

**ALLOCATION OF RESOURCES TO CAPITAL INVESTMENT PROJECTS:  
A CASE OF SELECTED COMPANIES IN THE CONSTRUCTION INDUSTRY IN  
KENYA**

**KIMANI, JOSEPH MWANGI**

**A research project submitted to the School of Economics in partial fulfillment  
of the requirements for Master of Arts degree in Economics of the University  
of Nairobi.**

**JUNE, 2013**

## DECLARATION

This research paper is my original work and has not been presented for an award of a degree in any other University.

Signed: \_\_\_\_\_ date \_\_\_\_\_

Joseph Mwangi Kimani

C50/P/7210/06

This research paper has been submitted for examination with our approval as University supervisors.

Signed . \_\_\_\_\_ date \_\_\_\_\_

Dr. Nelson Wawire

Signed \_\_\_\_\_ date \_\_\_\_\_

Dr. Mary Mbithi

## ACKNOWLEDGEMENTS

My thanks go to the Almighty God for giving me strength and grace always. I sincerely thank my supervisors, Dr. Nelson Wawire and Dr. Mary Mbithi, whose encouragement, guidance and support from the initial to the final level enabled me to develop an understanding of the subject.

I extend many thanks to all my Lecturers at the School of Economics for enabling me to successfully cope with the postgraduate challenges. In particular, I must mention Dr. Nelson Wawire, Dr. Mary Mbithi, Dr. Samanta, Prof. Wafula Maasai, Mr. Walter Ochoro, Dr. Kulundu Manda, Dr. Wilfred Nyangena, Dr. Samuel Nyandemo and Dr. Obere Almadi for giving me excellent training at the University of Nairobi.

I would like to also thank my family for encouragement and support during my study. It is a honor for me to mention my parents, wife- Leah and my children- Bramwel and Clara, Brothers- John and Paul and my Sister Jane for their moral support. I cannot also forget my niece Susan for her continuous support over the period. I am indebted to many of my classmates (MA Economics, 2006) for their immeasurable support.

Lastly, I offer my regards and blessings to all of those who supported me in any respect during the completion of this project. However, I bear sole responsibility for errors and or omissions in this paper.

# TABLE OF CONTENTS

DECLARATION .....	ii
ACKNOWLEDGEMENTS .....	iii
TABLE OF CONTENTS.....	iv
LIST OF TABLES.....	vii
LIST OF FIGURES.....	viii
OPERATIONAL DEFINITION OF TERMS.....	ix
ABBREVIATIONS AND ACRONYMS .....	xi
ABSTRACT.....	xii
CHAPTER ONE .....	1
INTRODUCTION .....	1
1.1 Background .....	1
1.1.1 Investment.....	1
1.1.2 Role played by the construction industry.....	2
1.1.3 Cost benefit analysis .....	8
1.2 The Statement of the problem .....	9
1.3 Research Questions .....	11
1.4 Objectives of the Study.....	11
1.5 The Significance of the Study.....	12
1.6 Scope and Limitations of the Study .....	12
CHAPTER TWO .....	13
LITERATURE REVIEW .....	13
2.1 Introduction .....	13
2.2 Theoretical Literature Review.....	13
2.2.1 Determinants of construction .....	13
2.2.2 Contingency budget estimation.....	14
2.2.3. Life –cycle cost analysis and lowest life –cycle cost.....	15

2.2.4. Linear programming .....	17
2.2.5. Project overruns .....	18
2.2.6 Optimization model.....	19
2.2.7. Utility function.....	20
2.2.8. Net present value.....	21
2.2.9. Benefit cost ratio .....	22
2.2.10. Internal rate of return .....	22
2.2.11. Payback period approach .....	23
2.3 Empirical Literature.....	24
2.4 Overview of the Literature.....	28
CHAPTER THREE .....	30
METHODOLOGY .....	30
3.1. Introduction .....	30
3.2. Research Design.....	30
3.3 Theoretical framework .....	31
3.4. The Model Specifications.....	33
3.5. Working Hypotheses.....	40
3.6. Description and Measurement of Variables .....	40
3.7. Data type and source .....	42
3.8. Target Population.....	43
3.9. Sampling Technique and Sample Size.....	43
3.10. Research Instruments .....	43
3.11. Pilot Study .....	44
3.12. Data Collection.....	44

3.13. Data Analysis .....	44
CHAPTER FOUR.....	46
EMPIRICAL RESULTS AND INTERPRETATION .....	46
4.1 Introduction .....	46
4.2 Response rate from the companies selected .....	46
4.3 Costs of activities in the construction project .....	46
4.4 Completion Times for the Activities.....	48
4.6. Likelihood of completing project within a scheduled date .....	55
CHAPTER FIVE .....	59
SUMMARY, CONCLUSION AND POLICY IMPLICATIONS .....	59
5.1 Introduction .....	59
5.2 Summary .....	59
5.3 Conclusion.....	60
5.3 Policy Implications .....	60
5.4 Areas for Further Research .....	61
REFERENCES .....	63
APPENDICES .....	67

## LIST OF TABLES

TABLE 1.1:Construction Contributions to GDP-----	04
TABLE 1.2:Comparison of Value of Plans Approved and Buildings Completed-----	06
TABLE 3.1:Precedence Table-----	32
TABLE 4.1:Industrial Cost of Activities-----	47
TABLE 4.2:Shortest ,Normal and Longest Activity Times-----	48
TABLE 4.3:Industrial Expected Times-----	49
TABLE 4.4:Completion Times-----	51
TABLE 4.5:Normal Cost-----	52
TABLE 4.6:Marginal Cost-----	53
TABLE 4.7:Total Project Cost-----	54
TABLE 4.8:Project variance-----	55

## LIST OF FIGURES

FIGURE 1.1: Percentage Contribution to GDP-----	05
FIGURE 1.2: Percentage Of Building Works Completed-----	07
FIGURE 3.1: Network Diagram-----	33
FIGURE 3.2: Time Cost Graph-----	36
FIGURE 3.3: Crash-Cost Graph-----	38
FIGURE 3.4: Probability Curve-----	39
FIGURE 4.1: Earliest And Latest Completion times-----	51
FIGURE 4.2: Total Project Cost Curve-----	55
FIGURE 4.3: Acceptance Region -----	57



## OPERATIONAL DEFINITION OF TERMS

**Project:** Project is a temporary endeavor with a beginning and an end undertaken to create a unique product or service.

**Optimal cost:** This the lowest (best) costs which can be incurred in completing an investment project in the shortest time after employment of extra resources.

**Critical path method:** This is the path activities where delays should not be allowed to occur as it can delay the overall project completion time. This can also influence change in cost.

**PERT:** This refers to Program Evaluation and Review Technique. This technique uses multiple time estimates for an activity to be undertaken in any investment. This technique encompasses the element of uncertainty in task duration.

**Most probable time:** This is the time required to complete the activity under normal conditions that is, when every activity is completed as envisaged in the project budget.

**Pessimistic time:** The maximum time that would be required to complete a construction project if the significant delays are encountered throughout the project. This is the longest duration an activity would take should everything go wrong during implementation.

**Optimistic time:** The minimum time required to complete an activity. This is the shortest time a task will be completed when the conditions existing are more favorable.

**Normal time:** This time taken to complete an activity under normal conditions. It is the modal time of completing activity duration. This time is always longer than the crash time since there are only fewer resources employed.

**Normal cost:** This is the expected cost to be incurred in carrying out a given task of a project. This cost is usually lower than the crash cost since few Factors of production are employed in carrying out a task.

**Crash time:** This is the shortest time in which an activity of a project can be completed if extra resources are employed in carrying a given task using the marginal cost criteria. Crash time is always less than normal time since more resources are employed in carrying out a task.

**Marginal cost:** This is the extra cost incurred as result of employing an extra unit of a factor of production in carrying out a given task.

**Activity:** This is a task or job of work which consumes time and resources. An activity is represented in a network by an arrow pointing to the right.

## **ABBREVIATIONS AND ACRONYMS**

CPM	- Critical Path Method.
GDP	- Gross domestic product
IRR	- Internal Rate of Return
LCCA	- Life Cycle Cost Analysis.
LP	- Linear Programming.
MARR	- Minimum Attractive Rate of Return
NFV	- Net Future Value
NPV	- Net Present Value
PERT	- Program Evaluation and Review Technique
RCPM	- Resource Constrained Critical Path.

## ABSTRACT

Building and Construction industry enhances economic growth in the economy through inter-linkages that spur investment. The sector contributed less than 5% to the GDP every year. Failure to complete an investment project on time means that a given investor would be caught up by the cost push inflation since the overall cost of material and labour indices in building and construction industry tend to rise with time. When many projects are not completed in the budgeted period, then the whole economy is affected negatively in terms of development. In order to unlock the full potential in the construction industry, there was need for an effective mechanism in which the resources are allocated in the construction industry. This study investigated how the resources in a construction project can be allocated through the Critical Path model guided by the marginal cost criteria in employing extra resources to a project in order to complete it on time or earlier than scheduled. To carry out the study, a random sample of thirty (30) Companies was picked from a population of three hundred (300) construction companies located in Nairobi County which had been registered with the Ministry of Public Works. The data for the survey was collected through questionnaires which were sent to the random sample of thirty construction companies located in Nairobi County. The questionnaires were presented to Project Managers of the companies selected and they were requested to fill them in within a week. From the questionnaires returned by the respondents, data on activity duration, normal time, normal cost, crash time, crash costs, frequency of project failure in terms of project completion time and cost overruns, criterion of employment of extra resources and estimation of likelihood of completing a project on a scheduled date was obtained. The data was tabulated and industrial expected times and costs were calculated. The network diagram was drawn and five critical activities A, C, E, G and I were obtained. The marginal cost of critical activities were calculated and arranged in ascending order. The critical activities were crashed in the order of marginal cost rankings starting with the activity with the lowest marginal cost. Total project cost showed that each and every time critical activity was reduced by a day as result of employment of more factors of production, the total cost was falling. A total project cost curve was plotted on a graph of cost against time and a turning point of the curve indicated the optimal point. At the optimal point, the project completion time and cost were obtained. The likelihood of completing the project within the optimal point was ascertained and found to be 0.9987. This represented almost a 100% chance of completing a project on time. Since the model could ascertain the likelihood of completing an investment project on time in order to avoid budgetary overruns in the construction industry. It was concluded that the critical path model through the marginal cost criteria was effective in allocating resources in a construction industry.

# CHAPTER ONE

## INTRODUCTION

### 1.1 Background

#### 1.1.1 Investment

The National Income of a country is a function of several factors among them investment. Investments can be done by the government or the private Sector. Private sector investments are profit driven instead of social welfare. Government investments are geared-towards creating enabling environment for the private sector investments to grow (Richard, 2002).

Investment in social capital is one of the areas where public expenditure is normally directed. This includes investment in the sectors like education, roads and transport, hydro-electric projects, health and recreation facilities. This means that if these projects are undertaken by the Government to completion, then opportunities for the growth in the private sector investments would be created. This investment by the Government provides a foundation in which private investments depend on. Investments in the road construction will create employment in that more goods and services will reach the market faster thus bringing more incomes to the people employed in those sectors that produced the output that was marketed. Other benefits from such investments include employment of more factors of production, availability of variety of goods and services in the market at low prices since the cost of production and transport are low.

The private investments in Kenya has continued to perform below expectation and to a large extent, the poor performance explains partly the slow economic growth that the economy has transited to. According to Republic of Kenya (2004), an in-depth analysis of private investment behavior in Kenya indicated that private sector investments are driven by factors including ,

growth in national income, profitability, interest costs, crowding -in factor of public investments and availability of credit to the private sector. Any investor is concerned with the project completion time so that the initial investment capital outlay can be recouped. Almost all capital investment projects are made with a loan component in it. Every investor is concerned with the time the investment will be completed since any delay means that the cost of the investment will rise because of the time value of money. This means that should there be a delay in the project, the investor's cost of the investment will rise and hence the net present value of the project will fall. This has led to numerous white elephant projects which are usually left incomplete in most of the third World countries (Faniran, 2002).

### **1.1.2 Role played by the construction industry**

Building and construction sector enhances growth in the economy through inter linkages that spur other investments. The number of people employed in the building and construction sector has been rising but not as high as in other industries (Republic of Kenya, 2010).

The level of wage payment in building and construction, the private sector level of wage payment has remained higher than the wage payment in the public sector. The wage payment in the building and construction industry has for a long time been ranked either number three or four from the bottom when compared with other industries in the economy. On the overall, the materials and labour cost indices in the sector have been on upward trend. This shows that should there be a delay in the construction process, the cost of the investment is likely to rise and overrun the budget. This means that the economy would not grow at the rate envisaged in the period.

Although the contribution of the building and construction sector to the GDP has stagnated at about 3.8%, its contribution to economic growth has been rising in the recent past. This is mainly

due to increased infrastructural investment by the government. Republic of Kenya (2010) showed that the bulk of the new jobs in the modern sector were created in building and construction, transport and communication, wholesale and retail trade, restaurants and hotels.

In the year 2010, the growth in the building and construction sector was 4.5 % while in the previous year 2009, the sector grew by 12.4%. This shows that there was great fall in growth in the sector during the year 2010. The total value of reported private buildings works completed in the selected main towns went up significantly from Kshs.21.8billion in 2009 to Ksh.37.3 billion in 2010. In the year 2011, the building and construction sector grew by 4.3%. The Republic of Kenya (2010) showed that the total value of private building works completed went up from 37.3 billion in 2010 to 43.1 billion in 2011.

Development of infrastructure is one of the key pillars in achieving the Vision 2030. The building and construction sector must be allocated resources in cost effective manner so that the Vision 2030 can be realized. From the analysis, it shows that the level of employment and growth in the building and construction sector can be affected by failure to allocate resources effectively to capital projects in the sector (Republic of Kenya, 2007).

Table 1.1 below shows how important the building and construction sector to the economy as it has been contributing a sizeable percentage of the GDP since 1996.

**Table 1.1: Construction contributions to GDP in Ksh. million for the period 1996- 2011**

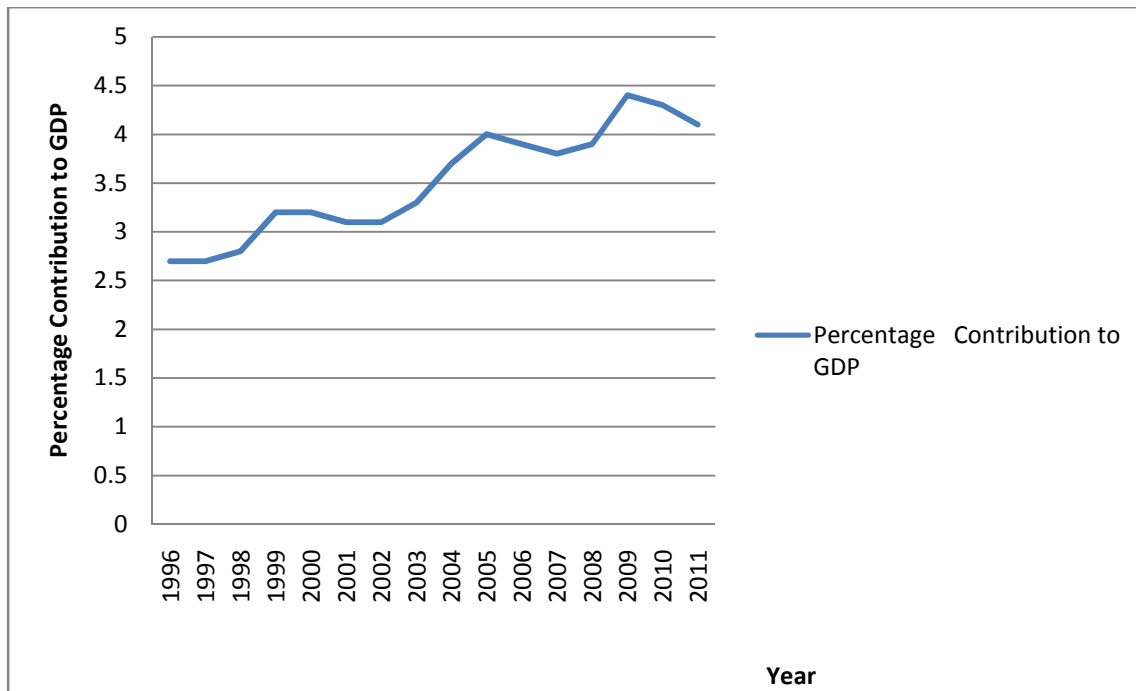
Year	GDP from Construction Industry	Percentage Contribution to GDP
1996	17,632	2.7
1997	19,482	2.7
1998	22,748	2.8
1999	27,352	3.2
2000	28,852	3.2
2001	28,158	3.1
2002	32,373	3.1
2003	37,669	3.3
2004	48,079	3.7
2005	56,121	4.0
2006	63,928	3.9
2007	69,556	3.8
2008	80,407	3.9
2009	99,013	4.4
2010	103,466	4.3
2011	107,941	4.1

Source: Republic of Kenya, (Various) Economic surveys, Nairobi, Government Printer.

From the Table 1.1 above, it shows that the GDP generated from the building and construction sector has been rising since 1996 to 2011. For the period 1996 to 2000, the sector's GDP changed from Ksh.17, 632m to Ksh.28, 852 which translates to 63%. During the same period, the GDP percentage contribution from the sector changed from 2.7% to 3.2% which translates the change to 18.5% over the period.

Also, from the years 2001 to 2005 in Table 1.1 above, the GDP generated by the sector changed from Ksh.28,158m to Ksh.56,121m which is 99.3% change but the percentage change in the sector's contribution percentage to GDP changed from 3.1% to 4.0% which comes to 29% change. The GDP generated by the sector for the years 2006 to 2011 changed from Ksh.63, 928m to Ksh.107, 941 which is 68.8% but the sector's contribution percentage to GDP changed by 0.2% which is 5% change. The Table 1.1 is represented as in Figure 1.1 below;





**Figure1.1: Percentage Contribution to GDP.**

Source: Republic of Kenya, (Various) Economic surveys, Nairobi, Government Printer.

From the graphical presentation, it shows that although the GDP from the building and construction industry has been raising showing improvement, the percentage contribution of the sector to GDP has remained less than 5%. This shows that the output from the sector was almost uniform but what was changing was the price level. For this reason, there was no much change in terms of output in the construction sector. This has negative effect on the side of employment of factors of production. This shows that the sector is as if it has been stagnating. This calls for effective allocation of resources employed in the construction industry in order to realize Kenya Vision 2030.

Under local authorities in the urban areas, the number of value of building plans approved is usually high but the number of Value of Building works Completed in every year is always low.

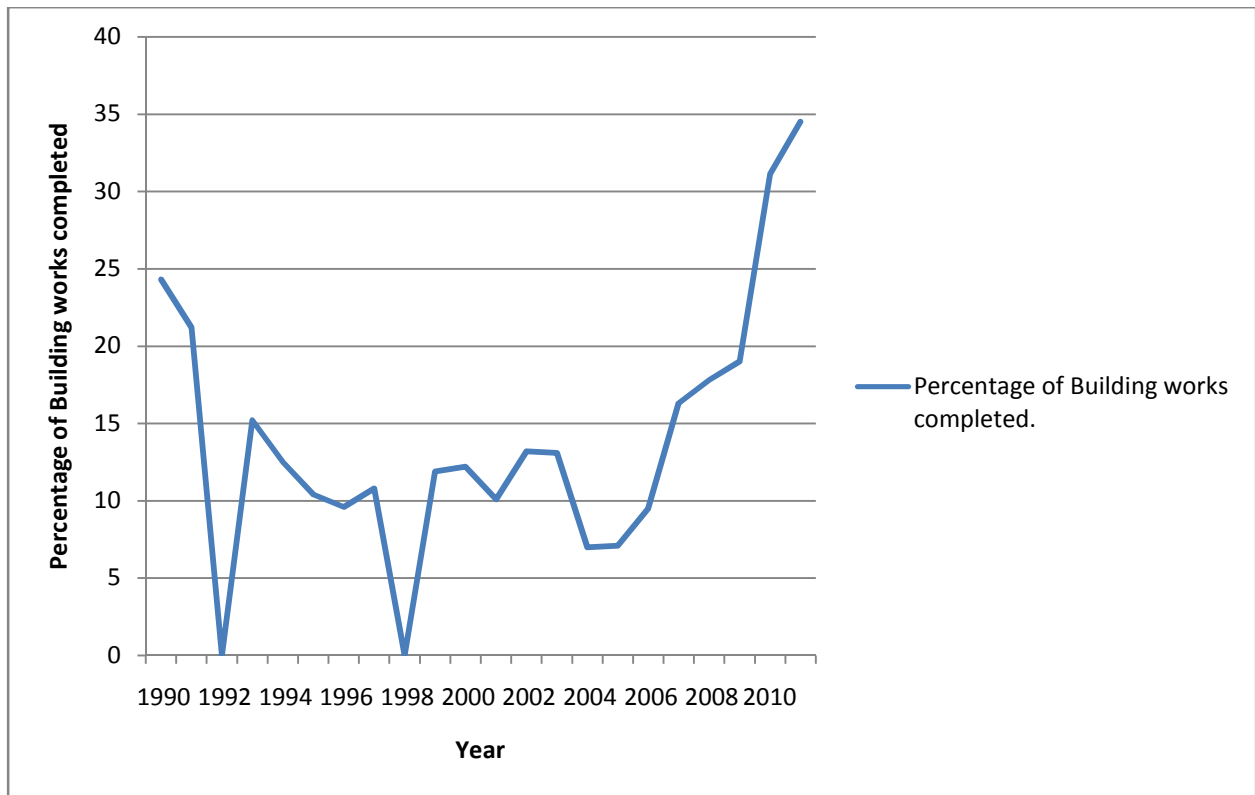
Table 1.2 shows the value of building plans approved versus the value of building plans actualized in a year.

**Table 1.2 Comparison of value of plans approved and buildings completed in urban areas in period 1990-2011 in Ksh. £million.**

Year.	Value of Plans Approved.	Value of Building works Completed.	Percentage of Building works completed.
1990	271.68	66.02	24.3
1991	299.09	63.52	21.2
1992	267.24	62.78	23.5
1993	333.1	50.50	15.2
1994	417.11	51.98	12.5
1995	637.75	66.21	10.4
1996	756.24	73.27	09.6
1997	748.84	80.51	10.8
1998	637.61	76.5	12.0.
1999	556.52	66.21	11.9
2000	498.77	60.82	12.2
2001	505.92	51.25	10.1
2002	530.37	69.78	13.2
2003	544.63	71.31	13.1
2004	1748.12	121.65	07.0
2005	1882.35	134.36	07.1
2006	1348.13	140.89	09.5
2007	3354.40	548.46	16.3
2008	3466.08	616.16	17.8
2009	3872.20	736.29	19.0
2010	4046.45	1259.80	31.1
2011	4220.45	1455.693	34.5

Source: Republic of Kenya, (1995 & 2011) Economic surveys, Nairobi, Government Printer.

From the year 1990 to 2011, the values of building plans approved by local authorities in the urban areas have been rising annually. The value of building works completed in every year from 1990 to 2001 was rising and sometimes falling but since 2002 to 2011, the value of building works completed in every year has been rising consistently. The Figure 1.2 below represents the percentage of building works completed;



**Figure 1.2: Percentage of Building Works Completed.**

Source: Republic of Kenya, (1995 & 2011) Economic surveys, Nairobi, Government Printer.

The Figure 1.2 shows that many of the building plans approved were not actualized as per the budget and this shows that there is need to effectively allocate the resources earmarked for development purposes more so construction in order to complete an investment on time and in a cost effective manner.

Investment projects more especially the capital intensive ones in the construction industry, usually have a time frame if cost savings are to be realized. In all the Capital projects and more especially in building and construction industry, activities involved for instance supplying raw materials, digging foundation, erecting walls, roofing and flooring, require different combinations of labour and capital factors. The raw materials and labour in the construction

industry keep on rising year after year. Should a project fail to be completed within the budgeted period, the cost increases and financing become a major problem. There is need to ensure that all approved valued building plans in a year are completed on time. This will ensure that desired rates of employment and wealth creation are realized as envisaged in the budgetary estimates. This will eventually make the building and construction industry influence the acceleration of economic growth and contribute a higher percentage to economy's GDP. As a driving engine for growth, the construction industry plays an important role in a country's economic development process.

### **1.1.3 Cost benefit analysis**

This refers to the systematic evaluation of government investment projects, as distinguished from transfer programs or consumption -oriented allocation expenditures such as judicial services (Richard, 2002). Deterministic discounted cash flow analysis is well established as a financial and economic tool for evaluating an investment's feasibility and in capital budgeting. There are uncertainties associated with the main analysis of parameters namely; discount rate, cash flows and investment plan (David, 2008). The objective of facility investment in the private sector is generally understood to be profit maximization within a specific time frame. Similarly, the objective in the public sector is the maximization of net social benefit which is analogous to profit maximization in private organizations. Given this objective, a method of economic analysis will be judged by the reliability and ease with which a correct conclusion may be reached in project selection.

The basic principle underlying the decision for accepting and selecting investment projects is that if an organization can lend or borrow as much money as it wishes at the minimum attractive rate of return, the goal of profit maximization is best served by accepting all independent projects

whose net present values based on the specified mark are nonnegative, or by selecting the project with the maximum nonnegative net present value among a set of mutually exclusive proposals (Joseph, 2000). The net present value criterion reflects this principle and is unambiguous when there is no budget constraint. Various methods of economic evaluation, when properly applied, will produce the same result if the net present value criterion is used as the basis for decision.

According to Gradl (2009), net present value is a technique that is used to assess the viability of projects based on the projected receipts and disbursements over the projects planning horizons. It can however, become difficult to arrive at credible single point estimates for some of these cash flows. Increases in project complexity, increases in planning horizons and the need to engage multiple sub-contractors are all factors that increase the risk in developing an accurate net present value. Many of the project evaluation methods assume that time to complete an investment is already known with certainty as well as the cost of the projects. Cost and schedule overruns of a project are never captured by these methods.

When the scheduled completion time of an investment is not achieved, the return from a given investment project and inter-linkages are also delayed. In order for the Government to ensure that there is continuous employment of factors of production in a more productive manner in the construction sector, a model needs to be applied to help investors in determining the shortest project completion time while at same time reducing the cost of investment. This will help in increasing the contribution of building and construction sector to economy's Gross Domestic Product.

## **1.2 The Statement of the problem**

Optimal cost of completion of any capital intensive project remains one of the many challenges facing most of the developing countries. Any investor in construction industry would like to

complete a given project at the shortest time and at the lowest cost possible. Failure to this, the building and construction sector will not be able to contribute a higher percentage to economy's Gross Domestic Product.

When the cost and time overruns in building and construction project occur, this means that the construction projects are not completed in time, thus the employment opportunities that would have arisen from the project are usually delayed and this slows down the rate of economic growth. When the scheduled completion time of an investment is not achieved, the returns from a given investment project and inter-linkages are also delayed. Also, most of the contractors who are required to implement the project also suffer penalties as a result of failure to complete a given project on time.

Failure to complete an investment project on time means that a given investor will be affected by the cost push inflation since the overall cost of material and labour indices in building and construction industry tend to rise with time (Republic of Kenya, 2007). Any delay in completing a project in the expected period means that amount of money budgeted for the project will not be enough to finance it in the subsequent period due to fall in purchasing power of money over time. When many such projects are not completed in the budgeted period, then the whole economy is affected negatively in terms of development.

In order for the Government to ensure that there is continuous employment of factors of production in a more productive manner in the construction sector, a model needs to be applied to help investors in determining the project completion time while at same time reducing the cost of investment. This will help in increasing the contribution of building and construction sector to economy's Gross Domestic Product. Hence tradeoff between time and cost is crucial to the efficiency of construction projects.

### **1.3 Research Questions**

- a) What are the costs of activities involved in construction project?
- b) What is the earliest and latest completion times for each of the activities involved in a project?
- c) What is the criterion to use when employing extra resources in an activity in an effort to reduce project duration?
- d) What is the likelihood of completing a project within a scheduled date?
- e) What are the policy implications?

### **1.4 Objectives of the Study**

The overall objective of the study was to determine the effective allocation of scarce resources to a capital investment project.

The specific objectives were to:

- a) Obtain the costs of the activities involved in a construction project.
- b) Determine the earliest and the latest completion times for activities / tasks in the building project.
- c) Calculate the marginal cost for each of the critical activities of the project.
- d) Find the probability of completing building/construction within a given scheduled/budget period.
- e) Draw policy implications on how resources can be effectively allocated in a construction project.

## **1.5 The Significance of the Study**

In order to formulate appropriate policies and directions to help in controlling fluctuating volume of construction work, a model that can reliably predict the feasible project completion time and cost and sequence of activities in the building and construction industry would be extremely useful to building and construction industrial players. This is very essential in that the value of a shilling today is not equal to the value of a shilling in one year's time. Time factor is very major factor in construction economics.

The purpose of this research is therefore an attempt to demonstrate how scarce resources can be allocated effectively in a construction project investment. The study will help many investors in estimating objectively both the cash flows to be generated by a given construction project and desired net present values.

## **1.6 Scope and Limitations of the Study**

This study focused on the effective allocation of resources to a capital investment project in construction industry in a given time period. The study chose construction industry because most major construction works are done there. The study advocated that, for a project to be completed on time and within budget, resources must be allocated using marginal cost criteria. The approach ignored other factors that could affect the completion time of a project.

Also, the study was limited in the sense that some important data for this analysis may not have been collected in the way suitable for the research. However, all the relevant data to the study was collected from random sample of thirty construction companies in Nairobi County. Also, for some of those companies which did not have readily data with them, they could have guessed for the figures thus limiting the objectives of the study.



## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

This chapter reviews studies related to effective allocation of resources to a capital investment project and how the cost of an investment can be influenced by the completion time of an investment. The completion time of a construction project is essential to an economy since the building and construction sector contribute a sizeable percentage towards GDP.

#### **2.2 Theoretical Literature Review**

##### **2.2.1 Determinants of construction**

In order to formulate appropriate policies and directions to help ease the impact of fluctuating volume of construction work, a model that can reliably predict the of various construction sectors after any economic turbulence would be extremely useful (Ryan and Thomas, 2010). The study used Box-Jenkins approach for model development due to its simplicity and sound theoretical background. The results illustrated that the Box-Jenkins models can reliably predict the medium-term total construction demand and residential demand covering a turbulent period of ups and downs in the construction demand. One of the main defects of this approach is that it does not come up with an approach in which the time and cost of a construction project can be reduced through effective allocation of resources.

Christopher (2000) described the relationship between land use regulation and residential construction. The study characterized regulations as adding explicit costs, uncertainty or delays to the development process. One implication of regulations that lengthen the development process as pointed out by the author is that the short and long run effects of demand shocks will

vary relative to conditions in the markets without such delays. Regulations that lengthen the development process or otherwise constrain new development project have larger and more significant effects. The study showed only what factors lengthen the development process or otherwise constrains new development but no effort was put to show how the construction cost and project durations would be reduced by the resource allocation process.

Cost estimation is an important task in construction projects. Since various risks-factors affect the construction costs, the actual costs generally deviate from the estimated costs in a favorable or adverse direction. Therefore, not only estimation of costs is needed but also an analysis of the uncertainty of the estimated cost is required (Onder, 2009). The study stated that this requirement gains more importance in projects constrained by money as the main driver. The author incorporates uncertainty and correlates effects in his correlated cost risk analysis model.

The model concentrates on the correlation of risks and costs but it does not address the reduction in the cost and duration of completing a construction investment.

### **2.2.2 Contingency budget estimation**

According to Chung (2009), investments in real estates, contingency budget is made available to cope with uncertainties that would incur schedule and cost overruns. Contingency estimation requires considering project cost, schedule and technology variability. This approach explicitly recognizes the uncertainty in the life cycle of a construction project and incorporates a dynamic project management mechanism into contingency estimation. The contingency is valued by minimizing the expected project cost via a multi-stage stochastic model that accounts for the variability of project cost and schedule. The approach requires the existence of a contingent budget in any investment project. This shows that the contingent is to act as a safety net in case

of cost overruns. The study does not help in reducing the cost and project duration but rather tries to show where the money will come from should there be unexpected expenditure.

### **2.2.3. Life –cycle cost analysis and lowest life –cycle cost**

Life-cycle cost analysis (LCCA) is a method for assessing the total cost of facility ownership (Sieglinde, 2010). It takes into account all costs of acquiring, owning and disposing of a building or building system. LCCA is especially useful when project alternatives that fulfill the same performance requirements but differ with respect to initial costs and operating costs but have to be compared in order to select the one that maximizes net savings.

Lowest life-cycle cost (LCC) is easy to interpret measure of economic evaluation. Building economists, certified value specialists, cost engineers, architects, quantity surveyors, operations researchers, use this technique to evaluate a project (Alphonze and Stephen, 2003). The approach to making cost-effective choices for building-related projects can be quite similar to what is called cost estimating, value engineering or economic analysis. Numerous costs associated with acquiring ,operating, maintaining and disposing of a building or building system include capital investment, fuel, operating, replacement, residual values, finance charges and other non-monetary benefits or costs.

To make cash flows time-equivalent, the LCC method converts them to present values by discounting them to a common point in time, usually the base year. The interest rate used for discounting is a rate that reflects an investor's opportunity cost of money over time, meaning that an investor wants to achieve a return at least as high as that of the next best investment. Hence, the discount rate represents the investor's minimum acceptable rate of return (Rosalier and Harold, 1990). After identifying all costs by year and amount and discounting them to present value, they are added to arrive at total life-cycle costs for each alternative:

$$\text{LCC} = \text{I} + \text{Repl} - \text{Res} + \text{E} + \text{W} + \text{OM\&R} + \text{O}$$

LCC = Total LCC in present-value (PV) dollars of a given alternative

I = present value of investment costs (if incurred at base date, they need not be discounted)

Repl = present value of capital replacement costs

Res = present value of residual value (resale value, salvage value) less disposal costs

E = present value of energy costs

W = present value of water costs

OM&R = present value of non-fuel operating, maintenance and repair costs

O = present value of other costs.

Lowest LCC is used in determining cost-effectiveness. If net savings are greater than zero, this is criteria for determining cost-effectiveness.

The most challenging task of an LCCA, or any economic evaluation method, is to determine the economic effects of alternative designs of buildings and building systems and to quantify these effects and express them in dollar amounts (Kent, 2003). This theory is not ideal for budgeting and also that it cannot help in estimating the project completion time. The model incorporates all the costs throughout the economic life of the project. It does not provide a solution in determining the shortest time possible in which a construction project can be completed at minimal cost.

#### **2.2.4. Linear programming**

Linear programming was developed during World War II, when a system with which to maximize the efficiency of resources was of utmost importance (Catherin, 2008). New war-related projects demanded attention and spread resources thin. 'Programming' was a military term that referred to activities such as planning schedules efficiently or deploying men optimally. George (1947), a member of the U.S. Air Force, developed the Simplex method of optimization in 1947 in order to provide an efficient algorithm for solving programming problems that had linear structures.

The assumptions of LP model are; the contribution of any variable to the objective function or constraints is proportional to that variable. This implies no discounts or economies to scale, the contribution of any variable to the objective function or a constraint is independent of the values of the other variables, decision variables can be fractions, all coefficients in the objective function and the constraints are known with certainty (Axel and Denis, 2004).

Since resources are always scarce, Managers are concerned with the problem of optimal resources allocation. It is a fact that in most maximization problem, the resource constraints are the natural part of the problem, while in the minimization problem the production constraints are the most important part of the problem (Arsham, 1998).

The linear programming model of allocating scarce resources is normally applied in finding the best mix to maximize returns of investment or minimizing costs. In a construction project, critical activities can be linear programmed and the least costly combination of various resources arrived at. The major drawback with linear programming is that it deals with one objective at a time. In construction, not all costs can be directly allocated to various units. The probability of

completing an investment within a given time cannot be obtained with linear programming (Lucey, 1996).

### **2.2.5. Project overruns**

According to Scott (1993), completing development projects after their deadlines is a common but expensive problem that has been well documented in the literature. Meeting schedule deadlines is often the most important concern for contractors (Wheelwright and Clark, 1992). To schedule performance, dynamic planning and concurrent development (Backhouse and Brookes, 1996; Pena-Mora and Park, 2001) and cross-functional development teams (Moffatt, 1998) need to be put in place. But the challenges of managing uncertainty in terms of cost and time still remain. The only weakness with this model is that the author concentrates on allocating resources in order to reduce project duration but does not strive to make an investment cost effectiveness.

Development project resource management can improve schedule performance by increasing the quantity of resources, productivity and utilization (Zee and David, 2007). Total resource quantities and associated productivities are often limited and difficult or expensive to improve, leaving resource utilization as a primary management tool to reduce project durations. Managers can have a large effect on resource utilization through the policies they use to allocate resources among development activities, even when the total quantity and productivity of resources are fixed. Applying too few resources to any given activity slows progress and applying too many can cause crowding effect that reduces productivity and wastes resources that could be used more efficiently by other activities. Therefore the effective and efficient allocation of scarce resources among development phases and among activities within phases is a realistic management opportunity for improving project schedule performance.

The work of Zee and David (2007) focused on resource allocation policies as a means of reducing project duration and sought to improve understanding of the impacts of those policies on project durations through project systems modeling and analysis. For all the development activities, allowed resources are modeled as the product of the total available resources (assumed to be constant), productivities (assumed constant and equal) and applied resource allocation fractions. Sterman's (2000) description of policies as decision-making rules was adopted by the two authors. They have shown that resource allocation policies are formal heuristics or guidelines which managers use to make individual decisions about where to apply resources. Improved understanding of how resource allocation policies impact project schedules can improve performance.

The model described above is heuristic in that different investors will apply their experiences, feelings and knowledge in assessing the cost and time of given construction project. This shows that the heuristic model does not guarantee an optimal allocation of resources as cost of an investment is relative. Also, shortening the project completion time cannot be determined objectively.

### **2.2.6 Optimization model**

Hong and Heng (2004) developed an optimization model that integrates discrete-event simulation with a heuristic algorithm developed to optimize dynamic resource allocation for construction scheduling. This heuristic algorithm is based on the objective of minimizing project duration and would consider activating multiple activities at the same time based on limited quantities of resources. The optimization is implemented through discrete-event simulation that is able to describe complex operational systems through simulation models, without the need to build mathematical models. The proposed methodology provides an alternative to optimize

resource flow for scheduling and broadens the application potential of discrete-event simulation in the construction field. The optimization model that integrates discrete-event simulation with a heuristic algorithm suffers from the short comings in that it incorporates human feelings into the model. Since human beings have different feelings, then different investors will always come up with different cost and time estimates and it will be very difficult to arrive at viable values in terms of cost and time.

### **2.2.7. Utility function**

Optimal resource allocation is a complex undertaking due to large-scale heterogeneity present in computational grid. The utility function is a promising method for grid resource allocation (Zhi and Chun, 2008). To tackle the issue of heterogeneous demand, the user's preference is represented by utility function, which is driven by a user-centric scheme rather than system-centric parameters adopted by cost functions. The goal of each grid user is to maximize its own utility under different constraints. In order to allocate a common resource to multiple bidding users, the optimal solution is achieved by searching the equilibrium point of resource price such that the total demand for a resource exactly equals the total amount available to generate a set of optimal user bids. The experiments run on a Java-based discrete-event grid simulation toolkit called GridSim are made to study characteristics of the utility-driven resource allocation strategy under different constraints. Results showed that utility optimization under budget constraint outperformed deadline constraint in terms of time spent, whereas deadline constraint outperformed budget constraint in terms of cost spent.

The conclusion indicates that the utility-driven method is a very potential candidate for the optimal resource allocation in computational grid. The weakness of the model is that it does not



heavily tend towards construction and it does not provide an investor with a clear approach of how to achieve a lower cost in resource allocation process. The model does not demonstrate how a project completion schedule can be shortened.

### **2.2.8. Net present value**

When an organization makes an investment, the decision maker looks forward to the gain over a planning horizon, against what might be gained if the money were invested elsewhere. A minimum attractive rate of return is adopted to reflect this opportunity cost of capital. The MARR is used for compounding the estimated cash flows to the end of the planning horizon, or for discounting the cash flow to the present (Hiller and Heebirth, 1965). Net present value is the difference between the present value of cash inflows and the present value of cash outflows. Net present value is used in capital budgeting to analyze the profitability of an investment or project. Net present value analysis is sensitive to the reliability of future cash inflows that an investment or project will yield. Formula (Jean and Nicholas, 1987) is,

$$NPV = \sum_{t=1}^T \frac{C_t}{(1+r)^t} - C_0$$

The profitability is measured by the net future value (NFV) which is the net return at the end of the planning horizon above what might have been gained by investing elsewhere at the MARR. The net present value (NPV) of the estimated cash flows over the planning horizon is the discounted value of the NFV to the present. A positive NPV for a project indicates the present value of the net gain corresponding to the project cash flows (Keeley, 1972).

One of the main weaknesses of net present value method is that it assumes cost of investment is known with certainty and so there is no effort to reduce it. Also, the time to complete an investment so that it can start producing a stream of cash flow is ignored. The model assumes

that the project is complete at year zero. The method is not suitable in the allocation of scarce in a construction project where lowest time and cost of investment are being sought.

### **2.2.9. Benefit cost ratio**

The benefit-cost ratio, defined as the ratio of discounted benefits to the discounted costs at the same point in time, is a profitability index based on discounted benefits per unit of discounted costs of a project (Chris, 1998). It is sometimes referred to as the savings-to-investment ratio .When the benefits are derived from the reduction of undesirable effects. Since some savings may be interpreted as a negative cost to be deducted from the denominator or as a positive benefit to be added to the numerator of the ratio, the benefit cost ratio is not an absolute numerical measure. However, if the ratio of the present value of benefit to the present value of cost exceeds one, the project is profitable irrespective of different interpretations of such benefits or costs. The formula is as follows;

$$\text{Benefit Cost Ratio} = \text{Present Value of Benefits} / \text{Present Value of Costs}$$

One of the main disadvantages is that it evaluates the projects viability in terms of profitability. It does not show how the resources are to be allocated in a construction project using the marginal cost criterion which guide in shortening the project duration and at the same time reduce the overall project cost.

### **2.2.10. Internal rate of return**

The internal rate of return or economic rate of return is the discount rate which sets the net present value of a series of cash flows over the planning horizon equal to zero. It is used as a profit measure since it has been identified as the "marginal efficiency of capital" or the "rate of return over cost. The IRR gives the return of an investment when the capital is in use as if the

investment consists of a single outlay at the beginning and generates a stream of net benefits afterwards. However, the IRR does not take into consideration the reinvestment opportunities related to the timing and intensity of the outlays and returns at the intermediate points over the planning horizon (David and Maria, 2008).

The higher a project's internal rate of return, the more desirable it is to undertake the project. As such, IRR can be used to rank several prospective projects a firm is considering. Assuming all other factors are equal among the various projects, the project with the highest IRR would probably be considered the best and undertaken first (Van, 1977).

Internal rate of return as a method of project investment appraisal neither consider how the costs of investment can be reduced nor does it consider the shortest period of completing an investment. In this respect, the method does not help in allocating resources in a project in order to ensure that the projection completion time and cost are minimized. It only considers the rate of interest at which the Net present value of an investment is equal to zero.

#### **2.2.11. Payback period approach**

The payback period (PBP) refers to the length of time within which the benefits received from an investment can repay the costs incurred during the time in question while ignoring the remaining time periods in the planning horizon. Even the discounted payback period indicating the "capital recovery period" does not reflect the magnitude or direction of the cash flows in the remaining periods (Giuseppe, 2006).

The time value of money is not taken into account. Payback period intuitively measures how long an investment takes to "pay for itself." All else being equal, shorter payback periods are preferable to longer payback periods. Payback period is widely used due to its ease of use.

However, if a project is found to be profitable by other measures, the payback period can be used as a secondary measure of the financing requirements for a project (Statman, 1984).

Major weakness of Payback period method of project appraisal method is that it does not help in determining the shortest time and the minimum cost in completing an investment project. This approach of economic evaluation projects ignores the aspects project completion time and project feasible cost. It only concentrates on the evaluation of a project with shortest payback period when faced with mutually exclusive investment projects.

### **2.3 Empirical Literature**

Town and David (1991) carried out a study on efficient allocation of limited resources in order to achieve high levels of construction project performance. Model outcomes focused on the impact of the project team, planning, and control efforts as they relate to achieving “overall” project success, better-than-expected schedule performance and better-than-expected budget performance. These results demonstrated that key success factors affect project outcomes differently. For example, increasing the number of budget updates has more of an impact on achieving better budget performance than it does on achieving better schedule and overall project performance. Implementation of a constructability program seems to have a significant impact on achieving overall project success and better schedule performance especially on fixed-price contracts. The findings were that reducing team turnover has a more significant impact on improving budget performance than it does in achieving better schedule or overall project performance. Olusegun (1999) explored the concept of optimal planning of construction projects by examining fifty two building projects undertaken in Australia. The relationships between planning input (ratio of planning costs to total project costs) and the probabilities of achieving poor performance and good performance were modeled using logistic, linear, and curvilinear

regression analyses. A probable optimum planning input based on the sample studied was derived. The study suggested that any additional planning efforts beyond this optimum point would be essentially wasted because the additional planning costs would not achieve any savings in project cost but merely add to the overhead costs and therefore increase the overall project cost. The study concluded that efficient allocation of resources for construction planning activities required construction planning resource requirements to be determined on a cost-effective and value-adding basis.

Khaled (2001) carried out research on how to optimizing resource utilization for repetitive construction projects. In order to significantly reduce the duration and cost of repetitive construction projects such as highways, high-rise buildings and housing projects the study advocated for identification of an optimum crew size and interruption strategy for each activity in the project. The study presented an automated and practical optimization model. The model utilized dynamic programming formulation and incorporated a scheduling algorithm and an interruption algorithm so as to automate the generation of interruptions during scheduling. This transforms the consideration of interruption options in optimizing resource utilization from an unbounded and impractical problem to a bounded and feasible one.

Faniran (2002) examined the relationship between contractors' planning practices and the occurrence of delays in the Nigerian construction projects. The relative significance of delay factors on projects undertaken by contractors who use the quantitative techniques for planning construction work and contractors who do not use quantitative planning techniques were also compared. The result of the study showed that although the use of quantitative planning techniques contributes significantly to improve the project delivery process, limiting factors in the Nigerian construction industry discourage contractors from engaging in quantitative

planning. The results indicated that a sizeable number of contractors who operated within the Nigerian construction industry did not apply any form of quantitative construction planning but rather preferred to depend on intuitive that were acting on the basis of hunches or previous experience in carrying out a project. The study concluded by stating that there is need for researchers to develop a body of knowledge on tools and techniques for successful management of construction projects in developing countries, taking into account the operating conditions within the local industries.

Doloi and Lim (2007) carried out a research in Australia designed to investigate the critical factors affecting on performance of construction project particularly in areas of time, cost, scope and quality of project management. This research project identified twelve critical factors that could affect the construction project performance. These critical factors were listed as follows: detailed planning in project budget and cost control, project time planning & schedule control, labour force, establishment of project quality control, ability to perform the required tasks, available of comprehensive project information & specification, competency of key personnel, close relationship between project time & cost management, project complexity, individual's experience in the construction industry, allowance for project contingencies, detailed project work breakdown structure and project milestones are clear and well defined.

The study showed that detailed planning in project cost and time management including control processes are important to increase the project performance. This is because these two components are always closely correlated in the project life cycle. The research showed that there is correlation between variables and the critical factors that grouped the highly correlated variables. The researcher showed that optimum project performance in construction industry can be achieved if more sophisticated approaches toward the above twelve identified critical factors

are adopted in the future. The study concluded by stating that it was reasonable to claim that a better understanding and analyses of these critical factors could lead to better control in construction project performance and hence minimizes the construction project risk.

Chung (2008) carried out a study on resource optimization approaches in various investment decisions. The researcher showed that investments in real estates require availability of contingency budget to cope with uncertainties that would incur schedule and cost overruns. To quantify contingency estimation, project cost, schedule and technology variability must be considered. This approach according to the study, not only explicitly recognizes the uncertainty in the life cycle of a construction project, but also incorporates a dynamic project management mechanism into contingency estimation. The contingency is valued by minimizing the expected project cost via a multi-stage stochastic model that accounts for the variability of project cost and schedule. This approach of resource optimization requires the existence of a contingent budget in any investment project.

Daniel and Yates (2009) carried out a study on construction project scheduling with time, cost, and material restrictions using fuzzy mathematical models and critical path method. The study evaluated the viability of using fuzzy mathematical models for determining construction schedules and for evaluating the contingencies created by schedule compression and delays due to unforeseen material shortages. Networks were analyzed using three methods: manual critical path method scheduling calculations, primavera project management software and mathematical models using the optimization programming language software. Fuzzy mathematical models that allow the multi-objective optimization of project schedules considering constraints such as time, cost, and unexpected inputs shortages were used to verify commonly used methodologies for

finding the minimum completion time for projects. The research also used a heuristic procedure for material allocation and sensitivity analysis to test five cases of input shortage, which increase the cost of construction and delay the completion time of projects. From the results obtained during the research investigation, it was determined that it is not just whether there is a shortage of inputs but rather the way inputs are allocated to different activities that affect project durations. It is important to give higher priority to activities that have minimum float values, instead of merely allocating materials to activities that are immediately ready to start.

## **2.4 Overview of the Literature**

In theoretical literature, some models covered were after predicting the various construction sectors after any economic turbulence. These did not help in cost containment in the construction industry. Also it was demonstrated how the regulations lengthen the development process.

Also some literature advocated for the existence of contingency budget estimation to cushion the contractor in case of budgetary allocation overruns. This tries to justify that time and budgetary allocation overruns are a must and it was unavoidable.

Models like Linear Programming, Box-Jenkins, Life-cycle cost analysis, discrete event simulations and utility functions were covered but none of the models tried to concentrate on how the construction project could be completed within the budgetary allocation period. Models outcome focused on the impact of the project team, planning, and control efforts as they relate to achieving “overall” project success, better-than-expected schedule performance and better-than-expected budget performance.

The discounted and discounted cash flow methods covered concentrated on the existence of a stream of cash flows from a project. These techniques did not cover how project cost could be



reduced or how the time taken to construct the project could be reduced. The cash-flow methods assumed that the costs were given.

In the empirical studies, it showed that most contractors do not use quantitative techniques for planning construction work. Also, some the critical factors that could affect the construction project performance were covered. It was also advocated for optimum crew size and interruption strategy as way of reducing the duration and cost of the project.

Fuzzy mathematical models for determining construction schedules and for evaluating contingencies. Although these models are applied in optimization, slacks are normally build to cater for delays and expected material shortages. Heuristic approach in allocation mechanism increases the cost of construction and delay the completion time of projects.

## **CHAPTER THREE**

### **METHODOLOGY**

#### **3.1. Introduction**

This chapter is subdivided into the following sections; research design, theoretical framework, model specifications, working hypotheses, description and measurement variables, data type and source, target population, sampling technique and sample size, research instruments, pilot study, data collection and data analysis.

#### **3.2. Research Design**

In order to study the allocation of scarce resources to a capital intensive project, the study used a survey design approach in order to investigate the way various construction companies allocated resources in order to complete a project within a short time and at a minimum cost. A simple random sample of size thirty was selected from a population of three hundred registered construction companies. The information obtained from the questionnaires was used in producing industrial statistical information and conclusions about how the resources could be allocated to a capital intensive project for example construction in order to ensure that development projects are completed within the budget and budget period.

The questionnaire was sent out to construction companies located in Nairobi County. The research involved collection of data on normal time, normal cost, crash time, crash cost, activity durations, project failure in terms of project completion time and cost overruns, criterion of scarce allocation, marginal cost concept and probabilistic approach in estimating project completion time.

### **3.3 Theoretical framework**

The study employed the critical path methodology to examine outcomes of construction project effectiveness in terms of time and cost. Critical path analysis is of great value where the investment projects contain many related and interdependent activities, many types of equipment or facilities, many labourers are involved and where constraints exist for example where projects have to be completed within a stipulated time or cost limits or where some or all of the resources are limited. For the critical path/network analysis model to work (Prensa, 2002), the whole project activities tasks involved are identified and the activity durations known. Critical path analysis provides planning and control information in terms of time, cost and resource aspects of a project. Each activity is assumed to have a known normal cost if completed in a normal time and a (higher) crash cost if completed in a (shorter) crash time. For each activity, three time estimates were obtained.

Once all the activities have been timed and their costs known, then a precedence table is presented showing all the activities in the order of occurrence. An example of a general precedence table as presented by Prensa (2002) is as shown in Table 3.1 below:

**Table 3.1: Precedence Table**

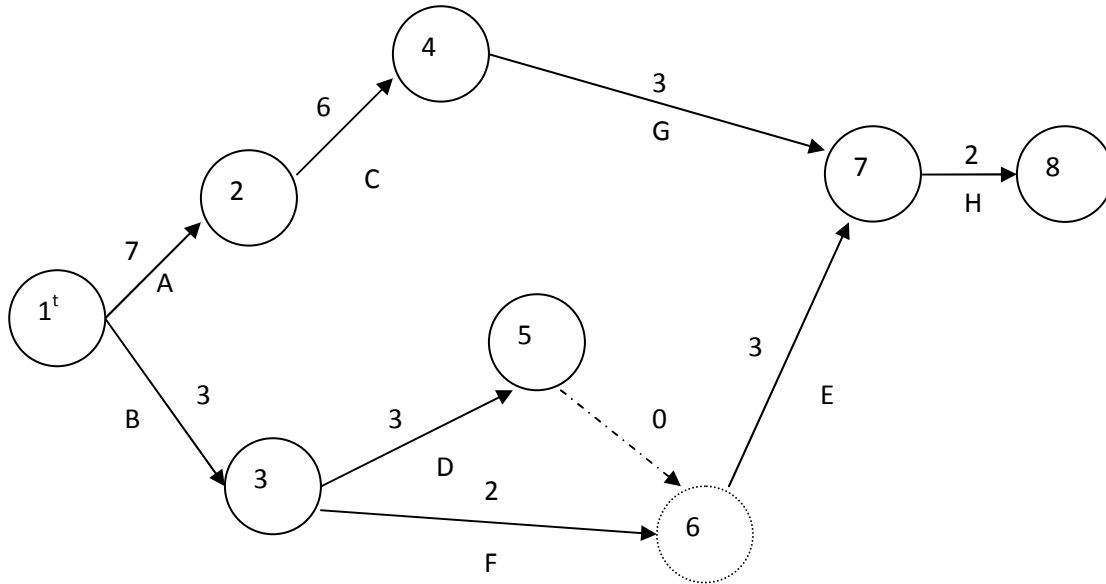
Activity/ task	Immediate predecessors	Expected duration(wks)
A	-	7
B	-	3
C	A	6
D	B	3
E	D,F	3
F	B	2
G	C	3
H	E,G	2

Source: Prensa (2002).

From Table 3.1, a network diagram is drawn ensuring that the following conditions are: There is only one point of entry i.e. start event and only one point of exit that is, finish event, every activity to have one preceding or 'tail' event and one succeeding or 'head' event. Activities may share the same 'tail' event or 'head' event. No two nodes in the network will be directly connected by more than one arrow. Before an activity can begin, all preceding activities must have been completed. An event is not complete until all activities leading to it are completed. All activities are then tied into the network that is, they must contribute to the progression or be discarded as irrelevant. Activities which do not link into the overall project are termed as 'danglers' (Lucey, 1996).

The earliest and the latest completion times for all the activities involved are then inserted into the circles which are located at the end of each activity as shown by Figure 3.1 below.

**Figure 3.1: Network diagram**



Source: Lucey, T (1996), Quantitative techniques 6<sup>th</sup> Ed. London, EMEA

After all the earliest and the latest completion times of activities have been inserted into the network diagram, critical activities are then identified. This path of activities is identified by the circles where the earliest and the latest completion times tally. The critical path of a network gives the shortest time in which the whole project can be completed. The path comprise of activities which need not be delayed because they can affect the overall project in terms time and cost overruns.

### 3.4. The Model Specifications

Time is very essential in economics because the value of a shilling today is much different in years to come. This can affect the net present value of a project. For this reason, in projects, three time estimates of each activity are normally applied. These three times estimates are:-

Optimistic time ( $a_{i,j}$ ) is the minimum possible time required to accomplish a task /activity, assuming everything proceeds better than is normally expected. This ensures that the actual cost of an activity tend to be lower than the budget amount because of the time value of money factor. This is when the rate of inflation is lower than expected in the budget. Also, the currency becomes stronger than what was expected in the budget. The optimistic time was stated in weeks.

Pessimistic time ( $b_{i,j}$ ) is the maximum possible/ longest time required to accomplish a task / activity, assuming everything goes wrong (but excluding major catastrophes). When the time taken is too long, the budgeted amount allocated for an activity tend to be less than the actual expenditure since the construction material cost tend to rise due to inflation and fluctuation of a currency. This time was expressed in weeks in the study.

Most likely time ( $m_{i,j}$ ) is the best estimate of the time or modal time required to accomplish a task, assuming everything proceeds normally. This is the time when price level is assumed to conform to the budget. In the study, this time was expressed in weeks.

Expected time ( $\mu_{i,j}$ ) accomplish is the best estimate of time required to accomplish a task /activity assuming everything proceeds as normal. The expected time is the average time the task would take if the task were repeated on a number of occasions by any company in the industry. Expected time of an activity is computed as follows (Model, 1983);

$$\mu(i, j) = \frac{1}{6}(a_{ij} + 4m_{ij} + b_{ij}) \quad 3.1$$

In order to arrive at the total cost of completing the project, the normal cost of completing all the activities are added up together.

If an investor wants to shorten the project duration, the following general algorithm specifications are followed; each activity is assumed to have a known normal cost if completed in the normal time and a (larger) crash cost if completed in a (shorter) crash time. The cost slopes or the marginal cost of each of the critical path activities are calculated. The marginal crashing costs (i.e. cost per unit time) for each activity is computed using the following formula (Whitehouse, 1973):

$$\text{Marginal Cost} = \frac{(Cost_{crash} - Cost_{normal})}{(Time_{normal} - Time_{crash})} \quad 3.2$$

Or

$$\text{Cost slope} = \frac{(Cost_{crash} - Cost_{normal})}{(Time_{normal} - Time_{crash})} \quad 3.3$$

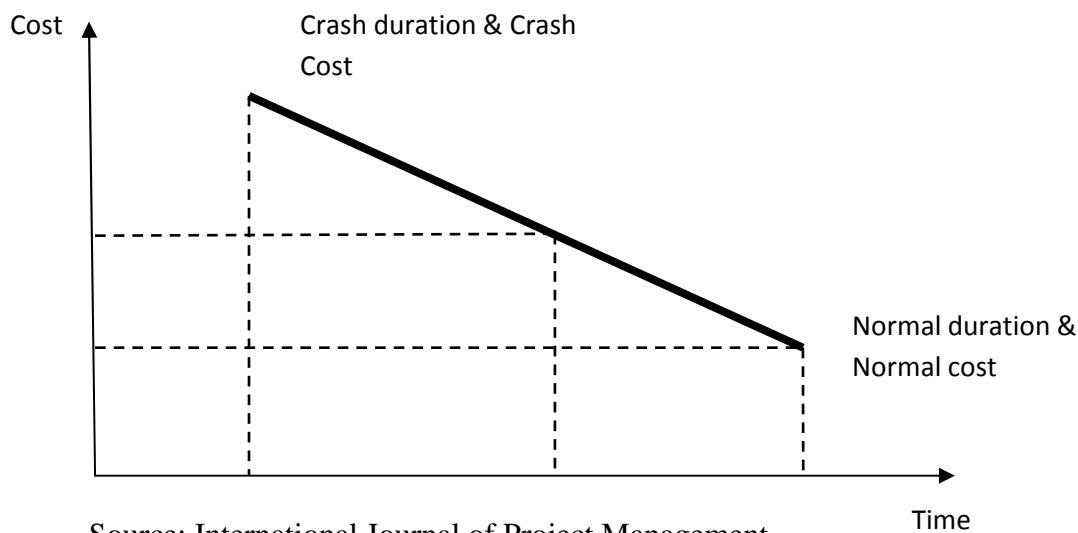
From the network, project activity marginal cost list is generated with available crash time (compression) for each of the activities. These marginal costs help in identifying the order in which the critical activities are crashed. The activity with the lowest marginal cost is given priority in crashing. So, more resources are employed in the activity that has the lowest cost slope since lower extra cost added to the total project cost.

Enumerate all the paths through the project network and list them with their normal time durations in the path list. Identify the critical path(s) as those with longest duration, and mark the critical activities. For the allocation mechanism to work, identify the expected project duration, the project cost and the critical path. Select that subset of critical activities which, when compressed in parallel, enable all current critical paths to become shorter and do so at the least group marginal cost, where the group marginal cost for a subset of critical activities is the sum of the marginal costs for activities in the group.

Compress the selected critical activities until one or both of the following two conditions occur: One or more of the compressed activities becomes fully crashed that is it's reduced to crash time or limit or a new path becomes critical. Record the selected activities, number of time periods compressed, the new project duration, the group marginal cost for the selected activities, the added cost resulting from the compression, the new total direct cost and the new critical path if any as items in the breakpoint or crash limit for that iteration. Update the compression availabilities and the path list to reflect the reduction in path lengths resulting from the selected compression.

Repeat crashing process until all activities on the same critical path become fully crashed that is optimal point which occurs at the turning point of total project cost curve. Crashing further after the optimal point, the cost increases instead of reducing. Plot the time-cost trade-off graph by linear interpolation between the time/cost pairs which occur in each row of the breakpoint crash limit. An optimal allocation has been reached. The time-cost graph showing linear time and cost trade-off for an activity is as shown in Figure 3.2;

**Figure 3.2: Time-Cost Graph**



Source: International Journal of Project Management

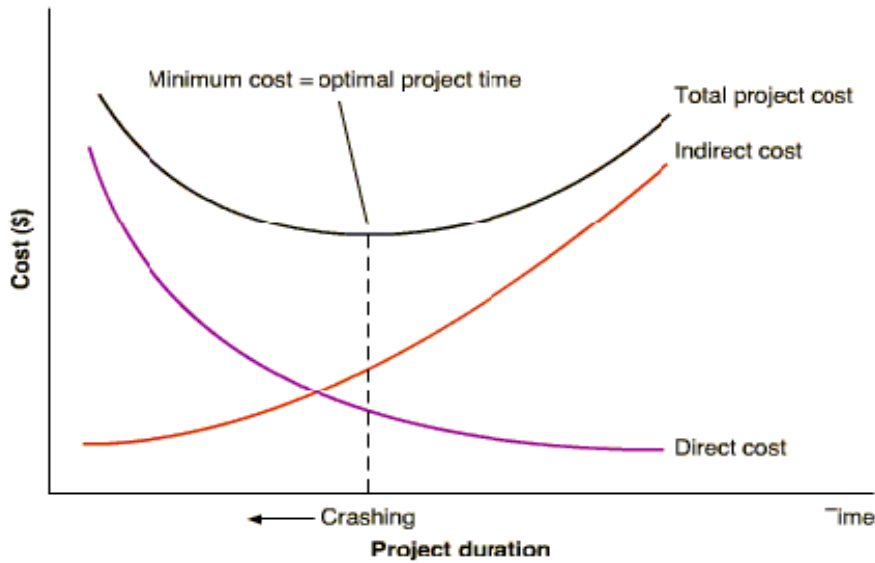


The Figure 3.2 is a simple representation of the possible relationship between the duration of an activity and its direct costs. Shortening the duration of an activity normally increase its direct cost. A duration which implies minimum direct cost is called the normal duration and the minimum possible time to complete an activity is called crash duration but at a maximum cost. The linear relationship shown above between these two points implies that any intermediate duration could also be chosen and what changes are the combinations of time and direct (variable) costs.

If the activity durations are reduced beyond the available crash time, then instead of the total project cost reducing, it rises. This shows that even if extra factors of production are employed beyond crash limits, the cost tend to obey the law of decreasing returns to scale. This results in the change of the former critical path which convenes to the model principle. So, scarce resource allocation will have been done in completing a construction project at the shortest time possible in the budgeted period.

Project crashing costs and indirect costs have an inverse relationship; crashing costs are highest when the project is shortened, whereas indirect costs increase as the project duration increases. So, the best project time is at the minimum point on the total cost curve as shown by Figure 3.3 below;

**Figure 3.3: Crash-Cost Graph**



Source: Journal of Engineering Economist.

In order to assess for the feasibility of completing the construction project within the budgeted (scheduled) period, the variance of each of the critical path activities is calculated. The formula applied is;

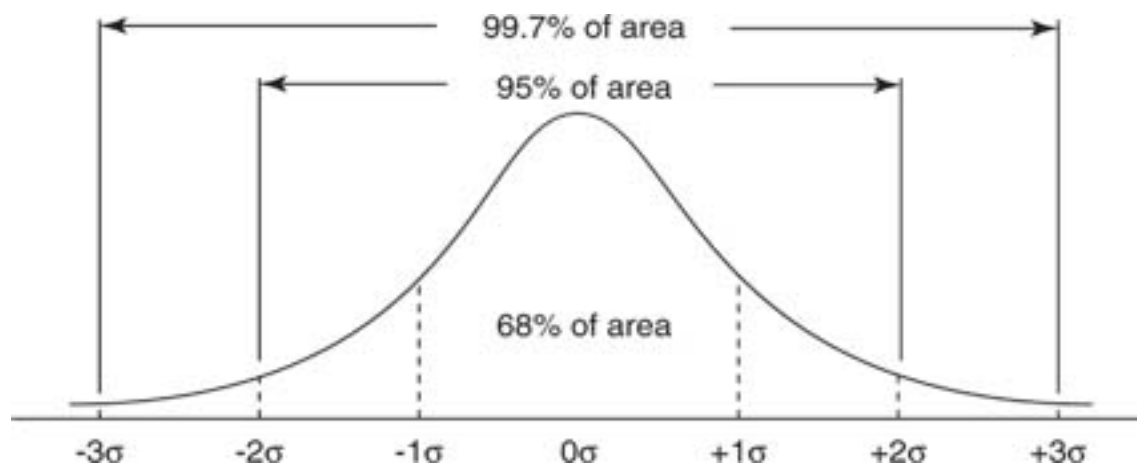
$$\delta^2(i, j) = \frac{1}{36} (b_{ij} - a_{ij})^2 \tag{3.4}$$

From the variances of these critical path activities, the standard deviation for each activity is derived. The overall project standard deviation is then calculated as follows;

$\delta = \sqrt{\sum_i \delta_i^2}$ ; where  $\delta_i^2$  represents the variance of an activity on the critical path of the project. This shows how the time varies from one activity to another one on average.

The probability of completing a given construction investment at a scheduled date will then be ascertained as shown below in Figure 3.4 on probability curve.

**Figure 3.4: Probability Curve**



Source: Bryc (1995), The normal distribution

In order to use the area of the normal curve to determine the probability of occurrence of a schedule date( $x$ ) of completing an investment project, the project date must be standardized or converted to a  $z$  score. To convert a value to a  $z$ -score is to express it in terms of how many standard deviations it is above or below the expected completion time( mean= $\mu$  ). The formula to compute a  $z$ -score is;

$$Z = \frac{X - \mu}{\delta} \tag{3.5}$$

After the  $z$ -score is obtained, its corresponding probability may be looked up in a normal probability distribution table and if the probability of completing a project within the scheduled date is low, the scheduled completion date is revised before the construction work begins. This is an effective way in which scarce resources can be allocated to a capital investment project. This ensures that development projects are completed on time without budgetary overruns. The probability element ensures that the fluctuations of currency or the inflationary elements are captured.

### 3.5. Working Hypotheses

- a) The costs of each of the activities involved in a construction project are never stated before construction work begins.
- b) The duration of activities involved in a construction project are not estimated before the commencement of a project.
- c) Companies working in the construction industry do not apply the marginal cost criterion in allocation resources to a project.
- d) Before the construction work begins, the likelihood of completing the project within a scheduled date is never ascertained.
- e) There is no policy on how to allocate resources to a project in the construction industry.

### 3.6. Description and Measurement of Variables

**Activity:** This is a task or job of work involved in a construction project and the task consumes time and resources. An example is erecting a wall.

**Activity duration:** It is the time taken complete a given task in a construction project. In order to obtain expected activity duration, three estimates of each activity times are used. This help in approximating the rate of inflation over a given period. The multiple time estimates brings in the element of certainty. It is calculated as follows;

$$\mu(i, j) = \frac{1}{6}(a_{ij} + 4m_{ij} + b_{ij})$$

**Normal time:** This time taken to complete an activity/task under normal conditions. It is the modal time of completing activity. This is the time when rate of inflation is moderate and the

currency is moderately strong to induce investment. This time is always longer than the crash time since there are only fewer resources employed.

**Normal cost:** This is the expected cost to be incurred in carrying out a given task of a project. This cost is usually lower than the crash cost since few factors of production are employed in carrying out a task.

**Crash time:** This is the shortest time in which an activity of a project can be completed if extra resources are employed in carrying a given task. Crash time is always less than normal time since more resources are employed in carrying out a task.

**Crash cost:** This the expected cost to be incurred in carrying out an activity in the shortest time possible after employing more resources to carry out a task.

**Marginal cost / cost slope:** This is the extra cost to be incurred in a project when an activity on the critical path is reduced by one unit of duration time as a result of employing more factors of production. The cost slopes or the marginal cost of each of the critical path activities are calculated. The marginal crashing costs (i.e. cost per unit time) for each activity is computed using the following formula (Whitehouse, 1973):

$$\text{Marginal Cost} = \frac{(Cost_{crash} - Cost_{normal})}{(Time_{normal} - Time_{crash})}$$

Or

$$\text{Cost slope} = \frac{(Cost_{crash} - Cost_{normal})}{(Time_{normal} - Time_{crash})}$$

**Project standard deviation:** In order to for the feasibility of completing the construction project within the budgeted (scheduled) period, the variance of each of the critical path activities is calculated. The formula applied is:

$$\delta^2(i, j) = \frac{1}{36} (b_{ij} - a_{ij})^2$$

From the variances of these critical path activities, the standard deviation for each of the activities derived. The overall project standard deviation is then calculated as follows;

$\delta = \sqrt{(\sum_i \delta_i^2)}$ ; where  $\delta_i^2$  represents the variance of an activity on the critical path of the project.

**Standard score (Z):** In order to use the area of the normal curve to determine the probability of occurrence of a schedule date(x) of completing an investment in a construction project, the expected completion date must first be standardized or converted to a z score. To convert a value to a z-score is to express it in terms of how many standard deviations it is above or below the expected completion time ( $\mu$ ). The formula to compute a z-score is;

$$Z = \frac{X - \mu}{\delta}$$

### 3.7. Data type and source

The data required for the study were activity duration estimates in days - optimistic time, most-likely time and pessimistic time in weeks, normal time and crash time in weeks, normal cost and crash cost in Kenya shillings, the frequency of project failure in terms of project completion

time overruns and project budgetary overruns and criterion of employment extra resources. The data came from thirty randomly selected companies in the construction industry which are located in Nairobi County.

### **3.8. Target Population**

The study targeted a population of three hundred registered Companies which were involved in the construction industry and were located in Nairobi County. The Companies selected had been registered with the Ministry of Roads and Public Works. The members of the population were assigned numbers from 001 to 300 as per the annex.

### **3.9. Sampling Technique and Sample Size**

Since all the members of a population were known with certainty and they had been numbered, simple random sampling technique was applied to each stratum according to company registration category in selecting the construction companies to constitute the sample to be studied. This ensured that all the members of a population had equal chance of being selected for the study. The numbers were randomized with help of a computer in order to generate a random numbers for the companies (members) that constituted the sample size of thirty. The companies were be picked / listed for the study as the numbers appeared until the last number to make thirtieth was picked.

### **3.10. Research Instruments**

The study was carried out through a well designed questionnaire where the questions had only one interpretation to different respondents. The questionnaire covered all the areas needed for the survey and were administered only to players in the construction industry. This made the

research instruments more reliable and valid for the survey. A sample of the questionnaire can be found in the appendices.

### **3.11. Pilot Study**

In order to ensure that the actual survey was carried out efficiently and effectively, a pilot study was carried out one week before the actual survey. A pilot study of three randomly selected companies in the construction industry in Nairobi County was conducted. This prior survey helped in identifying difficulties which were likely to be encountered during the actual survey. After the difficulties have been identified in advance, remedial measures taken to avoid a repetition of the same during the actual study. The findings of the pilot survey helped to determine the reliability of the results obtained from the actual survey.

### **3.12. Data Collection**

The questionnaires were delivered to the company representatives of the companies to be studied. After receiving it, the respondents signed on the delivery register maintained for the study. The respondents were requested to take one week to respond to the questionnaire.

After one week, the questionnaire forms were collected from the respondents. Whenever a form was picked from a respondent, the register was marked against the name of that company. This ensured that all the forms which were issued for the study were collected from the respondents.

### **3.13. Data Analysis**

The researcher tabulated the data on activity duration. The table had three columns that is, optimistic time, most likely time and pessimistic time. For each of the activities, the averages for each of the three time estimates were calculated in order to arrive at the industrial time estimates.



The expected duration times for the activities were calculated using the model. The expected durations were used in finding the earliest and latest completion times of activities. The summation of the critical activities of the project gave the completion time of the project.

The data on normal and crash costs for each of the activities were also tabulated and averages obtained for each of the activities in order to arrive at expected industrial normal and crash cost. Normal and crash times were also analyzed and marginal cost or cost slope derived from the model.

The variances of the critical activities of the project were calculated from the model in order to arrive at the industrial standard deviation. These statistics were used in calculating standard scores for the normal probability distribution table.

From the statistics calculated, the viability of completing a project on a scheduled date was assessed and marginal cost incurred in varying project completion period by one unit period was obtained. Industrial project completion failures in terms of time and budget overruns were obtained. This helped in drawing policy implications on how resources could effectively be allocated in a construction project.

## **CHAPTER FOUR**

### **EMPIRICAL RESULTS AND INTERPRETATION**

#### **4.1 Introduction**

In this chapter, the findings of the study are discussed and results interpreted. The chapter is subdivided into the following sections: response rate from the companies selected, costs of activities in the construction project, completion times for the activities, criteria of employing extra resources, likelihood of completing project within a scheduled date and summary.

#### **4.2 Response rate from the companies selected**

A questionnaire was delivered by hand to thirty construction companies out of three hundred companies registered with the Ministry of Public Works. Three (3) of the companies selected delayed in the submitting back the filled questionnaire for the study but submitted after several reminders. The thirty (30) companies selected for the study responded. This was largely due to the fact that pilot survey had been done in advance and potential difficulties had been cleared before the main survey was carried out.

#### **4.3 Costs of activities in the construction project**

The costs for each of the activities from the thirty respondents were obtained. All the cost of each of the activities for each of the respondents was averaged in order to arrive at the industrial cost and time for each the activities. From the sample, it was found out that 40% of the respondents in the construction industry indicated that they were able to complete project within the budget. It was also found out that, 60% of the companies in the construction industry did not complete

project within the budget hence experiencing budgetary overrun. The reasons were that construction period was not enough and cost of raw materials increased more than what they expected. From the sample of thirty respondents, 85% of them knew nothing about quantitative techniques employed in time/cost control. The study found similar results to the study on the relationship between contractors' planning practices and the occurrence of delays in the Nigerian construction industry as carried out by Famiran (2002).

The following Table 4.1 shows the industrial cost of carrying out activities in the project;

**Table 4.1 Industrial Costs of Activities**

Activity	Normal		Crash	
	Cost	Time	Cost	Time
A- Site clearing	11,980	3	25,060	2
B- Removal of trees	13,792	3	16,583	2
C- General excavation	17,957	3	20,304	2
D- Grading general area	31,708	3	38,043	2
E-Excavation for utility trenches	35,729	4	43,021	3
F-Placing formwork and reinforcement for concrete.	35,348	4	40,043	3
G-Installing sewer lines	34,043	4	38,304	3
H-Installing other utilities	17,087	3	23,652	2
I-Pouring concrete	42,217	1.5	47,565	1

Source: Own data.

From the Table 4.1, the normal cost is higher than the crash cost. Also the, normal time taken to complete an activity is higher than the time taken in a crash program. This is because, as more

factors of production are employed in a crash program, the cost tends to rise while the time taken falls.

#### 4.4 Completion Times for the Activities

In order to arrive at the industrial indices in terms of time, the respondents had been asked to estimate the shortest, normal and the longest times of activities involved in the construction of a three storey building at Mlolongo along Mombasa road in Nairobi County. In order to arrive at the industrial time interval for each of the activities involved, the times taken for each of the activities from thirty respondents were averaged and the data in Table 4.2 were obtained.

**Table 4.2: Shortest, Normal and Longest Times**

Activity	Shortest time (days)-a	Normal time (days) -m	Longest time (days)- b
A- Site clearing	2.3	3.2	3.9
B- Removal of trees	2.1	3.2	4
C- General excavation	2.7	3.7	4.2
D- Grading general area	2.2	3	3.5
E-Excavation for utility trenches	3.4	4.3	4.8
F-Placing formwork and reinforcement for concrete.	3.8	4.6	5.4
G-Installing sewer lines	3.6	4.5	5
H-Installing other utilities	3	4	4.5
I-Pouring concrete	1.4	1.6	2

Source: Own data.

The Table 4.2 shows the industrial shortest, normal and longest times which were obtained by calculating the average of the three time estimates from the thirty respondents.

In order to determine the allocation mechanism, the companies quoted the costs to be incurred in various activities involved in constructing the concrete slab foundation for a three storey building project at Mlolongo area in Nairobi County. The expected data for industrial time intervals in Table 4.2 were calculated using a model, that is;

$$\mu(i, j) = \frac{1}{6}(a_{ij} + 4m_{ij} + b_{ij})$$

Table 4.3 shows the industrial expected time  $\mu(i, j)$  .after the three time estimates were combined using the model.

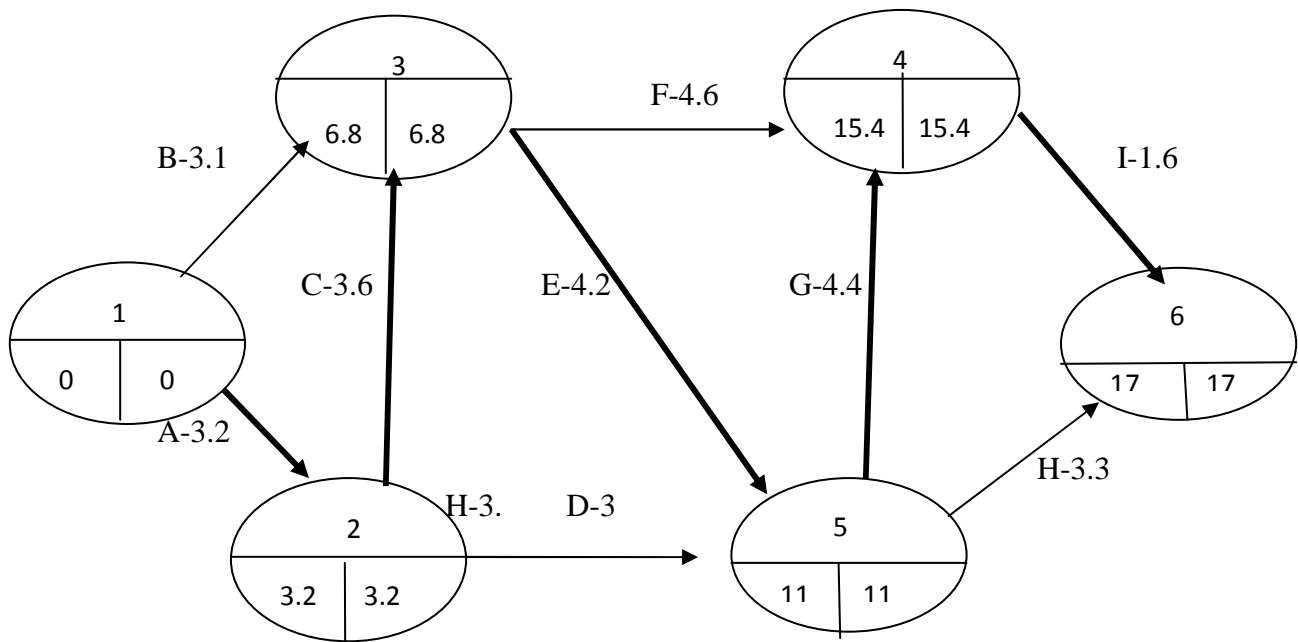
**Table 4.3: Industrial Expected Times**

<b>Activity</b>	<b>Shortest time (days)- a</b>	<b>Normal time (days) -m</b>	<b>Longest time (days)- b</b>	$\mu(i, j)$
A- Site clearing	2.3	3.2	3.9	3.2
B- Removal of trees	2.1	3.2	4	3.1
C- General excavation	2.7	3.7	4.2	3.6
D- Grading general area	2.2	3	3.5	3.0
E-Excavation for utility trenches	3.4	4.3	4.8	4.2
F-Placing formwork	3.8	4.6	5.4	4.6
G-Installing sewer lines	3.6	4.5	5	4.4
H-Installing other utilities	3	4	4.5	3.9
I-Pouring concrete	1.4	1.6	2	1.6

Source: Analysis of data.

The last column of Table 4.3 shows the industrial expected times calculated from the model in order to obtain the industrial expected times. These were then subjected to critical path analysis in order to obtain the completion time for the activities. The industrial expected times were then used in calculation of earliest and the latest completion times. From the network diagram, the earliest and the latest completion times for the activities were obtained. The following Figure 4.1 shows earliest and the latest completion times for the activities.

**Figure 4.1: Earliest and Latest Completion Times**



Source: Analysis of data

From the network diagram, the earliest and the latest completion times for the activities were obtained. The thick line on the Figure 4.1 indicates critical activities A, C, E, G and I which affect project duration and costs if resources are not allocated optimally. These findings concurred with the study done by Daniel and Yates (2009) on construction project scheduling with time, cost, and material restrictions using fuzzy mathematical models and critical path method although the allocation of materials was done heuristically.

The following Table 4.4 shows the completion times of activities.

**Table 4.4: Completion Times**

Activity	Earliest completion time	Latest completion time
A- Site clearing	3.2	3.2
B- Removal of trees	3.1	6.8
C- General excavation	6.8	6.8
D- Grading general area	6.2	11
E-Excavation for utility trenches	11	11
F-Placing formwork	11.4	15.4
G-Installing sewer lines	15.4	15.4
H-Installing other utilities	14.3	17
I-Pouring concrete	17	17

Source: Analysis of data.

From the network diagram, the earliest and the latest completion times for the activities were obtained. The difference between the two completion times shows slack times. The critical activities have 0 slack time differences. The starting and ending completion times for both earliest and latest times tally since a project must have a starting point one end point. The highest figure, which is 17 in Table 4.4 and it shows the project completion time of the project. This shows that construction companies could predetermine the completion time before implementing a construction a project.

#### **4.5 Criteria of Employing Extra Resources**

From the study, of all the thirty companies, none of them used marginal cost concept in employing scarce resources. The companies used heuristic approach in employing extra resources to capital projects as found in the empirical literature. In order to determine the

allocation mechanism, the total cost for the project was calculated and the results were as follows;

**Table 4.5: Normal Cost**

Activity	Normal Cost
A- Site clearing	11,980
B- Removal of trees	13,792
C- General excavation	17,957
D- Grading general area	31,708
E-Excavation for utility trenches	35,729
F-Placing formwork and reinforcement	35,348
G-Installing sewer lines	34,043
H-Installing other utilities	17,087
I-Pouring concrete	42,217
Total cost	239,861

Source: Analysis of data.

The total cost for the project at the industrial expected duration of 17 days was Ksh.239, 861. This was a summation of normal costs of activities involved in the project. The marginal cost of each activity was calculated from the model. The marginal costs were then calculated using the model below;

$$\text{Marginal Cost} = \frac{(Cost_{crash} - Cost_{normal})}{(Time_{normal} - Time_{crash})}$$

The Table 4.6 below shows the marginal costs of activities involved.



**Table 4.6: Marginal Cost**

Activity	Normal		Crash		Marginal cost
	Cost	Time	Cost	Time	
A- Site clearing	11,980	3	25,060	2	<b>13,080</b>
B- Removal of trees	13,792	3	16,583	2	<b>2,791</b>
C- General excavation	17,957	3	20,304	2	<b>2,347</b>
D- Grading general area	31,708	3	38,043	2	<b>6,335</b>
E-Excavation for utility trenches	35,729	4	43,021	3	<b>7,292</b>
F-Placing formwork and reinforcement for concrete.	35,348	4	40,043	3	<b>4,695</b>
G-Installing sewer lines	34,043	4	38,304	3	<b>4,261</b>
H-Installing other utilities	17,087	3	23,652	2	<b>6,565</b>
I-Pouring concrete	42,217	1.5	47,565	1	<b>5,348</b>

Source: Analysis of data.

The marginal cost of critical activities A, C, E, G and I were obtained as 13,080, 2,347, 7,292, 4,261 and 5,348 respectively. In order to reduce project duration and time, employment of extra resources was in the order of critical activity with the lowest to highest marginal cost that was; 2347, 4261, 5348, 7292, 13080.

To reduce the project completion time by one day, the total project cost was increasing by the marginal cost of the critical activity crashed and at the same time reducing with indirect cost taken as Ksh. 8,000 per day. The Table 4.7 below shows the trend in the total cost with employment of extra resources to each of the critical activities.

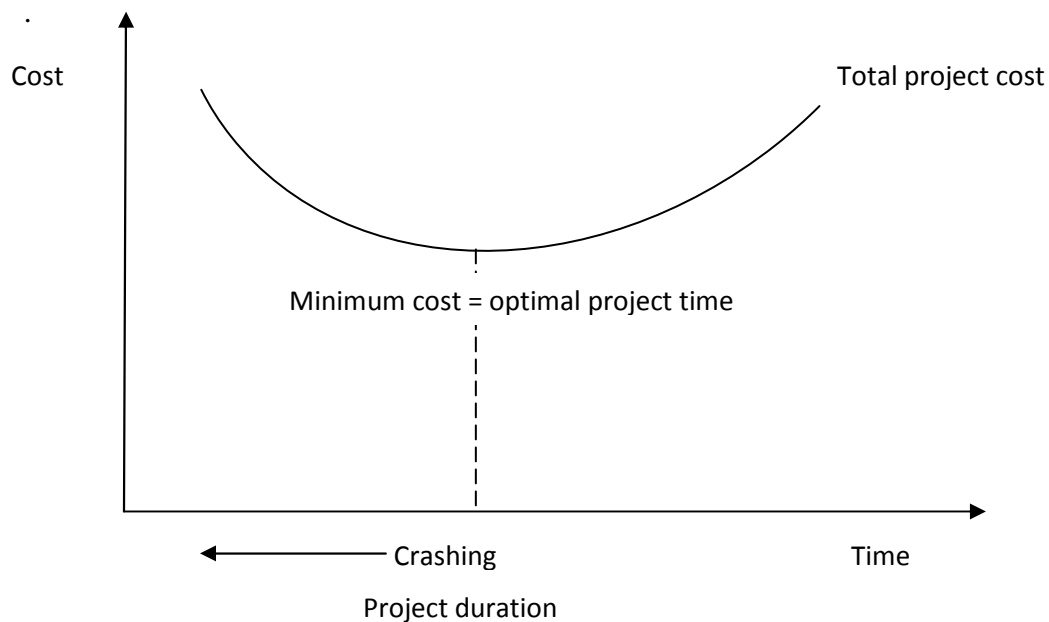
**Table 4.7: Total project cost**

Critical activity.	Marginal cost	Saving in indirect cost per day crashed.	Number of days crashed (reduced).	Total project cost.
With no activity crashed.	0	0	0	239,861
C- General excavation.	2,347	-8,000	1	234,208
G-Installing sewer lines.	4,261	-8,000	1	230,469
I-Pouring concrete.	5,348	-8,000	1	227,817
E-Excavation for utility trenches.	7,292	-8,000	1	227,109
A- Site clearing.	13,080	-8,000	1	232,189

Source: Analysis of data.

When the critical activities were crashed to optimal level, the former none critical activities become critical and any employment of extra resources resulted to rise in project cost since when indirect cost were falling, direct cost was rising at higher rate which led to rise in the total project cost as shown by Table 4.7. The Figure 4.2 below shows the trend in the total project cost curve.

**Figure 4.2: Total Project Cost Curve**



From Figure 4.2, when activities were crashed by a total of four days, the lowest point which is the turning point of the total project cost curve was identified and the optimal project completion time and cost identified. The total cost and duration of completing a construction project were identified as 13days and Ksh. 227,109 respectively.

#### 4.6. Likelihood of completing project within a scheduled date

The study found out that, 25 respondents, which is 85% of respondents, did not complete projects on time which implied that investors were affected by time value of money factor. It was also found that companies did not employ probability in trying to estimate the likelihood of completing a project given the various economic conditions like rate of inflation and fluctuations of a currency which may affect the project cost as a result of time value of money.

In order determine the probability, the industrial project standard deviation was calculated using the critical activities A, C, E, G and I as shown in Table 4.8 below. The model used was:

$$\delta^2(i, j) = \frac{1}{36} (b_{ij} - a_{ij})^2$$

**Table 4.8: Project Variance**

Activity	Shortest time (days)-a	Normal time (days) -m	Longest time (days)- b	Variance
A- Site clearing	2.3	3.2	3.9	0.0711
C-General excavation	2.7	3.7	4.2	0.0625
E-Excavation	3.4	4.3	4.8	0.0784
G-Installing sewer lines	3.6	4.5	5	0.0544
I-Pouring concrete	1.4	1.6	2	0.0100
			Total	<b>0.2764</b>

Source: Own data.

$$\delta^2(i, j) = \frac{1}{36} (b_{ij} - a_{ij})^2 = 0.2764. \text{ This is the industrial project variance.}$$

Industrial standard deviation was then found as  $\delta = 0.526$ . In order to have certainty of completion time of a project within a specified budget, normal probability was calculated from the model as follows;

$$Z = \frac{X - \mu}{\delta}$$

The probability of achieving project completion time of 13 days which was a reduction from

17 days was obtained through the model that was  $Z = \frac{X - \mu}{\delta}$

$$Z = \frac{13 - 17}{0.526} = -7.6. \text{ From the normal distribution table, probability was found as 0.9987. This}$$

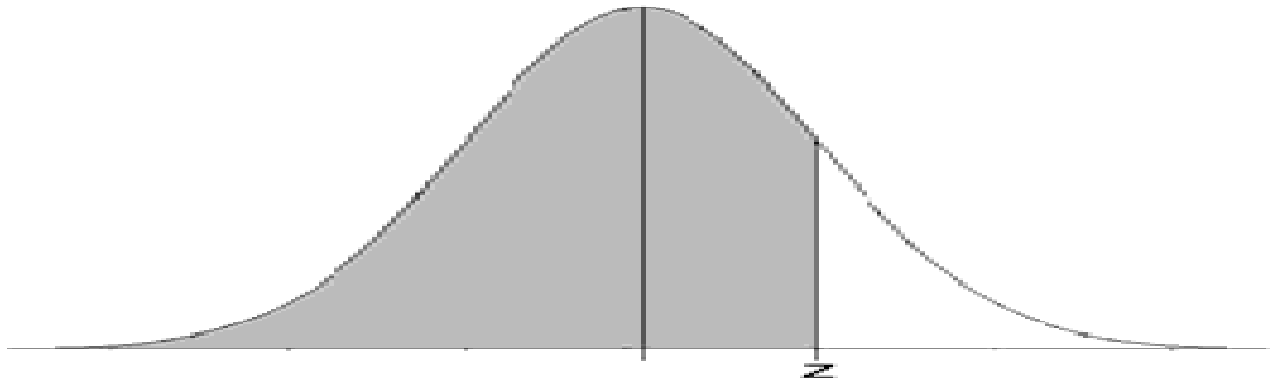
showed that probability of completing the project by four days earlier than the scheduled date of 17 was 0.9987 which was high and that showed the certainty of completing the project on time. In that case, the investor could have finished the project comfortably without much fluctuation in cost or much variation in time.

The first and second null hypothesis were rejected in that costs and durations of each activity are never stated in advance before the commencement of the project and the alternative hypothesis was accepted.

For the third, fourth and the fifth null hypothesis that marginal cost criteria was never practiced by companies, companies were not assessing probability of completing project and that there was no policy on how to allocate resources were accepted at significance level of  $\alpha = 0.01$  and

alternative hypothesis rejected since  $Z_{\text{computed}} = z_c = \infty$  was greater than  $z_a = 2.33$  at  $\alpha = 0.01$  level of significance. Figure 4.3 below shows  $z = 2.33$ .

**Figure 4.3: Acceptance Region**



Source: NIST/SEMATECH e-Handbook of Statistical Methods

Figure shows that  $(z_a = 2.33) < (z_c = \infty)$  and since  $z_c$  lies in the rejection region (un-shaded area) null hypothesis is accepted.

This confirmed the findings of the study in that none of the respondents had applied marginal cost criterion in allocation mechanisms. Also, the respondents were found not to apply the probability concept and that there was no policy on how to allocate resources in construction industry. The findings tallied with the study done by Doloi and Lim (2007) in Australia designed to investigate the critical factors affecting on performance of construction project particularly in areas of time and cost. Also, from the literature,

## **4.7 Summary**

The study was done based on a sample of 30 registered construction companies registered with the ministry of public works. Questionnaires were sent to the companies and data on cost and time was obtained. The response rate was 100%. It was found out that the only quantitative planning tools were budget and experience over time. The data on the shortest, normal and

longest time for the activities were applied into the model and industrial expected times obtained. These durations were then used in drawing network diagram to obtain the earliest and the latest completion time of the activities. Critical path of activities for the project were obtained. The project completion time and total cost was obtained.

The study showed that the industry did not apply marginal cost criteria in employing extra resources in the construction project. Marginal cost of all the activities were derived from the model in order to determine the criteria of employing extra resources in a project. The project duration was reduced by unit time for each of the critical activities and the total project curve indentified showing the turning point which was the optimal point.

From the companies studied, 60% of them did not complete projects as scheduled and none of the companies used probability approach to ascertain the chances of completing projects on time. In order to find the likelihood of completing a project, the industrial standard deviation of 0.526 was calculated from the model. The standard score was calculated and probability of obtained which confirmed that the project could comfortably be completed on time. The study supported the study on the relationship between contractors' planning practices and the occurrence of delays in the Nigerian construction projects. The literature indicated that a sizeable number of contractors who operated within the Nigerian construction industry did not apply any form of quantitative construction planning but rather preferred to depend on previous experience in carrying out a project. The literature review did not show a robust application of probability in project completion time assessment.

## **CHAPTER FIVE**

### **SUMMARY, CONCLUSION AND POLICY IMPLICATIONS**

#### **5.1 Introduction**

This chapter presents the summary of the findings and the conclusion thereof. It also gives the policy implications for the construction industry.

#### **5.2 Summary**

The trend in the construction and the building sector performance in terms of its contribution to the GDP of the Kenyan economy has remained low. The percentage contribution of the sector to the Kenyan's GDP has been less than 5% annually. The objective of this study was to investigate how allocation of resources could be done to capital investment projects in construction industry in order to raise the output from the sector by actualizing the plans within the budget period. A survey was done from random sample of thirty construction companies in Nairobi County. The respondents were asked to give data on a construction project through a questionnaire. The data on costs of activities involved in the project were obtained. The cost was categorized as normal and crash. The data on the activity durations were also obtained and categorized as normal and crash time. The activity durations and costs collected were averaged and then subjected into the model to obtain industrial time and cost estimates. Using the critical path model, the network diagram was drawn and the earliest and the latest completion times were obtained which helped in the identification of critical activities. The earliest and the latest completion time determined project completion time. The marginal cost for all the activities derived from the model using the data on normal and crash time and cost. The activities in the critical part were ranked in ascending order of marginal cost. Only activities on the critical path could affect the project duration and cost and so allocation of extra resources was based on additional cost to be incurred

when project duration was reduced by a unit time. It was found out that as more extra days were crashed, completion period was improving and total cost was falling. Using the critical path model, the project cost and duration were determined as Ksh.239, 961 and 17days respectively before crashing. In order to reduce the project duration, marginal cost criteria was applied in resource allocation mechanism and project duration reduced from 17days to 13 days while the total cost reduced from Ksh.239, 961 to Ksh.227, 109. The total project cost curve was drawn the turning point indentified. That was the optimal point and was identified as project duration 13 days at a total cost of ksh.227, 109. In order to find the likelihood of completing the project on day 13 after reducing the project duration by 4days, the industrial project standard deviation was derived from the model. The Z score was derived from the model and subjected to the normal distribution table in order to obtain the corresponding probability of 0.9987.

### **5.3 Conclusion**

For the capital projects in the construction industry to be completed on time and within the budget, probabilistic quantitative resource planning techniques need to be applied in resource allocation. The study revealed that stakeholders in the construction industry have been relying on budget and experiences as the only tools for planning and resource allocation. The critical path model via the marginal cost criteria were found to be viable planning technique in resource allocation to capital projects in construction industry as it assesses the certainty of project success in terms time and cost effectiveness before a project is implemented.

### **5.3 Policy Implications**

For many years, construction and the building sector performance in terms of its contribution to the GDP of the Kenyan economy has remained less than 5%. The number of building plans approved by the Local authorities for implementation has remained high but the number of plans



actualised in a year continued to be less than 35%. The inputs for construction industrial have been rising consistently.

In order to ensure that project in the construction industry are completed with certainty with respect to time and cost, the players construction industry should apply critical path model in allocating resources in effort to anticipate the completion time and project cost. In order to enhance project completion period as well cost control, critical path model via the marginal cost criteria in project resource allocation as well as the likelihood of project success are applied.

The study found out that the current planning tools in the construction industry have not been making the anticipated outcome thus frequent budgetary overruns. Instead of construction companies building budgetary slack to act as a safety net in case of budgetary overruns, the study found out that the model is able to predict the cost, time and the certainty of achieving the target with precision. This means that the players in the construction industrial will have more control in the project budget and time to complete the project.

#### **5.4 Areas for Further Research**

The study was based on allocation of resources to capital investment projects with case of selected companies in the construction industry. The objectives of the study were met but the study cannot be said to answer all the aspects as to why many construction projects are not completed on time and within the budget thus experiencing cost overruns. Due to unforeseen limitations of the study through unrepresentative sample, bias selection of the region covered and data obtained not being reliable, feasible conclusion would have not been obtained.

Further research need to be done on the contribution occasioned by all the other factors which were ignored by the study but could affect the completion time and cost of a project. Some of

these factors are: not receiving construction materials on time, fluctuations of currency, inflation, sample not being representative, data not being reliable and data for the study may have been collected in the way not suitable for the research.

## REFERENCES

- Ariel, H., Giora, H. (2005), "Project valuation with varying cash-flows: A Bayesian approach", *Journal of Engineering Economist*, Vol. 50 pp.337 – 359.
- Au, T., Au, P. (1991). *Engineering Economics for capital investment analysis*, 2<sup>nd</sup> edition, New Jersey, Prentice Hall.
- Axel, P., Denis, B. (2004), "Breakdown a long –run marginal cost of a Linear Programming model into a marginal operating cost and marginal equivalent cost", *Journal of Engineering Economist*, Vol. 49 No.4, and pp.307.
- Bhatia, H.L (2003). *Public finance*. 24<sup>th</sup> Ed. New Delhi, Vikas publishing house PVT ltd.
- Bierman, H., Smidt, S. (1984). *The capital budgeting decision: The economic analysis of investment projects*. 5<sup>th</sup> Edition, New York, Macmillan.
- Bradley, J.B., Jeremy, R.T. (2007). *Program Evaluation and Review Technique and Critical Path Method*. 2<sup>nd</sup> Edition, Iowa, CRC Press.
- Carlo, A. (2011), "Aggregate return on investment and investment decisions: A cash flow Perspective", *Journal of engineering economics*, Vol.56 No. 4 pp140-169.
- Caroline, L., Frances, J. (1996). *Principles of cost-benefit analysis for developing countries*. Great Britain, Cambridge University press.
- Carruthers, J.A., Battersby, A. (1966). "Advances in Critical Path Methods", *Operation Research*, Vol.17, No.4 pp359-380.
- Cigdem, Z. (2009), "Mid – cycle capital planning optimization", *Journal of Engineering Economist*, Vol. 54 No.2, pp.250-265.
- David, A. (1988). *Foundations in public economics*. New York, Cambridge university press.
- David, G., Maria, C. (2008), "Probabilistic discounted cash flows analysis and capital budgeting

- and investment”, *Journal of Engineering Economist*, Vol. 53 No.1, pp.84 – 102.
- Edward, M. (2001), “The cut off benefit cost ratio should exceed one”, *Journal of Engineering Economist*, Vol. 46 No. 4 pp.312 – 319.
- Giuseppe, A. (2006), “Payback period and Internal Rate of Return in real options analysis”, *Journal of Engineering Economist*, Vol. 51 No.2, pp.237 – 257.
- Graeme, L. (2010), “Managing construction projects”, *Journal of Construction Management and Economics*, Vol. 28 No.10, pp1115- 1116.
- Hodgson, T., Breban, S. (2000), “The concept of investment efficiency and its application to investment management structures”, *British actuarial journal*, Vol. 6 No.1 pp.451- 545.
- Hong, Z. (2010), “Multi-objective particle swarm optimization for construction time- cost trade-off problems”, *Journal of Construction Management and Economics*, Vol. 28 No.1, pp75-88.
- Huseyin, S., Gokce, P. (2010). “Probability distribution function of the Internal Rate of Return for short –term projects with random cash flows and extensions”, *Journal of Engineering Economics*, Vol.55 No.5 pp350-378.
- John, L. (2003). *A course in public economics*. Ontario, Cambridge university press.
- Josef, B. (2010), “Integrating model of the financial analysis methods of investment projects”, *Journal of Engineering Economist*, Vol. 55 No.1, pp.60– 70.
- Judith, M., Brian, D. (2003), “Calculating developer charges for urban infrastructure. A feasible method for applying marginal cost pricing”, *Journal of Engineering Economist*, Vol. 48 No. 6 pp.218 – 240.
- Kampe, R., (2012), “Urbanisation in Kenya”, *African journal of economic and sustainable development*, Vol. 1 No.2 pp.4 -26.
- Khalied, H. (2009), “Automated trade –off between time and cost in planning repetitive

- construction projects”, *Journal of Construction Management and Economics*, Vol. 27 No.8, pp749-761.
- Lewin, G., Carne, S. (1995), “Capital projects”, *British actuarial journal*, Vol. 3 No. 2 pp155-249.
- Michael, G., Trefor, P. (2001), “Using bidding statistics to predict completed construction cost”, *Journal of Engineering Economist*, Vol. 46 No.5 pp.114 – 128.
- Ronald, E., Shrivies, J. (2001), “Free cash flow, economic value added and net present value. A reconciliation of variations of discounted cash flow valuation”, *Journal of Engineering Economist*, Vol. 51 No. 8 pp.33 – 52.
- Michael, P.T (1986).*Economics for a developing world*. 2<sup>nd</sup> Ed. Harlow Essex, Longman Group ltd.
- Onder, O., Ahmet, O. (2010). "Construction cost analysis under uncertainty with correlated cost risk analysis model." *Construction management and economics*, Vol.28 No.2 pp.203-212.
- Paul, R., Alisha, D., Sampson, E. (2009), “Considering risk within net present value calculations for government projects’”, *Journal of Engineering Economist*, Vol. 54 No.2, pp.152 – 174.
- Ravipim, C., Alice, E. (2003), “Economic valuation of capital projects using neural network Models”, *Journal of Engineering Economist*, Vol. 48 No.4 pp.1 – 30.
- Raymond, Y., Sivaguru, G. (1997). "Causal relationship between construction flows and GDP." *Construction management and economics*, Vol. 15. No.4 pp371-376.
- Republic of Kenya. (1989). *Development plan*. Nairobi, Government Printers.
- Republic of Kenya. (1995). *Economic survey*. Nairobi, Government printers
- Republic of Kenya. (2004). *Economic survey*. Nairobi, Government printer.

- Republic of Kenya. (2007). *Economic survey*. Nairobi, Government printers.
- Ronald, D., Richard, V. (2010), "Project balances or division coefficients and implications of rate of return analysis", *Journal of Engineering Economist*, Vol. 55 No.1, pp.38 – 51.
- Scott, S. (1993), "The nature and effects of construction delays", *Journal Construction Management and Economics*, Vol. 11 No.5, pp.358-369.
- Soulaymane, K., Jerome, L. (2005), "A robust optimization approach to capital rationing and capital budgeting ", *Journal of Engineering Economist*, Vol. 51 No.2, pp.195 – 229.
- Tabish, S., Kumar, N. (2011), "Identification and Evaluation of Success Factors for Public Construction Projects", *Journal of Construction Management and Economics*, Vol.29, No.8 pp 809-823.
- Udayangani, K. (2009), "Critical success factors of construction measures and Development", *Journal of Construction Management and Economics*, Vol. 27 No.9, pp 891-900.
- Willie, T. (2011), "Project finance in construction: a structured guide to Assessment", *Journal of Construction Management and Economics*, Vol.29 No.10, pp1074- 1075.

## APPENDICES