining what questions to ask and how to ask them. Again, very short and concise questions were used as questions that are long and wordy may appear confusing to respondents. This was done in order to ensure that the responses are reliable.

Close-ended questions were used which were accompanied by a list of possible alternatives from which respondents selected the answer that best described the situation. Close-ended questions were used because they are easier to analyze since they are in an immediate usable form. They are also easier to administer and are economical to use in terms of time and money.

The Questionnaire was divided into the following parts:

Section 1a: organizational details: - such as whether private or public firms, number of years in construction and projects undertaken.

Section 1b: personal information which were questions about the respondents details such as formal qualification, status in organization and experience

Section 2: information about past performance of projects in terms of time and cost. Data on past performance of projects were obtained from firms. Some of which formed the parameters in the model. The main questions include:

- Type of facility
- Type of project, either private or public
- Initial contract time and cost
- Final contract time and cost
- Size of the project
- Number of floors
- Floor area

Section 3: questions on construction project processes.

A 5–point likert scale was utilized in the questions on the degree of influence of factors on effective management of building projects.

1 = no impact or not important
2 = low importance
3 = moderate importance
4 = important
5 = very important

Pre-testing of the questionnaire In order to check the questionnaire and make sure it accurately captures the intended information, a pre-testing was undertaken among a smaller subset of target respondents before the main survey

1) Ways of administering the questionnaire

Questionnaires were sent to the respondents through mail or hand delivery and they completed on their own. The questionnaire was used to interview respondents where the subjects had no ability to easily interpret the questions mostly because of their educational level. Internet was also used where the people sampled for the research received and responded to the questionnaire through their websites or e-mails.

2) Follow-up techniques

Polite Follow-up letters were sent asking subjects to respond. Telephone calls were also used to remind respondents of questionnaire feedback and sometimes where accessible the researcher visited the office of the professionals.

Population

A population is a group of individuals or objects of same species/characteristics occupying a particular geographic area. The population of this research was all the building projects in Mombasa. The projects that were considered here are the projects undertaken within a period of not more than 10 years with a contract sum of 1 million and above. Four categories of respondents in the construction industry were identified for data gathering. These are:

- Architects
- Engineers
- Quantity surveyors

Table 1: Commercial office – Public

Number of floors [Noflrs]	Floor area [Floarea] (m2)	Initial contract time [initime] (weeks)	Final contract time [Finatime] (weeks)	Initial contract time [initicost] (million)	Final contract cost [finacost] (million)
2	800	3	3	2.28	2.28
13	25575	40	75	223	245
8	840	144	164	115	115
9	1100	192	216	120	135
1	465	48	76	95	95
4	1250	240	288	60	64
2	850	96	120	80	80
3	455	45	68	90	110
24	22420	84	117	325	345
10	1700	245	264	226	226
7	13500	24	34	115	127
11	23560	38	73	210	232
10	2100	288	312	235	250

- Building contractors

3) sampling technique

The purposive sampling technique was used for data collection. This is because the study involves persons who have specific expertise like architects, engineers, contractors and quantity surveyors in the construction industry

4) Methods of data analysis

The method of data analysis used in this study is descriptive statistics. Descriptive statistics are used to describe the basic features of the data in a study. These include use of frequency distribution tables and mean or averages, enabling presentation of data in a manageable form or a simpler summary.

Multiple regression was also used to show the relationship between independent variables and dependent variable. A t-test was used to evaluate the individual relationship between each independent variable and the dependent variable

Regression analysis

Multiple regression is a statistical technique that allows us to predict someone's score on one variable on the basis of their scores on several other variables. Multiple regression is a technique that allows additional factors to enter the analysis separately so that the effect of each can be estimated.

The equation is written as:

$yp = \alpha + \beta 1x1 + \beta 2x2 + ... \beta kxk + €$

Where:

α = a constant on the y-axis

$\beta 1$ to βk are coefficients so chosen as to minimize the sum of squared discrepancies between the predicted and obtained values of yp.

€ = error term of random variable with mean 0

K = number of independent variables or parameters

IV. RESULTS

Below is a sample of the results as analyzed using multiple regression and same procedure was adopted for all other types of facilities.

Regression – Time model from SPSS

Descriptive Statistics

	Mean	Std. Deviation	N
Finatime	139.2308	100.88620	13
Noflrs	8.0000	6.20484	13
Floarea	7278.0769	10074.75900	13
initime	114.0000	96.18818	13
initicost	145.8677	89.96722	13

Correlations

		Finatime	Noflrs	Floarea	initime	initicost
Pearson Correlation	Finatime	1.000	.138	-.364	.994	.257
	Noflrs	.138	1.000	.709	.107	.899
	Floarea	-.364	.709	1.000	-.420	.646
	initime	.994	.107	-.420	1.000	.221
	initicost	.257	.899	.646	.221	1.000
Sig. (1-tailed)	Finatime	.	.326	.111	.000	.199
	Noflrs	.326	.	.003	.364	.000
	Floarea	.111	.003	.	.076	.009
	initime	.000	.364	.076	.	.234
	initicost	.199	.000	.009	.234	.
N	Finatime	13	13	13	13	13
	Noflrs	13	13	13	13	13
	Floarea	13	13	13	13	13
	initime	13	13	13	13	13
	initicost	13	13	13	13	13

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	initicost, initime, Floarea, Noflrs[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: Finatime

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.996[a]	.992	.989	10.81391

a. Predictors: (Constant), initicost, initime, Floarea, Noflrs

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	121200.8	4	30300.196	259.108	.000[a]
	Residual	935.525	8	116.941		
	Total	122136.3	12			

a. Predictors: (Constant), initicost, initime, Floarea, Noflrs

b. Dependent Variable: Finatime

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	12.631	6.619		1.908	.093
	Noflrs	-.951	1.255	-.058	-.757	.471
	Floarea	.001	.001	.118	1.790	.111
	initime	1.101	.051	1.050	21.456	.000
	initicost	.000	.088	.000	.004	.997

a. Dependent Variable: Finatime

- **Correlations**

Only three predictor variables are correlated with the dependent variable and are not all positive.

- **Model summary**

As R2 increases the standard error of the estimate will decrease (i.e. for better fit there is less estimation error) on average the estimate of time with this model will be wrong by 2.00

- **Variables contributing to the model**

Only three of the variables contribute to the model. Correlation and multiple regression analyses are conducted to examine the relationship between time and other various potential predictors. The first table summarizes the descriptive statistics and analysis results. As can be seen each of the variables is significantly correlated with dependent variable.

The multiple regression model with all four predictors produced R2 = 0.992, F (259.108). R2 indicates that the predictive ability of the model is high. The coefficient for initial cost is 0 and therefore the model is as follows:

Final time = (-0.951*noflrs) + (0.001*floarea) + (1.101*initime) + 12.631

Regression analysis was conducted to determine the kind of relationship between variables. The following are the results: Based upon the regression analysis conducted in the questionnaire, the equation for predicting the actual construction time and contract cost are given as:

Commercial office – private

Final time = (0.04*initicost) + (1.308*initime) + (-0.005*floarea) + (-4.786*noflrs) + 17.262

Commercial office – public

Final time = (-0.951*noflrs) + (0.001*floarea) + (1.101*initime) + 12.631

Hotel/Motel – private

Final time = (-3.203*noflrs) + (0.001*floarea) + (1.206*initime) + 0.81*initicost + 3.378

Industrial factories – private

Final time = (6.782*noflrs) + (0.002*floarea) (1.161*initime) + (0.034*initicost) + (-21.524

Institutional education – private

Final time = (-2.933*noflrs) + (-0.003*floarea) + (0.959*initime) + (0.178*initicost) + 20.662

- Institutional education – public

Final time = (-12.199*noflrs) + 0.001*floarea) + (1.184*initime) + (0.506*initicost) + 12.775

- Residential houses – private

Final time = (9.604*noflrs) + (-0.013*floarea) + (0.949*initime) + (0.006*initicost) + 2.098

- Residential houses – public

Final time = (-0.465*noflrs) + (0.005*floarea) + (1.039*initime) + (0.186*initicost) + 10.477

V. SUMMARY AND CONCLUSIONS

Success in construction projects relies on completion of projects within the budget and on or ahead of time and through certain standards of quality. In order to ensure conformance to these criteria for success, it is vital for project managers to orchestrate effective control of productivity and consumption of resources. The purpose of this study was to develop a model for effective management of building construction projects. The model can help project managers to be more effective in control and management of construction projects by gaining a better understanding of construction process issues.

For development of model for effective management of building projects, contract duration constraints, contract budget and the scope were considered. For the model of estimating contract duration and budget were developed from a survey of construction practitioners in Mombasa. For the project management tool for construction process, a review of related literature was reviewed. After identification of management factors, professionals of construction were asked to rank those factors by their degree of influence on effective management of building construction projects at every stage of the construction process. The construction practitioners have first-hand knowledge of day-to-day operations and onsite situations. After the model for effective management of projects was developed, validation was done to evaluate for its workability and suitability. The study was conducted in Mombasa.

Several regression equations for estimating the final contract period of projects in the construction industry are recommended for use as illustrated above. However, more data is required for developing the other models for hotel/motel, industrial (factories and commercial recreational centers.

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REFERENCES

1. Burke, R. (2000). Project management planning and control technique, 4th ed. Hong Kong. Burke publishing.p27-39
2. Chang, A. (2002).Reasons for cost and schedule increase for engineering design projects, p29-36.
3. Frank and Maccaffer, R. (1990). modern construction management. 8th edition, Prenttice Hall, New Jersey, Ohio.p25-35
4. Harry, F., & Stevens, c. (1991). Statistics Concepts and Applications. Cambridge.p65-98.
5. Harper, W. (1991). Statistics. 6th edition. Prentice Hall.p 23-89
6. Ivor, s. (1987). civil engineering contract administration and control.p67-89.
7. Jason. (2009). A guide to the project management body of knowledge, PMBOK guide, project p34-87
8. Kaming, P. O. (1997). Factors influencing construction time and cost overruns on high-rise projects in Indonesia, construction management and economics, p83-94.
9. Love, P. &. (2005). Time-Cost relationships in Australia building construction projects, Journal of construction engineering and management, pg 187-194.
10. Peter, M. (1969). Contracting for engineering Management and Construction Projects. 5th edition. Gower Publishing Company.p34-56
11. Silverman, D. (2000). Doing qualitative research: A practical handbook, London. sage publication.p35-57
12. Susong, M. K. (2005). the construction project: phases, people, terms, paperwork processes. In m. susong. ABA publishing. 3rd ed. p125-142
13. Talukhaba, A. (1998). An investigation into factors causing construction project delays in kenya, a case study of high rise building projects in Nairobi. unpublished ph.D thesis, university of Nairobi.121-145
14. Twort. (1985). civil engineering supervision and management. 4th ed. (pp. 50-67). John Wiley & sons.

AUTHOR PROFILE

Alex John Kalume is a masters student in construction engineering and management at Jomo Kenyatta University of Agriculture and Technology.

Stephen Diang'a is a Lecturer, School of Architecture and Building Science, at Jomo Kenyatta University of Agriculture and Technology.