DEVELOPMENT OF MODELS FOR FORECASTING TIME AND COST OF BUILDING CONSTRUCTION PROJECTS

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Development of Models for Forecasting Time and Cost of Building Construction Projects

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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This thesis has been submitted for examination with our approval as the university supervisors

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DEDICATION

To my wife and brothers, for their support throughout the research process

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LIST OF ABBREVIATIONS/ACRONYMS

NOFL: Number of floors

FLAR: Floor area

FCT: Final contract time

FCC: Final contract cost

ABSTRACT

The owner, lending organizations, contractors, or designers need early cost estimate at the very early stages of the project for several purposes, including but not limited to the determination of the feasibility of the project, financial evaluation of number of alternatives and establishment of initial budget (Mehmet, 2005). However, very limited design information is usually available for a project at this early stage. The scope is usually not finalized at the conceptual phase and predicting the likely cost of building works is a challenging task. Under such circumstances, a quick, inexpensive and reliable technique is necessary in order to obtain a cost estimate with reasonably accuracy. Previous researchers have exhaustively studied the causes of delays and cost overruns but little research has been done on methods of predicting construction project cost and time in Kenya. Models developed in other countries cannot be applied in Kenya due to different construction environment and therefore the contents of variables differ. The objective of this study is to develop models for forecasting time and cost of building construction projects at the inception stage of a project. To achieve this, models for realistic estimation of contract duration and budget were developed based on data collected through a survey of construction practitioners comprising of architects, engineers, contractors and quantity surveyors. Questionnaires were used to collect information on past public and private building projects performance in terms of cost and time. Multiple regression technique was used in the analysis of data for the study obtained from 45 respondents.

The study developed models for forecasting project duration, FCT = 37.58 + 6.43NOFL + 0.001FLAR and final cost, FCC = -13.370+22.659NOFL+.012FLAR. The model for forecasting project duration was recommended for use.

CHAPTER ONE

INTRODUCTION

1.1. Background to the study

Time, cost, quality target and participant satisfaction have been identified as the main criteria for measuring the overall success of construction projects (Jagboro, 2008). Of these, cost and time tend to be the most important and visible, always considered as very critical because of their direct economic implications if they are unnecessarily exceeded. However, Ifte (2010) concluded that the estimation of time has continued to be a problem of great concern and interest to both researchers and contractors.

The process of estimation of project cost and implementation period has been a subject of numerous studies for example, the 'Time-cost' model which was developed in the sixties by an Australian researcher Brimilow (1969) aiming to provide the most accurate construction time estimation possible in the early project phases. The model was defined as a function of construction cost and as such was limited to the Australian context. After its initial research, credibility of this model was later confirmed on many occasions in Great Britain, China, Texas, Malasyia, and Croatia (Ogunsemi & Jagboro, 2008).

In the last three decades, construction research in Kenya has focused on the entities that constitute the construction industry – particularly the projects, the contractors and the labour force – deducing the performance of the industry as a whole from the observations made on its parts. Key areas of research have been procurement methods (Mbaya 1984, Kithinji, 1988 and Mbatha 1993); project performance – causes of delays, cost overruns and labour output (Wambugu 2013, Gichunge 2000, Wanyona, 2005, Wachira 1996, Talukhaba 1999) and construction business performance - indigenous contractors, marketing and labour output (Magare, 1987 and Gitangi, 1992). However, none of these recommendations have effectively addressed the issue of time and cost estimation in building construction projects.

Building cost model can be described as a system that produces forecasted price from historical data (Jagboro, 2008). These models can be used in any initial construction project decisions, despite the project scope having not yet been finalized and limited information regarding the detailed design available during these early stages.

Estimation of cost is carried out during various phases of construction to assess total project cost or to predict costs that may be incurred during different stages (Hendrickson and Au, 2008). There are two types of estimates, as described by Faghri (2005), scratch based estimate and bid based estimate. Scratch based estimate uses information such as price, quantity, equipment, manpower and construction procedure, while bid based estimates use data available from similar projects in the past to predict the cost of the project (Faghri, 2005). At the feasibility phase of the project a screening estimate is prepared to assess the feasibility of the project, followed by a conceptual estimate which is based on conceptual design of the facility to make a “go/no go” decision (Hendrickson & Au 2008). Scratch based cost estimation is a tedious and time consuming process which not only requires detailed knowledge of the scope of the project but also the unit cost of each activity. There is need for a quick and reliable technique for estimating projects costs (Pawar, 2007). Pawar (2007) suggested that if data from previous projects with similar scope of work are available, statistical models may be developed to predict final costs.

The early or conceptual phase is the first phase of a project in which the need is examined, alternatives are assessed, the goals and objectives of the project are established and a sponsor is established (Holm et al. 2005). The term early estimate is used to describe the process of predicting a project cost before the design of the project is completed (Muhamid, 2011). At this stage, estimate accuracy is between ±25% and ±50% (Schexnayder, 2003). The accuracy of cost estimation improves towards the end of the project due to detailed and precise information.

Early stage (pre-design) cost estimation is a crucial element of any construction project for planning and feasibility studies. The accurate estimation of the early cost will support the project managers in decision-making process. It allows the managers to choose adequate alternatives. The cost of a project is also impacted significantly by the decisions taken at the pre-design phase. Early cost estimating is considered as the most significant starting process to influence the fate of a new project (Sodikov, 2005).

Construction clients require early and accurate cost advice in order to enable them to take a right decision regarding the feasibility of proposed project. However, a number of difficulties arise when conducting cost estimation during the early phase. Major problems include lack of preliminary information, lack of database of works costs, lack of appropriate cost estimation methods, and the involvement of many environmental, political, social, and external uncertainties (Muhamid, 2011).

One of the methods commonly used in estimating time in Kenya is that based on standard procedures which involve comparing estimated time with similar projects based on documented facts and personal experience. Reliable and practical estimation depends on planners' experiences and knowledge and planning process becomes an intuitive and subjective process. Models developed in this study overcome these problems in estimation of construction period and cost at the planning stage. Consultants and graduate students can use the models to estimate building cost and construction period of projects in feasibility and schematic design phases.

1.2 Statement of the problem

Predicting realistic costs and implementation time of building projects at the pre-contract stage has been a challenge to consultants for a long time. Previous researchers identified a number of problems in the estimation of cost and time at early stages of a building project; one of them is lack of proper mathematical models for predicting cost and construction period of projects at the project planning stages.

In the initial stages of a building project, there is limited available data and lack of appropriate time and cost estimation methods, where most of the common estimation techniques that are used are still inadequate. In the earliest phases of planning and design, only the most basic and functional decisions about the project have been made and the data available for predicting project cost is highly subject to change. Traditional methods for predicting the cost such as cost build-up and unit cost become inaccurate or impossible to implement.

Appropriate and accurate cost estimate at the project planning stages allows owners and consultants to evaluate project feasibility and implementation strategy which is a very important step in construction as a client would want to know an accurate project estimated cost and construction period. Preparing reliable and accurate estimates to help decision makers is the most challenging assignment that estimators face. An estimate is not only necessary for proposal preparation but also for several project management functions. Despite the importance of estimating, it has remained a very time consuming process. It is difficult to make decisions at early stages of a project without proper methods of estimating the duration. There are difficulties on project financing which involves planning, analysis and selection if the cost of the project in not known at the initial stages. Consultants therefore are in need of an alternative technique to help them predict the costs of their projects with accuracy and reliability using the limited available data in the early phases of the project.

1.3 Study justification

Time and cost are the major considerations and can be regarded as the most important parameters of a project and the driving force of project success. At the beginning of a project by the owner, prior to any design, only limited information is known about a project. However, the owner must know the approximate cost to evaluate the economic feasibility of proceeding with the project. Thus, there is need to determine the approximate cost of a project during its conceptual phase.

The results of this study are of practical use in the construction industry as it provides a basis for construction practitioners in estimation of construction period and cost of buildings at the planning stage. This study is important to the construction industry as follows:

1) The model will assist consultants to formulate more realistic contract periods.
2) Consultants will be able to estimate or benchmark the construction cost

All parties involved in construction project are in need of reliable information about the time and cost of a project in the early stages. During the planning stage of a project, clients need an indication of the likely construction period to create a cash and material flow plan in a pre-set time and can make optimum funds available to the project.

1.4 Main objective

The main objective of this study is to develop predictive models for application in the prediction of building project cost and construction period at the inception stage of a project.

1.5 Specific objectives

1) To establish factors that influences the determination of project cost and construction period.
2) To develop a model for accurate estimation of project cost using factors influencing estimation of project cost.
3) To develop a model for accurate estimation of project construction period using factors influencing estimation of project construction period.

1.6 Research questions

1) What factors affect the cost and duration of construction projects?
2) How can a model for estimating project cost be developed using factors influencing project cost estimation?

3) How can a model for estimating project construction period be developed using factors influencing project construction period estimation?

1.7 Scope

The primary objectives of any construction project is to optimize quality, cost and time. This research work therefore focuses on two of the basic requirement – cost and time. The study was therefore conducted within the spheres of building and construction within the Mombasa County. The concern was based on completed projects with records on project cost and construction period from contractors and consultants. The study establishes factors that affect cost and duration of projects. It further focuses on developing models for estimating both time and cost of projects.

1.8 Limitations

Every effort was made to seek information from relevant stakeholders, and to review different standard literatures. However, the thesis work is limited by several factors. The target population was all the contractors, developers and consultants in Kenya but due to resource and time constraints, the researcher conducted the study in Mombasa County. The study does not cover time and cost of civil engineering works and external works, therefore estimates can be made for the main building works only.

1.9 Definition of terms

For the purpose of the study, the following definition of terms will be used.

- **Model**: Building cost or time model can be described as a mathematical relationship that produces forecasted price or time from historical data
- **Cost**: a monetary valuation of effort, materials, resources, time and utilities consumed, risks incurred, and opportunity forgone in production and delivery of a good or service.
- **Time**: this is the period taken to complete a project
- **Budgeted cost**: an expense that has been planned for in advance and for which funds are typically put aside to cover a given project
- **Cost overrun**: amount by which the actual cost exceeds the budgeted, estimated, original, or target cost.
- **Time overrun**: this is the extended time which a project takes beyond the specified time in project plan
- **Project**: A temporary endeavor undertaken to create a unique product or service or result which takes place within stipulated time frames with a start and an end date
- **Contractor**: organization or individual that contracts with another organization or individual (the owner) or the construction of a building, road or other facility.
- **Consultant**: a professional who provides expert advice in a particular domain or area of expertise
- **Private hotel/motel**: means a building for accommodation whose the owner is not the government

- **Public hotel/motel**: means buildings where the financier or owner is the government of Kenya

1.10 Outline of the study report

The study report is organized in five chapters. Chapter I discusses construction projects time and cost estimation in the global construction industry, and describes the problem with methods of estimation of time and cost in Kenya. The need to develop models for forecasting contract period and cost in the country is discussed, and the objectives stated.

Chapter II describes the challenges facing the construction industry. Research work previously done in modeling of construction time and cost are discussed and finally the literature gap highlighted.

Chapter III discusses the methodology used in conducting the study. The research design, data collection procedures, variables in the study and data analysis procedures are discussed.

Chapter IV presents analysis of the data and the results observed. Variables are defined and regression models are built up from the data and tested. The results are also discussed in this chapter and the ability of the models to predict time and cost are described

Chapter V covers conclusions of the study findings and gives areas of further research

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Cost estimating is an essential part of construction projects, where cost is considered as one of the major criteria in decision making at the early stages of building design process (Gunaydin & Dogan, 2009). The cost of construction project needs to be estimated within a specific accuracy range, but the largest obstacles standing in front of a cost estimate, particularly in early stage, are lack of preliminary information and larger uncertainties as a result of engineering solutions (Sonmez, 2011). Cost models provide an effective alternative for conceptual estimation of construction costs. This chapter reviews literature related to the time and cost estimation modeling organized around four major topics namely: time and cost estimation, construction cost and time modeling, multiple regression, theoretical and conceptual framework of the study.

2.2 Time and cost estimation

Goud (2009) defined estimate as an appraisal, an opinion, or an approximation as to the cost of a project prior to its actual construction. According to Jelen et al. (2000), estimating is the heart of the cost engineer's work and consequently it has received appropriate attention over the years.

Ahuja et al. (2008) state that estimating is the primary function of the construction industry; the accuracy of cost estimates starting from an early phase of a project through the tender estimate can affect the success or failure of a construction project. They also state that many failures of construction projects are caused by inaccurate estimates.

A cost estimate establishes the base line of the project cost at different stages of development of the project. As Hendrickson and Au (2008) point out, a cost estimate at a given stage of a project development represents a prediction provided by the cost engineer or estimator on the basis of available data.

Holm et al. (2010) lists several reasons for making estimate, including:

- Feasibility studies
- Selection from alternate design
- Selection from alternate investment
- Appropriation of funds
- Presentation of bids and tenders

There are several methods and techniques for cost estimation at different phases of a project, including; traditional detailed breakdown cost estimation, cost estimation per activity, cost estimation based on cost functions (Cheng et al. 2010). Comparative cost estimating and regression models assume a linear relationship between the final cost and the basic design variables of the project (Gunaydin & Dogan, 2004). In this study, the estimation of cost is by use of regression models.

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 (Project Management Institute, 2008).

In practice, there are two common methods of estimating project completion time:

1) According to the client's time constraints e.g. occupancy need, or
2) Through a detailed analysis of work to be done and resources available, using estimates of the time requirements for each specific activity (Al-momani, 2005).

Method (2) is known to be very tedious and is often impractical in view of the time limitations imposed on the contractors at the tendering stage. Detailed estimating of construction activities also relies on the estimators' experience and judgement to correctly interpret project and site information and make the best possible decisions (Teicholz, 2004).

2.3. The definition of building cost

The concept of cost is defined in various ways. In most general sense, cost means the monetary value of the goods and services used in order to perform an operation (Yaman, 2007).

In terms of building construction participants of the projects, the owner, the designer, the contractor, the user and the society are concerned with the building cost in various ways, due to the diverse expectations and the objectives of the participants (Yaman, 2007).

Decisions on investment of building projects, owner's evaluation of bids prepared by contractors, calculation of the tender price of the contractors, cost control during the decisions on design are all bound to the correct or almost correct cost estimation. Therefore, in order to appraise the design of a building it is necessary to use a convenient cost model.

Models have been developed in this study to assist in evaluation of alternative building projects at the planning stage.

2.4. Construction costs and time modeling

This section covers models for estimation of cost and time by other researchers and from this the research gap was identified.

A number of cost prediction models have been developed. An Australian researcher, Brimillow (1969) studied several projects in his own country Australia and suggested that size is related to the cost of the project and it can be used to establish the cost and the time performance level of a certain project. The Brimillow-Time-Cost (BTC) model (Brimillow, 1969) was developed to provide a quick and quantitative means of estimating project construction time. The model attempts to predict construction time using the estimated final cost of construction project as expressed,

$$T = K \cdot C^B$$

Where:

T = duration of construction period in working days from the date of possession of site (effective commencement of construction) to practical completion.

C = estimated final cost of project in millions of dollars adjusted to constant labour and material prices

K = a constant describing the general level of time performance for a $1 million project

B = a constant describing how the time performance was affected by project size as measured by cost.

Brimillow's (1969) study revealed that the time taken to construct a project is highly correlated with the size as measured by cost. Construction time in working days (T) could be expressed as a function of final contract sum in millions of shillings (c) based on the regression line of best fit and upper and lower quartile limits derived from the historical data. However, one potential shortcoming of the BTC model is that it fails to consider factors other than cost when establishing the construction time (Walker, 2004). Several research studies have been carried out to improve the accuracy of the BTC model.

Walker (2004) also measured the contract time performance, this time in terms of the gross floor area of a building. In this case, problems occurred due to the construction cost including a significant external works component, presenting difficulties in measuring construction scope per unit of construction time. Despite these problems, Walker (2004) concluded that the BTC model is the best predictor of construction time; the principal advantage of using construction cost per time period as a measure of project scope being that all elements of a building can be expressed in a single unit of scope measurement.

Other studies have considered additional factors, such as the construction project scope, extent of varying construct period and fixed budget construction (Ling, 2004).

There are other researchers who developed models for estimation of construction cost and time in different countries. The model equations are as stated in the following statements.

Ogunsemi and Jagboro (2006) did a study in Nigeria and obtained a predictive equation as: $T = 118.563 - 0.401c$ ($C>408$) or $T = 603.427*0.610c$ ($c > 408$), where $R^2 = 0.765$ which shows a high predictive power. The letters C and T stand for cost and time respectively.

Love et al. (2005) conducted a research in Australia and obtained a predictive equation as: log (t) = 3017.8 + 0.274 log (GFA) + 0.142 log (floor) where: t = completion time; GFA = gross floor area, and floor = No. of floors

Proverbs and Holt (2000) developed a model equation in UK: Y = 14.439 + 13.377 (“concrete pump” transportation method) + 4.125(“property” types of formwork) + 3.609 (productivity of erecting formwork to floor slabs) + 1.690 (number of supervisions). R^2 = 0.473 (Average predictive power).

Mahamid et al. (2010) developed multiple linear regression models for preliminary cost estimating of road construction activities as a function of project’s physical characteristics such as terrain conditions, ground conditions and soil drillability.

Lowe et al. (2006) developed linear regression models in order to predict the construction cost of buildings, based on 286 sets of data collected in the United Kingdom. They identified 41 potential independent variables, and, through the regression process, showed five significant influencing variables such as gross internal floor area (GIFA), function, duration, mechanical installations, and piling. Recent work reveals that there are still many problems in cost estimation at the conceptual stage of a project.

2.5 Factors that influences the determination of project cost and construction period

There are several key parameters that affect building cost and time. Many researchers studied these parameters and implemented in their models according to various parameters. Table 2.1 presents the influential factors used in empirical models.

Table 2.1: Influential factors adopted in previous researches

No.	Chosen factors	References
1	Floor area	• (Kim, et al. 2004) • (Gunaydyn & Dogan, 2004) • (Cheng,et al. 2010) • (Sonmez, 2011) • (Wang, et al. 2012) • (Arafa & Alqedra, 2011)
2	Number of storeys	• (Kim, et al. 2004) • (Gunaydyn & Dogan, 2004) • (Cheng,et al. 2010) • (Sonmez, 2011) • (Wang, et al. 2012)
3	Slab type	• (Kim, et al. 2004) • (Dogan, 2005)
4	Finishing grades	• (Kim, et al, 2004)
5	Foundation type	• (Kim, et al. 2004) • (Gunaydyn & Dogan, 2004) • (Wang, et al. 2012) • (Arafa & Alqedra, 2011)
6	Number of elevator	• (Wang, et al. 2012) • (Arafa & Alqedra, 2011) • (Sonmez, 2011)
7	Type of project	• (Elsawy, et al. 2011)
8	Type of contract	• (Elsawy, et al. 2011)
9	External finishing	• (Wang, et al. 2012) • (Sonmez, 2011)

2.6 **Challenges of time and cost estimation in the Kenyan context**

Cost estimating is an essential task for budgeting and bid preparation for any construction project. A good estimate depends on many factors including time given to the estimator, estimator's experience, and a wide range of assumptions regarding the project (Jrade & Alkass, 2007). Construction cost estimating involves collecting, analyzing, and summarizing all available data for a project (Holm et al., 2005).

Construction cost estimating is considered one of the most important and critical phases of a construction project. An accurate estimate helps in decision making but is a challenge to consultants. These estimates are usually required for project management functions beginning with proposal preparation. Despite the importance of estimating, it has remained a very time consuming process. The most inefficient part of construction cost estimating is the determination of the amount of resources needed for the construction of a project which is known as quantity takeoff. Quantity takeoff is a very long and error-prone process that is performed manually by estimators. Missing or duplicating work items are among the errors that can occur during the quantity takeoff process (Kagiri, 2010).

Construction cost estimating is a cumbersome process. It takes a long time for an estimator to complete an accurate estimate and construction contractors must prepare cost estimates quite often in order to prepare bids for new projects. This presents a challenge to an estimator who has to prepare several estimates in a short period of time. (Kagiri, 2010)

2.7 Multiple regression

This section describes the method which was used for the development of time and cost models. 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 (Harry & Stevens, 2001).

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 (Harry & Stevens, 2001).

According to Harper (2005), 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.

2.7.1 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 (Harper, 2005). The three main types of multiple regression analysis are:-

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

i. Standard multiple regression

Harper (2005) 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 and was adopted in this study.

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 (Harry & Stevens, 2001). 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 (Pallart, 2005). There are a number of problems with these approaches and some controversy in the literature concerning their use.

2.7.2 Application of multiple regression

Harry and Stevens, (2001) mention 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.

2.8 Theoretical and conceptual framework of the study

The literature review was to examine the previous researches and assist to conceptualise areas so as to sufficiently develop the main focus of the research. The literature available hardly covers models for estimation of construction time and cost in Kenya with the variables adopted in this study.

2.8.1 The project management triangle

The study covers the elements of time, cost and scope which are the only constraints, i.e. by developing models for time and cost estimation.

The project management triangle (also called *triple constraint*) is a model of the constraints of project management (Project Management Institute, 2008). 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 (Project Management Institute, 2008).

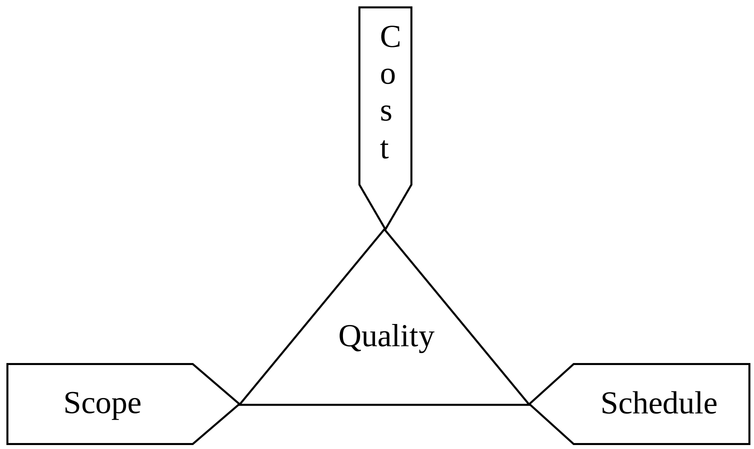

Figure 2.1: The project management triangle (Source: Project Management Institute, 2008).

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.

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 (Project Management Institute, 2008). 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). Actual cost of previous, similar projects can be used as a basis for estimating the cost of current project. According to Project Management Institute (2008), 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

As defined by the project management body of knowledge (PMBOK), cost estimation is the iterative process of developing an approximation of the monetary resources needed to complete project activities. Project teams should estimate costs for all resources that will be charged to the project. This includes but is not limited to labour, materials, equipment, services, software, hardware, facilities and contingency costs

Cost process areas are:

- 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

2.8.2 Conceptual framework

A conceptual framework is a visual or written product that explains, either graphically or in narrative form, the main things to be studied such as key factors, concepts, or variables and the presumed relationships among them.

To prepare an elemental cost plan the following information should be assembled:

- A cost analysis of a previous similar building
- Sketch plans and elevations of the proposed project
- Outline specification/levels of services installation, etc. for the proposed project

The preparation begins with a request made by management, consultants or owner to estimate the cost of a new project. The most important part of the request is the project scope. The first task for the estimator is to collect historical data related to similar past projects. The selection and usage of these data is crucial for the estimating preparations because inappropriate information will negatively affect the estimate. The number of units or size of the project is the only available information. The outputs from this stage are the project conceptual cost. It is very important to describe in detail all the information, assumptions, adjustments, and procedures considered in the estimate. The resulting conceptual cost estimate is then submitted to management, consultants or owner for decision-making. A conceptual framework is shown in Figure 2.2.

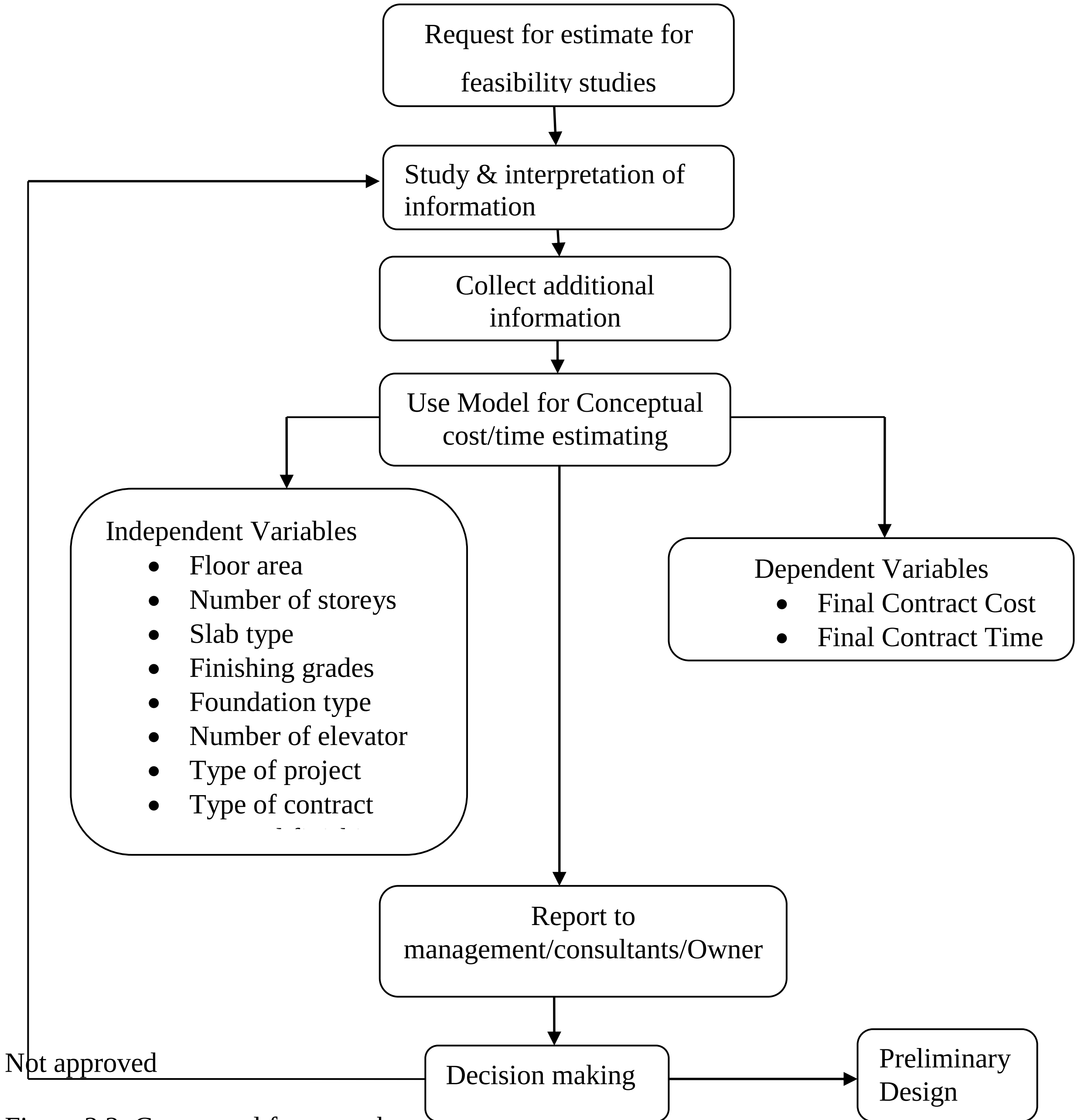

Figure 2.2: Conceptual framework

2.9 Summary

In conclusion, some research work has previously been done in developing regression models for estimating cost in other countries but not in Kenya. The review of literature has shown that research work has previously been done in developing regression models for predicting construction time in the UK, the US, Australia and Singapore.

In the literature reviewed, no records of prior research work were found on models for predicting construction time and cost of building projects in Kenya. It is for that reason that this study attempts to develop a tool for predicting construction time and cost of building projects.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methodology used to collect the data and to analyze them. These include research design, questionnaire design, and the data collection techniques.

3.2 Research design

The purpose of this study is to predict construction time and cost, therefore, the data involved is numeric and the quantitative approach was adopted for the study. This is a descriptive research as it describes data and characteristics about the population being studied. Furthermore, it involves selecting an appropriate sample of participants, collecting valid and reliable data and reporting conclusions.

Field survey methodology was adopted to obtain data on past building projects from practitioners. The research adopted quantitative approach to obtain information about the floor area and number of floors of buildings. Close-ended questions were used in the questionnaire to obtain information about respondents' personal information, their organizations and performance records of past projects in terms of cost and time which generated quantitative data. The study also involved correlation which helped in identifying the relation of one variable to another.

3.3 Questionnaire design

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.

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. Information from sections 1a and 1b shows that the organizations might have undertaken enough projects and if their staffs are experienced to enable them to answer questions contained in the questionnaire regarding the industry.

Section 2: information about past performance of projects in terms of time and cost. Data on past performance of projects were obtained from firm 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
- Number of floors
- Floor area

The types of facilities are classified as residential, commercial (office and recreational), hotel/motel, Industrial – factories, and institutional – education.

3.4 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. Simple random sampling technique was conducted to construction professionals who were contacted on phone to brief them on the aim and objectives of the study and also seek their readiness to be part of the pre-testing of the study. These professionals were selected due to their level of experience in the construction industry.

The pre-testing provided a platform to brainstorm with respondents to understand their problems with answering any of the questions, if they were able to understand the question correctly and how they felt about the questions. The pre-testing was undertaken via e-mails and visits to the offices of the professionals.

3.5 Data collection

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.

3.6 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.

3.7 Population

The population of this research was all the construction practitioners in Mombasa County. Four categories of respondents in the construction industry were identified for data gathering. These are architects, engineers, quantity surveyors and building contractors.

3.8 Sampling technique

The samples were randomly selected using stratified random sampling technique of probability sampling in order to give everyone that falls into any of these identified target groups equal and independent chance of being included in the sample. Stratified random sampling offers several advantages over simple random sampling. Firstly, a stratified sample can provide greater precision than a simple random sampling of the same size. Because it provides greater precision, a stratified sample often requires a smaller sample, which saves money.

3.9 Sample size.

The research sample was taken from stakeholders in the construction industry mostly contractors and consultants, that are selected depending on their direct exposure to building construction activities. They were selected from Mombasa County, home to Kenya’s second largest city. The contractors were identified from the National Construction Authority register after applying a filter of Mombasa as the town the contractor is registered under.

The number of architects and quantity surveyors were obtained from Architectural Association of Kenya while the number of engineers was obtained from Engineers Board of Kenya. The number of Architects, engineers, contractors and quantity surveyors were 10, 35, 25, 10 respectively.

The size of the sample is perhaps the most important parameter of the sample design, because it affects the precision, cost and duration of the survey more than any other factor. Sample size was considered both in terms of the available budget for the survey and its precision requirements.

A sample of 76 of all practitioners was obtained using sample size calculator. Sample sizes for each stratum were determined by the following equation and the results tabulated in table 3.1.

$n_h = (N_h / N) \times n$……………………………………………………………………….3.1

Where: n_h is the sample size for stratum *h*, N_h is the population size for stratum *h*, N is total population size, and n is total sample size. The sample size can also be obtained from table 1 appendix 2.

Table 3.1: Determination of sample size

Practitioners(Stratum)	Population	Percentage	Sample size
Architects	10	12.5%	10
Engineers	35	43.75%	32
Contractors	25	31.25%	24
Quantity surveyors	10	12.5%	10
Total		**100%**	**76**

3.10 Methods of data analysis

Data analysis was done with the help of a software programme, Statistical Package for Social Sciences, SPSS version 13.5 which is the most current version in the market. 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.

3.11 Modeling

Regression analysis was used to develop sets of mathematical equations for estimating construction costs and contract period. The aim of regression analysis is as follows:

- To determine whether a relationship exists between the variables or not

- To describe the relationship in terms of a mathematical equation
- To evaluate the accuracy of prediction achieved by the regression equation
- To evaluate the relative importance of independent variables in terms of their contribution to variation in the dependent variable.

The independent and dependent variables are all connected in a regression model. Number of floors and floor area the independent variables which were used to develop the models. The dependent variables were final contract time and cost which are the variable which were observed and measured to determine the effect of the independent variable.

3.12 Multiple regression

Statistical package for the social sciences (SPSS) software package was used for statistical analysis.

Multiple regression as a statistical technique allowed prediction of final cost and time on the basis of the scores on several other independent variables, namely, floor area, number of floors, initial cost and initial time. Multiple regression technique is used to express a dependent variable (Y_p) in terms of the independent variables x_1, x_2 … x_n for investigating the functional relationship between a dependent variable and one or more independent variables. The general equation representation is as follows:

$$Y_p = \alpha + \beta_1 x_1 + \beta_2 x_2 + ... \beta_k x_k \qquad 3.2$$

Where:

Y_p = dependent variable

α = regression constant

β_1 to β_k = partial regression coefficient of $x_{1,\ 2,\ 3 \ldots . k}$

x_1 to x_k = independent variables or parameters

For analysis of the output of the computer software, SPSS the following parameters were considered which are explained in subsequent section:

- Pearson's correlation coefficient (R) or r
- Coefficient of determination R^2
- Correlation analysis

3.12.1 Pearson's correlation coefficient (R) or r.

The Pearson correlation coefficient quantifies the strength of the linear relationship between two variables (Chaterjee, 2002). The correlation coefficient is a dimensionless number; it has no units of measurements.

Interpretation

The value of r is such that $-1 < r < +1$. The + and – signs are used for positive linear correlations and negative linear correlations, respectively.

- Positive correlation: if x and y have a strong positive linear correlation, r is close to +1. An r value of exactly +1 indicates a perfect positive fit. Positive values indicate a relationship between x and y such that as values for x increase, values for y also increase.
- Negative correlation: if x and y have a strong negative linear correlation, r is close to -1. An r value of exactly -1 indicates a perfect negative fit. Negative values indicate a relationship between x and y such that as values for x increase, values for y decrease.

- No correlation: if there is no linear correlation or a weak linear correlation, r is close to 0. A value near zero means that there is a random, nonlinear relationship between the two variables. Note that r is a dimensionless quantity; that is, it does not depend on the units employed.
- A perfect correlation of ± 1 occurs only when the data points all lie exactly on a straight line. If r = +1, the slope of this line is positive. If r = -1, the slope of this line is negative.

  A correlation greater than 0.8 is generally described as strong, whereas correlations less than 0.5 are generally described as weak. These values can vary based upon the type of data being examined.

3.12.2 Coefficient of determination R^2 or r^2

The coefficient of determination R^2 is a descriptive measure of the strength of the regression relationship, a measure of how well the regression line fits the data (Chaterjee, 2002). The coefficient of determination, r^2 is useful because it gives the proportion of the variance (fluctuation) of one variable that is predictable from the other variable. It is a measure that allows a researcher to determine how certain he can be in making predictions from a certain model/graph.

Interpretation

If $R^2 = 1$: perfect match between the line and the data points

If $R^2 = 0$: there are no linear relationship between x and y

In general, the higher the value of R^2, the better the model fits the data.

3.12.3 Correlation analysis

Correlation analysis show whether and how strongly pairs of variables were related (Harry & Stevens, 2001). The variables are not designated as dependent or independent. The two most popular correlation coefficients are:

- Spearman's correlation coefficient
- Pearson's product-moment correlation coefficient

The value of a correlation coefficient for ordinal data, spearman's technique is used. For interval or ratio-type data, the Pearson's technique is used.

The value of a correlation coefficient can vary from minus one (-1) to plus one (+1). Negative (-1) indicates a perfect negative correlation, while a +1 indicates a perfect positive correlation. A correlation of o (zero) means there is no relationship between the two variables. When there is a negative correlation between two variables, as the value of one variable increases, the value of the other variable decreases, and vice versa. In other words, for a negative correlation, the variables work opposite each other. When there is a positive correlation between two variables, as the value of one variable increases, the value of the other variable also increases. The variable move together (Harry & Stevens, 2001)

3.13 Model validation

The regression models for estimation of contract period and cost developed were validated to test their suitability for practical use. A questionnaire was used to collect data for validating the model. The questionnaires were sent construction professionals in Mombasa County. Each of the models was validated with results from different facilities.

CHAPTER FOUR

RESEARCH RESULTS AND DISCUSSION

4.1. Introduction

The purpose of this study was to develop models for forecasting construction cost and time of building projects. In order to achieve the purpose of study, a methodology consisting of a review of literature and a survey of construction practitioners was conducted. This chapter explains the results of the study.

4.2 The response rate

The sample size consisted of 76 professionals in the construction industry. Of these 10 were architects, 24 were contractors, 10 were quantity surveyors and 32 were engineers. Among the questionnaires mailed electronically, 45 were returned and 31 declined to participate. A response rate of 59.21% was thus achieved. The respondents were given one month to respond, however, some respondents required longer time to finalize their responses.

Table 4.1: Response rate

Professional	Sample size	Questionnaires received	Response Rate by professionals (%)	Response rate (%)
	A	B	C (C=B/Ax100)	D (D=B/45x100)
Architects	10	4	40	8.9
Engineers	32	26	81.25	57.8
Quantity surveyors	10	4	40	8.9
Contractors	24	11	45.8	24.4
Total	**76**	**45**	**59.21**	**100**

Response rate by professionals was 59.21%. According to Denscombe (2010) response rate of 50% and above is sufficient for statistical analysis.

4.3 Profile of companies

i. Sector

Table 4.2 shows that 93.3% of respondents were in private sector and 6.7% in public sector.

Table 4.2: Sector of respondents

Sector	**Frequency** (A)	**Percent** A/45x100
Private	42	93.3
Public	3	6.7
Total		**100**

ii. Number of years of organization in construction

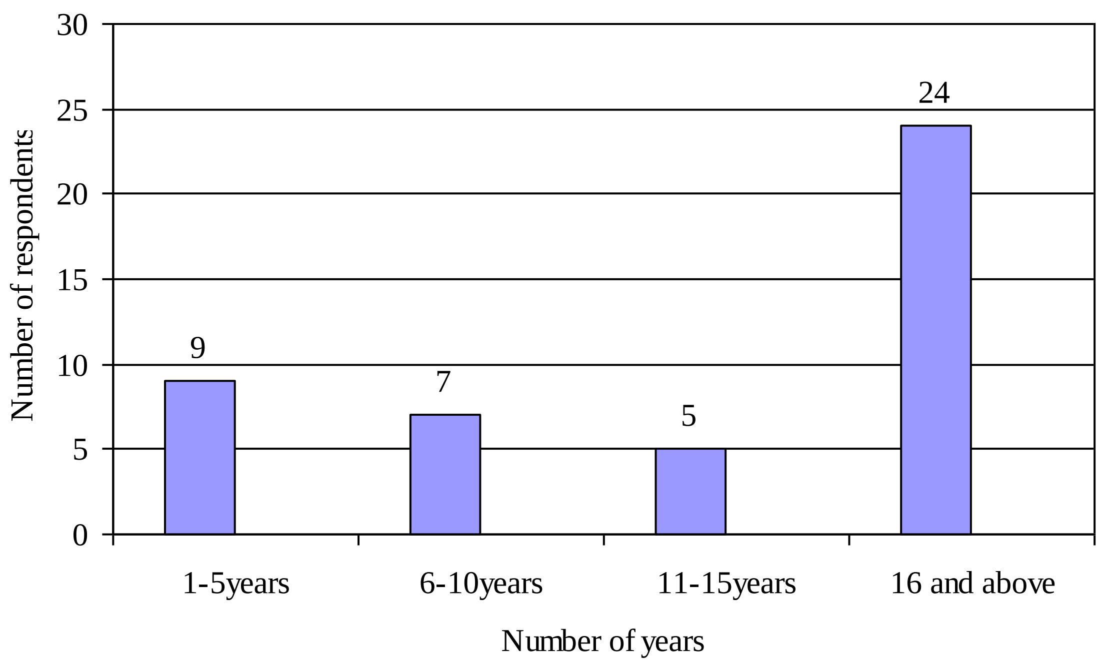

Figure 4.1: Number of years organization has been in construction

Figure 4.1 shows that majority of the organizations constituting up to 53.3% have been in construction for over 16 years. This shows that the companies have undertaken enough projects and have enough information showing that the answers to questionnaires are reliable.

iii. Number of projects undertaken in the last five (5) years

Figure 4.2 shows that 12 companies have had 16 projects and above, 4 companies have had between 11 and 15 projects, 9 companies have had 6 to 10 projects and less than five projects were 20 companies. This show the companies are well experienced and the answers to questionnaire are reliable.

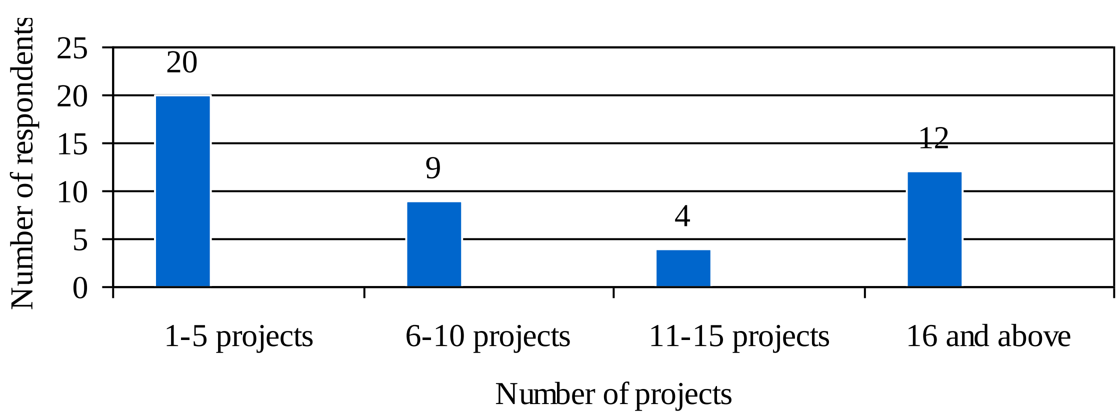

Figure 4.2: Number of projects undertaken in the last five years

4.4: Characteristics of respondents

a) **Highest formal qualification**

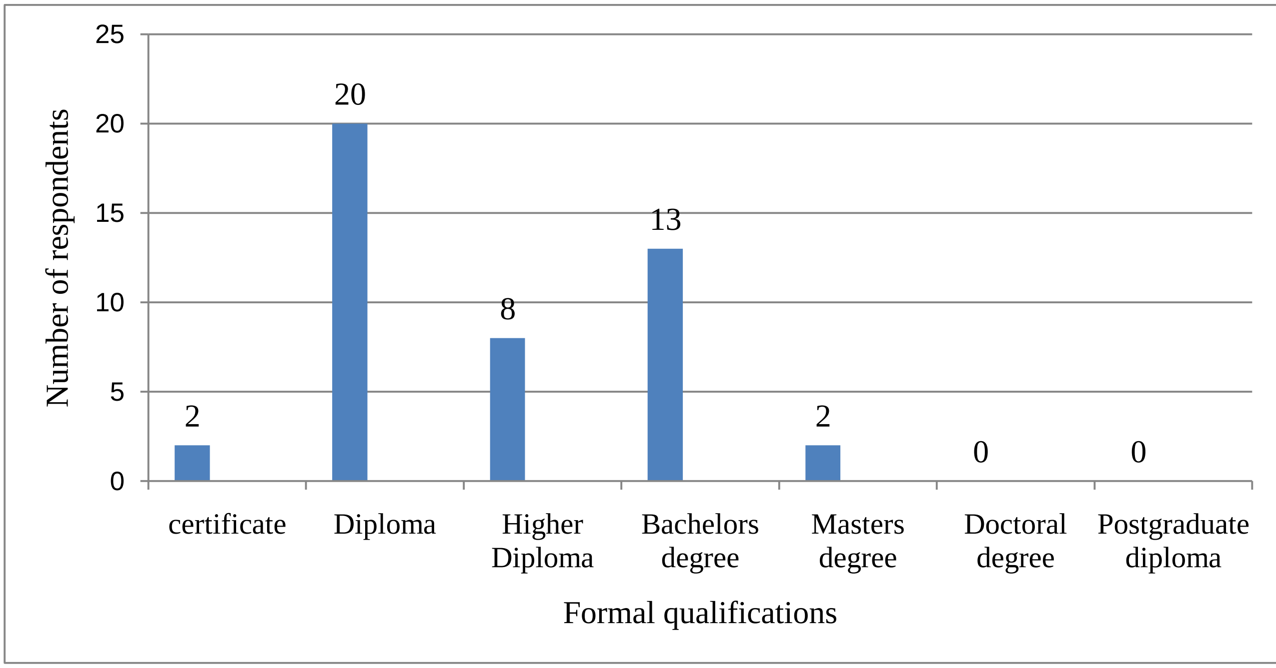

Figure 4.3: Highest formal qualification of respondents.

Figure 4.3 shows that 44.4% of all respondents have diplomas, and they are the majority in the sample, followed by bachelor's degree at 28.9%. Respondents with master's degree and certificate were 4.4%. There were no respondents with both doctoral degree and postgraduate diploma. This analysis indicates that well qualified workers are employed in the construction industry with good experience as shown in figure 4.5 hence a good performance and their views can be relied upon.

b) Respondents' status in company

Figure 4.4 shows that supervisors at 40% predominate among the respondents. Following senior staffs at 20% are managing directors, trainees, and directors/senior executives at

(11%). The lowest were technicians at 2%. This shows that the data obtained from the questionnaire is reliable.

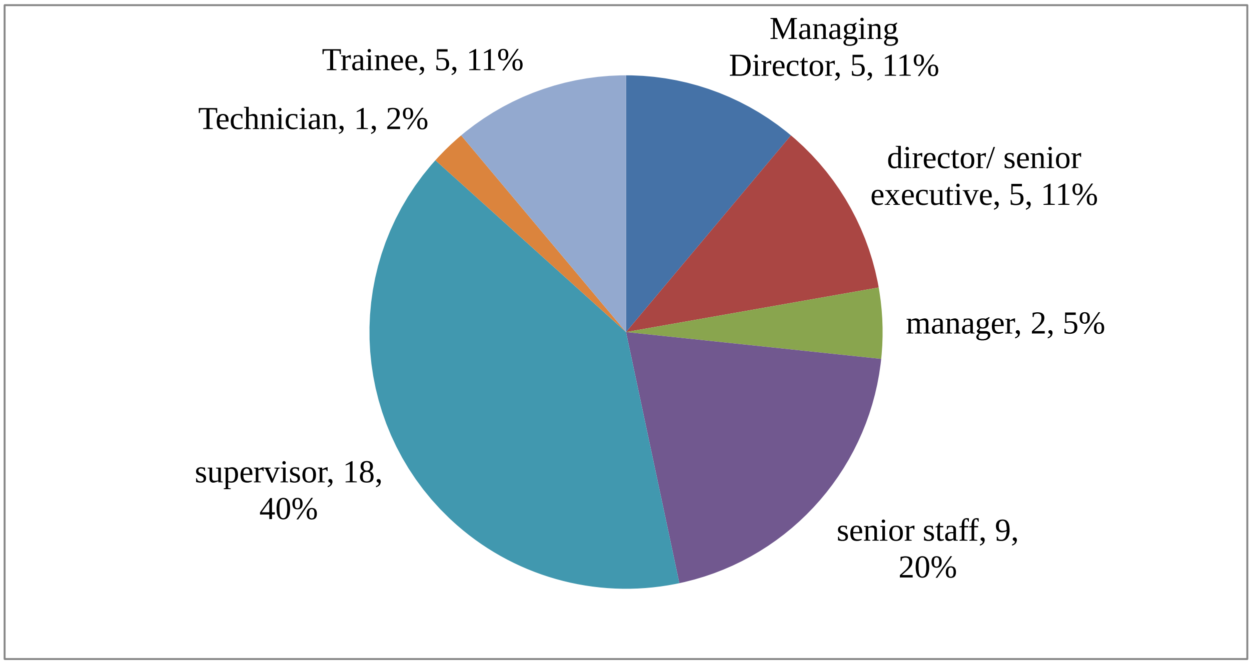

Figure 4.4: Respondents' status in organization.

c) Respondents' years of experience

The years of respondents in terms of experience are as shown in Figure 4.5. The percentages of respondents with less than 5 years were the majority at 44.7%, followed by those with 11 to 15 years at 22.2%. Those with 21 years and above were 13.3%. The lowest had 16 to 20 years of experience at 2.2%.

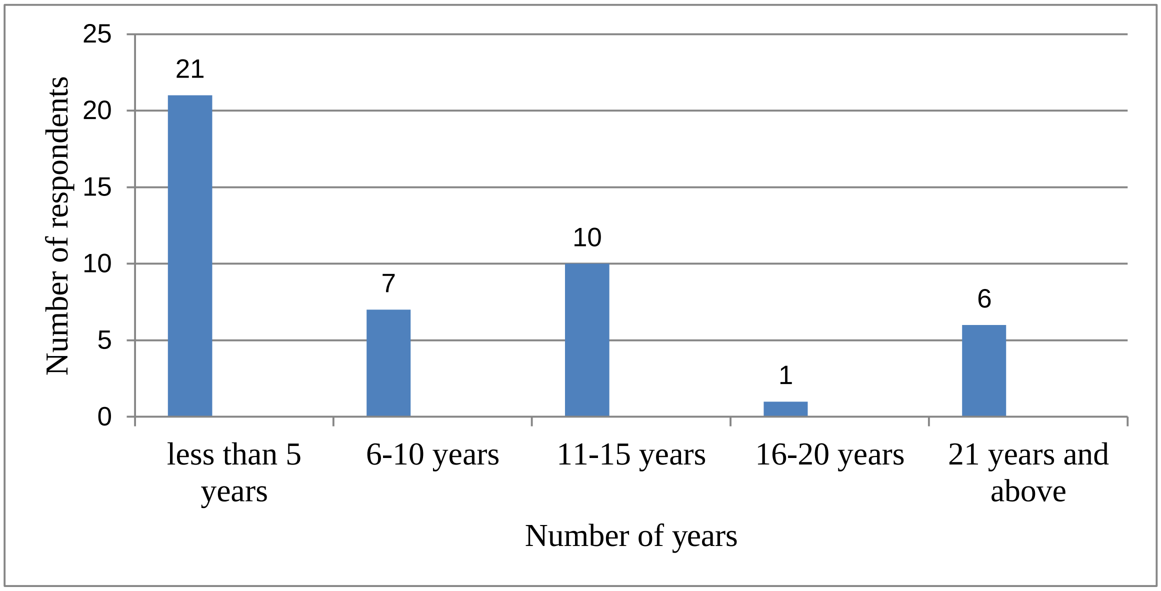

Figure 4.5: Respondents' years of experience.

Respondents with 6 years and above experience constitute to 55.3% and are considered to be knowledgeable in their area of specialization and therefore the data collected is reliable.

d) Age of respondents

Figure 4.6 shows that majority of respondents are between 20 to 29 years, making up to 51.1 %. Those above 30 years constitutes to 48.9%. This shows that the survey respondents were more experienced and their performance at work is good; thus the information obtained for analysis reflects the performance of experienced staff of construction companies.

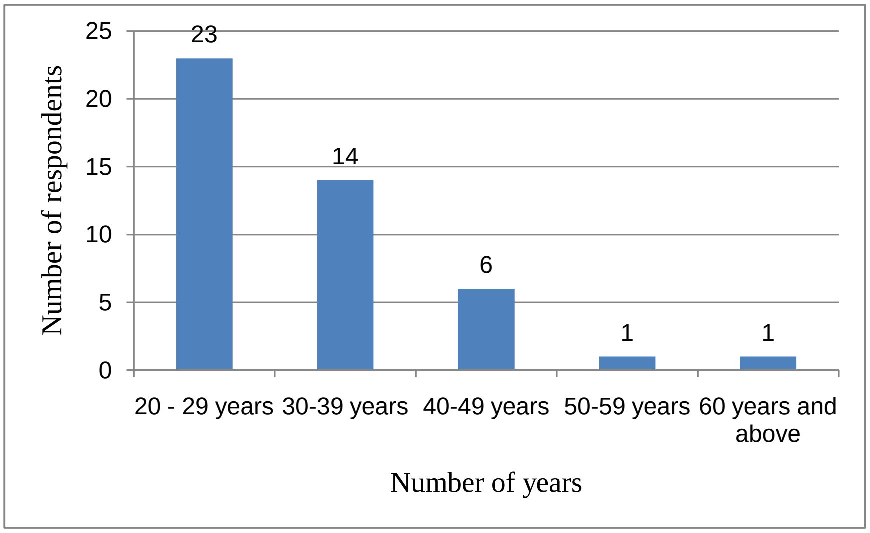

Figure 4.6: Age of respondents

4.5 Type of facility constructed

The area of interest for the study was on building projects. Residential offices were the majority at 36.4% of the population, followed closely by commercial offices at 23.8%. Hotel/motel and industrial factories were third at 11.4%, followed by institutional educational at 10.2% and the least was commercial offices recreational at 6.8%.

Table 4.3: Type of facility constructed

	Frequency	Percentage
Residential	32	36.4%
Commercial – office	21	23.8%
Commercial – recreational	6	6.8%
Hotel/motel	10	11.4%
Industrial – factories	10	11.4%
Institutional – educational	9	10.2%

4.6 Influential factors adopted in the research for the determination of project cost and construction period

There are several key parameters that affect building cost and time. Selecting the most influential parameters is one of the superior challenge of building the model. One of the most significant key in building the models is identifying the factors that have real impact on the time and cost of building projects. Depending on this great importance of selecting these factors, several techniques were adopted carefully to identify these factors including reviewing literature studies, questionnaire and conducting expert interviews that acquired a final identification of most influential factors on building project time and cost.

Table 4.4: Ranking of influential factors adopted in the research

Factors	Rank
Number of storeys	1
Floor area	2
Type of project	3
Type of contract	4
Foundation type	5
External finishing	6
Slab type	7
Finishing grades	8
Number of elevator	9

The most influential factors adopted in the research are floor area and the number of floors with ranking 1 and 2 and which generates quantitative data.

4.7 Development of models by use of multiple regression

A software programme, Statistical Package for Social Sciences, (SPSS) version 13.5 was used to analyze the data and determine the kind of relationship between variables. The following are the results:

4.7.1 Data for all facilities

Data obtained from field survey for all facilities are as follows:

Table 4.5: Combined data for all facilities

Number of floors[Noflrs]	Floor area[Floarea] (m^2)	Initial contract time[initime] (weeks) A	Final contract time[Finatime] (weeks) B	Variance (%) (B-A/A)x 100	Initial contract cost[initicost] (million) C	Final contract cost[finacost] (million) D	Variance (%) (D-C/C)x 100
1	400	22	22	0	8	8	0
6	2543.84	48	72	50	63.6	70	10
4	300	48	48	0	44	44.5	1.1
4	850	120	96	20	20.4	27.2	33.3
5	2310	50	52	4	75	82	9.3
2	632	28	35	25	63	63	0
2	55	72	80	11.1	10	10	0
3	98	24	48	100	8	7	12.5
1	480	24	22	8.3	7.5	7.8	4
5	3800	72	72	0	160	–	–
4	8400	96	104	8.3	520	515	1
5	1464	60	48	20	58	60	3.4
7	4200	96	192	100	496	520	4.8

Number of floors[Noflrs]	Floor area[Floarea] (m^2)	Initial contract time[initime] (weeks) A	Final contract time[Finatime] (weeks) B	Variance (%) (B-A/A)x 100	Initial contract cost[initicost] (million) C	Final contract cost[finacost] (million) D	Variance (%) (D-C/C)x 100
12	1080	32	32	0	72	90	25
–	55	–	28	–	4.5	4.7	4.4
–	1300	–	8	–	5.08	5.3001	4.3
3	300	48	96	100	50	53	6
1	300	36	36	0	7.2	7.2	0
13	25575	40	75	87.5	223	245	9.9
1	800	12	–	–	4	–	–
7	1000	–	96	–	–	–	–
8	–	144	–	–	115	115	0
–	–	192	–	–	120	135	12.5
1	–	48	–	–	95	95	0
4	–	240	–	–	60	64	6.7
1	248	8	11	37.5	3.698153	3.698153	0
3	5600	72	120	66.7	475	350	-26.3
1	312	48	72	50	24	26	8.3
7	5000	72	108	50	250	300	20
4	5534	72	64	11.1	270	275	1.9
9	4050	80	76	-5	210	214	1.9
4	430	72	96	33.3	240	246	2.5
1	357	32	40	25	7.497	7.497	0
–	576	52	48	-7.7	126	120	-4.8
3	3675	60	80	33.3	215	242	12.6
3	3135	60	60	0	225	237	5.3
1	8000	96	120	25	100	100	0
1	2400	48	44	-8.3	54.6	57.8	5.9
2	675	24	36	50	7.36	7.04	4.3
4	1680	40	56	40	42	45	7.1
5	9625	110	145	31.8	365	375	2.7
2	1000	24	–	–	–	–	–
2	–	96	–	–	15	15	0
1	224	36	36	0.0	20.5	22	7.3

Number of floors[Noflrs]	Floor area[Floarea] (m^2)	Initial contract time[initime] (weeks) A	Final contract time[Finatime] (weeks) B	Variance (%) (B-A/A)x 100	Initial contract cost[initicost] (million) C	Final contract cost[finacost] (million) D	Variance (%) (D-C/C)x 100
1	640	32	36	12.5	15	15.5	3.3
1	384	12	14	16.7	7.2	8	11.1
1	320	48	36	-25.0	5.76	5.76	0.0
4	3200	56	72	28.6	176.000520	198.590825	12.8
4	495	48	48	0.0	19.619516	22.411961	14.2
3	420	72	80	11.1	14.251085	14.251000	0.0
3	1300	48	48	0.0	51.858861	51.858861	0.0
5	1505	72	84	16.7	80.150924	82.384735	2.8
3	1435	48	56	16.7	73.794349	73.794349	0.0
3	1000	72	96	33.3	60	70	16.7
1	214.2	15	20	33.3	3.176526	3.681010	15.9
5	483	72	–	–	85	–	–
4	980	96	120	25.0	24.36	24.36	0.0
2	225	24	32	33.3	4.5	4.5	0.0
3	300	32	48	50.0	6.15	6.3	2.4
3	441	48	72	50.0	14	14.6	4.3
4	1100	96	144	50.0	19.72	22.4	13.6
4	2240	36	40	11.1	48	48	0.0
5	2188	56	58	3.6	74	76	2.7
2	500	72	96	33.3	250	270	8.0
2	300	16	18	12.5	8	8.2	2.5
2	380	18	20	11.1	8	8.9	11.3
1	122	48	48	0.0	5	5.5	10.0
13	1487	40	144	260.0	–	728	–

Number of floors[Noflrs]	Floor area[Floarea] (m^2)	Initial contract time[initime] (weeks) A	Final contract time[Finatime] (weeks) B	Variance (%) (B-A/A)x 100	Initial contract cost[initicost] (million) C	Final contract cost[finacost] (million) D	Variance (%) (D-C/C)x 100
–	1394	40	120	200.0	–	49	–
14	250	96	–	–	1200	–	–
8	190	72	–	–	500	–	–
9	300	96	–	–	800	–	–
4	2037	32	48	50.0	51	52	2.0
3	864	24	28	16.7	21.6	22	1.9
1	285	24	20	-16.7	2	2.6	30.0
2	70	12	12	0.0	0.5	0.55	10.0
4	980	96	120	25.0	24.36	24.36	0.0
2	225	24	32	33.3	4.5	4.5	0.0
3	300	32	48	50.0	6.15	6.3	2.4
3	441	48	72	50.0	14	14.6	4.3
4	110	96	144	50.0	19.72	22.4	13.6
3	338	32	40	25.0	34	38	11.8
3	318	32	40	25.0	33	35	6.1
7	8158.62	–	48	–	250	–	–
3	288	56	64	14.3	20.736	20.736	0.0
5	480	96	76	-20.8	14.4	19.2	33.3
8	518	144	120	-16.7	27.7	37	33.6
2	380	48	36	-25.0	4.5	6.1	35.6
1	285	24	20	-16.7	2	2.6	30.0
2	70	12	12	0.0	0.5	0.55	10.0
1	450	35	36	2.9	65	71	9.2
2	–	40	58	45.0	12.5	15	20.0
2	450	52	67	28.8	12	12.8	6.7
4	508	52	80	53.8	12	17.5	45.8
1	70	32	32	0.0	2.5	2.5	0.0
1	600	8	–	–	1	1.3	30.0
2	320	40	48	20.0	14	20	42.9
2	100	8	6	-25.0	1.2	1.8	50.0
2	400	44	52	18.2	54	56	3.7
3	264	32	40	25.0	23.2	25	7.8
1	520	32	48	50.0	18	24	33.3

Number of floors[No flrs]	Floor area[Floarea] (m^2)	Initial contract time[initime] (weeks) A	Final contract time[Finatime] (weeks) B	Variance (%) (B-A/A)x 100	Initial contract cost[initicost] (million) C	Final contract cost[finacost] (million) D	Variance (%) (D-C/C)x 100
1	640	36	32	-11.1	11	11	0.0
1	510	44	48	9.1	22	22	0.0
11	9055	104	112	7.7	360	365	1.4
2	172	20	26	30.0	7.5681	8.0496	6.4
3	441	16	14	-12.5	10.6	10.35	-2.4
7	1400	–	96	–	–	–	–
45	–	144	–	–	100	120	20.0
–	2500	28	28	0.0	5.300163	6.3123	19.1
–	160	–	8	–	28.361	29.6301	4.5
	150	12	10	-16.7	3.5	3.75	7.1

4.7.2 Regression analysis

Input parameters used in the model are listed below. Only three variables are considered at a time since models with too many variables are often over fit and hard to interpret.

- Number of floors
- Floor area
- Final contract time
- Final contract cost

4.7.3: Regression output for cost and time model

a) Descriptive statistics

Table 4.6: Descriptive statistics for cost model

	Mean	Std. Deviation	N
FCC	80.8911	134.35879	87
NOFL	3.2989	2.60194	87
FLAR	1650.5522	3306.69562	87

Table 4.7: Descriptive statistics for time model

	Mean	Std. Deviation	N
FCT	61.5222	37.28729	90
NOFL	3.4667	2.63597	90
FLAR	1748.4073	3328.19060	90

Tables 4.6 and 4.7 display descriptive statistics for each variable. The mean is the average value, for example the mean for the number of floors is 3.2989. The standard deviation measures the variability (or spread) of the values and N is the number of cases with non-missing values. In this study the cases were 113 but only 87 were used as the other cases had missing values.

b) Correlations

Tables 4.8 and 4.9 tables display pearson correlation coefficients, significance values, and the number of cases with non-missing values. These tables give details of the correlation between each pair of variables. Pearson correlation coefficients assume the data are normally distributed. The pearson correlation is a measure of linear association between two variables and the values of the correlation coefficient range from -1 to 1.

Table 4.8: Correlations for cost model

		FCC	NOFL	FLAR
Pearson Correlation	FCC	1.000	.598	.531
	NOFL	.598	1.000	.547
	FLAR	.531	.547	1.000
Sig. (1-tailed)	FCC	.	.000	.000
	NOFL	.000	.	.000
	FLAR	.000	.000	.
N	FCC	87	87	87
	NOFL	87	87	87
	FLAR	87	87	87

Table 4.9: Correlations for time model

		FCT	NOFL	FLAR
Pearson Correlation	FCT	1.000	.500	.332
	NOFL	.500	1.000	.545
	FLAR	.332	.545	1.000
Sig. (1-tailed)	FCT	.	.000	.001
	NOFL	.000	.	.000
	FLAR	.001	.000	.
N	FCT	90	90	90
	NOFL	90	90	90
	FLAR	90	90	90

The values in table 4.8 are acceptable as they are all between 0 and 1. The sign of the correlation coefficient indicates the direction of the relationship (positive or negative). All the two predictor variables are correlated with the dependent variable and are all positive. The absolute value of the correlation coefficient indicates the strength, with larger absolute values indicating stronger relationships. The correlation coefficients on the main diagonal are always 1.0, because each variable has a perfect positive linear relationship with itself. Correlations above the main diagonal are a mirror image of those below, e.g. 0.598 appears twice in above table.

The significance of each correlation coefficient is also displayed in the correlation table. The significance level (or p-value) is the probability of obtaining results as extreme as the one observed. If the significance level is very small (less than 0.05) then the correlation is significant and the two variables are linearly related. If the significance level is relatively large (for example 0.50) then the correlation is not significant and the two variables are not linearly related. The significance level in table 4.8 is 0.05 indicating that the variables are linearly related. N is the number of cases with non-missing values.

Pearson correlation results range from 0.332 to 0.5 for final construction time model while for the cost estimation model ranges from 0.53 to 0.6. The correlation values are acceptable as they are all between 0 and 1. The two predictor variables are correlated with the dependent variable and are positive meaning that as the number of floors and floor area increases, the final cost and time also increases.

c) Variables entered

Table 4.10: Variables entered/ removed for cost model

Model	Variables Entered	Variables Removed	Method
1	FLAR, NOFL	.	Enter

All requested variables entered. Dependent variable**:** FCC

Tables 4.10 and 4.11 displays the variables entered and/or removed at each step. The variables entered into the model at each step are listed in the variable entered column.

Table 4.11: Variables Entered/Removed for time model

Model	Variables Entered	Variables Removed	Method
1	FLAR, NOFL	.	Enter

All requested variables entered.
Dependent Variable: FCT

All the two predictor variables were entered simultaneously. The variables removed from the model at each step are listed in the variables removed column and here no variable was removed.

The method column displays the selection method that was used to remove or enter the variable.

Table 4.12: Model summary for cost model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.646	.417	.403	103.81745

Predictors: (Constant), FLAR, NOFL

Table 4.13: Model Summary for time model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.505	.255	.238	32.54103

Predictors: (Constant), FLAR, NOFL

Tables 4.12, and 4.13 displays R, R squared, adjusted R squared, and the standard error. R, the multiple correlation coefficient, is the correlation between the observed and the predicted values of the dependent variable. The values of R for models produced by the regression procedure ranges from 0 to 1. Larger values of R indicate stronger relationships. R shows the correlation between final contract cost and the two predictor variables. R squared is the proportion of variation in the dependent variable explained by the regression model. The values of R squared range from 0 to 1. Small values indicate that the model does not fit the data well. R squared tends to optimistically estimate how well the model fits the population. The adjusted R^2 is intended to control for overestimates of the population. Adjusted R squared attempts to correct R squared to more closely reflect the goodness of fit of the model in the population. R squared should therefore be used to help in determining which model is best. A model with a high value of R squared and that does not contain too many variables is good. In table 4.9, the R squared is 0.417 indicating that the model moderately fits the data meaning that FLAR and NOFL account for 41.7% of the variation in FCC.

The standard error of the estimate is the standard deviation of the residuals. The larger the R^2 the smaller this will be relative to the standard deviation of the dependent variable. As R^2 increases the standard error of the estimate will decrease (i.e. for better fit there is less estimation error).

Table 4.14: ANOVA for cost model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	647139.2	2	323569.608	30.021	.000
	Residual	905357.3	84	10778.063		
	Total	1552496	86			

Predictors: (Constant), FLAR, NOFL

Dependent variable: FCC

Table 4.15: ANOVA for time model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	31614.549	2	15807.275	14.928	.000
	Residual	92125.906	87	1058.918		
	Total	123740.5	89			

Predictors: (Constant), FLAR, NOFL

Dependent variable: FCT

Tables 4.14 and 4.15 summarize the results of an analysis of variance. The sum of squares, degrees of freedom, and mean square are displayed for two sources of variation, regression and residual. The output for regression displays information about the variation accounted for by the model. The output for residual displays information about the variation that is not accounted for by the model. The output for total is the sum of the information for regression and residual. A model with a large regression sum of squares in comparison to the residual sum of squares indicates that the model accounts for most of variation in the dependent variable. Very high residual sum of squares indicate that the model fails to explain a lot of the variation in the dependent variable, and additional factors may be required to help account for a higher proportion in the dependent variable. In table 4.14, there is no large difference between regression sum of squares and residual sum of squares.

The mean square is the sum of squares divided by the degrees of freedom. The F statistic is the regression mean square (MSR) divided by the residual mean square (MSE) i.e. 323569.608 divided by 10778.063, giving F = 30.021. The regression degrees of freedom is the numerator df and the residual degrees of freedom is the denominator df for the F statistic. The total number of degrees of freedom is the number of cases minus 1. If the significance value of the F statistic is small (smaller than say 0.05) then the independent variables do a good job explaining the variation in the dependent variable. If the significance value of F is larger than say 0.05 then the independent variables do not explain the variation in the dependent variable. In table above, the significance is less than 0.05 indicating that the independent variable explains well the variation in the dependent variable.

Table 4.16: Coefficients for cost model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-13.370	18.223		-.734	.465
	NOFL	22.659	5.139	.439	4.409	.000
	FLAR	.012	.004	.291	2.923	.004

Dependent variable: FCC

Table 4.17: Coefficients for time model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	37.580	5.741		6.546	.000
	NOFL	6.430	1.560	.455	4.121	.000
	FLAR	.001	.001	.084	.765	.446

Dependent variable: FCT

Tables 4.16 and 4.17 summarize the coefficients for the independent variables. The unstandardized coefficients are the coefficients of the estimated regression model. The model for the final cost = -13.370+22.659NOFL+0.012FLAR and the final construction time = 37.58+6.43NOFL+0.001FLAR.

The independent variables are measures in different units. The standardized coefficients or betas are an attempt to make the regression coefficients more comparable. The t statistics can help in determining the relative importance of each variable in the model. Useful predictors have t values below -2 or above +2. The standardized Beta coefficients give a measure of the contribution of each variable to the model. Number of floor is the best predictor of the final contract cost with a value of 0.439. the largest Beta weight has the greatest correlation with the final contract cost. A large value indicates that a unit change in the predictor variable has a large effect on the criterion variable. The t and sig (p) values give a rough indication of the impact of each predictor variable – a big absolute t value and a small p value suggests that a predictor variable is having a large impact on the criterion variable.

Each of the variables contributes to the model. Correlation and multiple regression analyses are conducted to examine the relationship between costs and time and other various potential predictors. It was observed that the models sometimes underestimate since construction projects are unique and there are challenges that come up during construction that are different from one site to another.

Based upon the multiple regression analysis conducted, the equations for predicting the actual construction period and contract costs are given as:

FCC = -13.370 + 22.659NOFL +0.012FLAR

FCT = 37.58 + 6.43NOFL + 0.001FLAR.

4.8 Validation of the models

Below is a presentation of data and its analysis for model validation.

Table 4.18: Data for commercial office

Number of floors[Noflrs]	Floor area[Floarea] (m^2)	Initial contract time[initime] (weeks)	Final contract time[Finatime] (weeks)	Initial contract cost[initicost] (million)	Final contract cost[finacost] (million)
6	2543.84	48	72	63.6	70

- Time model

FCT = 37.58 + 6.43NOFL + 0.001FLAR.

The period of time on implementation of the project was 72 weeks and from the model, the contract duration was 78.9weeks. This is a better estimate than the initial project time estimate of 48 weeks, indicating that the model can be used for estimation of project duration.

- cost model

FCC = -13.370 + 22.659NOFL +. 012FLAR

The model gives an estimate of 153.1 million shillings which is more than twice the final cost of 70 million, indicating that the model cannot be used for estimation of project cost.

- **Industrial factories – Private**

Table 4.19: Data for Industrial factories

Number of floors[Noflrs]	Floor area[Floarea] (m^2)	Initial contract time[initime] (weeks)	Final contract time[Finatime] (weeks)	Initial contract cost[initicost] (million)	Final contract cost[finacost] (million)
1	2400	48	44	54.6	57.8

- Time model

The period of time on implementation of the project was 44 weeks and from the model, the contract duration was 46.41 weeks which is a good estimate. The initial project time estimate was 48 weeks, indicating that the model can be used for estimation of project duration.

- cost model

The model gives an estimate of 38.1 million shillings which is lower than the amount used of 57.8 million. The Model gives a big error and is not recommended for estimation of project cost.

- **Institutional education – Public**

Table 4.20: Data for Institutional education – Public

Number of floors[Noflrs]	Floor area[Floarea] (m^2)	Initial contract time[initime] (weeks)	Final contract time[Finatime] (weeks)	Initial contract cost[initicost] (million)	Final contract cost[finacost] (million)
2	400	48	60	9	12

- Time model

The period of time on implementation of the project was 60 weeks and from the model, the contract duration was 50.84 weeks which is a better estimate than the initial estimate of 48 weeks, indicating that the model can be used for estimation of project duration.

- cost model

The model gives an estimate of 36.75 million shillings which is more than the final cost of 12 million shillings. The model gives a large error and therefore it is not recommended for estimation of project cost.

- **Residential houses – Private**

Table 4.21: Data for Residential houses – Private

Number of floors[Noflrs]	Floor area[Floarea] (m^2)	Initial contract time[initime] (weeks)	Final contract time[Finatime] (weeks)	Initial contract cost[initicost] (million)	Final contract cost[finacost] (million)
1	148	48	48	14	14.2

- Time model

The period of time on implementation of the project was 48 weeks and from the model, the contract duration was 44 weeks which is a good estimate. The initial estimate was 48 weeks, indicating that the model can be used for estimation of project duration.

- cost model

The model gives an estimate of 11.1 million shillings which is less than the amount used of 14.2million. The Model gives a big error and is not recommended for estimation of project cost.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents general conclusions and recommendations of this study. The area for further research is also highlighted at the end of this chapter.

5.2 Summary

The models of estimating contract duration and budget were developed from a survey of construction practitioners in Mombasa County. The study started with a review of related literature and then involved construction practitioners who have first-hand knowledge of day-to-day operations and onsite situations. The models were then validated to evaluate for their workability and suitability.

5.3 Conclusions about the research aim and objectives

All the objectives of the study were achieved and, consequently, the aim of the study also achieved. The study aim was to develop models for forecasting time and cost of building construction projects which ensures project delivery within stipulated period and budget. The specific objectives were:

1) To establish the factors that influences the determination of project cost and construction period.
2) To consider factors influencing estimation of project cost in the development of a model for accurate estimation of project cost.

3) To consider factors influencing estimation of project construction period in the development a model for accurate estimation of project construction period.

The following are the conclusions made in respect of each objective.

5.3.1 Conclusions about factors that influences the determination of project cost and construction period.

From the literature reviewed, there are many factors which affect the construction cost estimate but the ones with significant impact on project time and cost were selected.

The floor area and the number of floors were considered as the main variables in the regression model. The variables were tested for correlation and their significance levels. The values of the correlation coefficient range from -1 to 1. This fairly shows a strong relationship between the variables. The significance level is very small (less than 0.05) and the correlation is significant and the two variables are linearly related indicating that the two variables have an impact of final cost and time of building projects.

5.3.2 Conclusions about determining project cost

The construction cost in Kenya is significantly different for projects in private and public sectors. It was concluded that:

1) The cost regression model developed in this study show relatively large errors compared to time models.
2) As the number of floors and floor area increases, the final contract cost also increases.
3) The model for cost estimation was validated and was not recommended for use due to large errors observed.

5.3.3 Conclusions about determining realistic contract period.

The study concluded that:

1) The construction period can be estimated by use of a model at the early stage of construction when precise information is not known about the project.
2) As the number of floors and floor area increases, the final contract period also increases.
3) The model for contract period estimation show good predictive powers and it was recommended for use as: FCT = 37.58+6.43NOFL+0.001FLAR.

5.4 Recommendations

The regression equation for estimating the final contract time of projects in the construction industry is recommended for use. Section 5.2.3 of chapter 5 indicates the equation that was recommended for use. However, it is recommended that:

1) More data is required for improving the models and developing other models.
2) Data could also be collected for external works so as to be able to make estimates of overall construction works.
3) Data could be collected to develop models to estimate time and cost for civil engineering works.
4) The study can also be conducted to cover other towns of Kenya.
5) A comparative study is also recommended for projects in rural areas and urban areas.

5.5 Areas for further research

1) There are variables that affect time and cost of building projects which do not generate quantitative data which their relationship could be studied with possibility of developing a model.
2) Time, cost, quality and scope are the constraints of project management. Therefore, quality and scope could also be incorporated in the model to achieve effective management of projects.

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APPENDICES

Appendix 1: Questionnaire

Jomo Kenyatta University
of agriculture and Technology,
P.O Box 62000, Nairobi
Tel: (067) 52711
17th October, 2012

Dear Sir/Madam,

I am a masters student in the department of construction engineering and management at Jomo Kenyatta University of Agriculture and Technology. For my final thesis, I am developing models for prediction of time and cost of building construction projects. The data collected will provide useful information regarding management of construction projects.

I am inviting you to participate in this research study by completing the accompanying questionnaire below. All information that you provide through your participation in this study will be kept confidential. Further, you will not be identified in the thesis or any report or publication based on this research.

Thank you for taking time to assist me in my educational endeavors. If you require additional information or have questions, please do not hesitate to contact me at the number and e-mail address listed below. Use this e-mail address for your response.

Sincerely,

Alex Kalume

0737 044988
alexkalume@yahoo.com

SECTION 1

A) ORGANISATIONAL

1. In what sector do you work?

Private sector	
Public sector	

2. Location of organization………………………..

3. Please indicate the actual number of years your organization has been involved in construction..

4. Number of projects undertaken within the last 5 years

1-5 projects		11-15 projects	
6-10 projects		16 and above	

B) PERSONAL

5. Please indicate your gender

Male	
female	

6. Please indicate your highest formal qualification:

Certificate		Bachelors degree	
Diploma		Masters degree	
Higher diploma		Doctoral degree	
Postgraduate diploma		Other(please specify)	

7. Kindly indicate from below the category of construction profession you belong to.

Architect		Contractor	
Engineer		Quantity surveyor	

8. Please indicate your status in the organization:

MD		Supervisor	
Director/senior executive		Trainee	
Manager		Other(please specify)	
Senior staff			

9. Kindly indicate your actual years of experience in the building construction Industry.

less than 5 years		16-20 years	
6-10 years		21 years and above	
11-15 years			

10. Indicate your age below

20 – 29 years		50 – 59 years	
30 – 39 years		60 years and above	
40 – 49 years			

11. Kindly indicate from below the type of facility constructed.

Residential		Industrial - factories	
Commercial – office		Institutional - education	
Commercial – recreational		Other(please specify)	
Hotel/motel			

SECTION 2: PERFORMANCE RECORDS OF PROJECTS.

No	Type of facility (*see item 11 above*)	Type of project		No. of floors	floor area (m^2)	Initial contract time	Final contract time	Initial contract cost	Final contract cost
		private	Public						

Are there any other comments you want to bring to the attention of the study?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

Thank you for your time.

A Kalume

Appendix 2: Table for Determining Sample Size from a Given Population

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size.
S is sample size.