FACTORS IMPACTING DELIVERY RELIABILITY OF KENYAN CONSTRUCTION INDUSTRY: A SURVEY OF ROAD PROJECTS AND PROJECT MANAGERS' PERCEPTIONS

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DECLARATION

This management research project is my own original work and has not been presented for award of a degree in this or any other university.

Signed .... Date 09/11/2007

Karani Cyrus Muchiri (D61/P/8978/01)

This management research project has been submitted for examination with my approval as the university supervisor

Signed .... Date 12/11/2007

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DEDICATION

This Research Project is dedicated to my Lord and the source of all knowledge and wisdom – Jesus Christ – before whom every knee shall bow and every tongue confess that he is the LORD (Isaiah 45:22-23; Philippians 2:9-11). He has purposed to turn the University of Nairobi into "the CEOs' drawing board", and he is already doing it. To him be honour and glory now and forever. Amen.

ACKNOWLEDGEMENT

Rarely is any meaningful output delivered by one man alone. This research project is no exception.

First and foremost, I express my sincere gratitude to my supervisor Mr Onserio Nyamwange for his steadfast contribution in giving me pertinent guidance on some research aspects and for bearing with me to the very end.

I am also grateful to my fellow engineers in the road construction sub-sector. In particular, I recognise the invaluable inputs of Mr Julius Gakubia and Margaret Ogae of Kenya Roads Board, Mr Joseph Kirumba of Uniconsult (K) Limited, Mr Joshua Maitho of Ministry of Local Government, Mr John Ogango of the Ministry of Roads and Public Works, and Mr John Ndemi of Norken (K) Limited. In addition there are other respondents who cannot be enumerated in this short section. Without them, my research effort would not have borne any tangible fruit.

A special word of my blessings goes to my dear wife Susan for her understanding and encouragement when at some point in my academic work I felt it almost unbearable and the option of throwing in the towel was not too distant. It is always helpful to have someone who has endured a similar crucible.

To all those who played a part in the realisation of this research, I can only pray "May God our Father, through the Lord Jesus Christ, give you everything you need for abundant life in him."

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ABSTRACT

This study attempted to investigate project delivery reliability from Kenyan road rehabilitation context under two objectives: establish the main factors that lead to delays in road rehabilitation projects; and determine the predictability of project delivery time using Bromilow's time-cost model. The study used a self-administered questionnaire that sought both primary and secondary data from respondents.

From the research, the critical factors contributing to project delivery delays were found to include underestimation of project duration, contractor's and client's cash flow or budgetary problems, delayed payment to contractor, inadequate supervision of works, and increase in scope of works.

Moreover, the study established that the duration of Kenyan road rehabilitation projects can be modelled using Bromilow's time-cost formula in the form $T = KC^B$, where T is the duration in days, C is the contract cost in millions, K is a constant characteristic of rehabilitation time performance, and B is a constant indicative of the sensitivity of time performance to cost level or project size. Regression analysis was used to compute the values of K and B. The coefficient of determination (R^2) was used to establish how well the model actually fits the data.

The conclusion from the study is that the estimation of road projects duration in Kenya is far below the actual duration taken to complete them. This suggests pervasive project time overruns in the economy's infrastructure projects, an operational conundrum beckoning for serious leadership, professional and managerial intervention.

CHAPTER ONE: INTRODUCTION

1.0 Background to the Study

Construction sector plays an important role in the economy since it produces and maintains the built environment comprising infrastructure, commercial and industrial buildings, and housing. Its importance is based on the type of output it creates, the span of industries it covers and the number of people it involves. The output of construction industry can be seen as a series of investments since decisions to invest are taken with a view to receiving benefits for many years in future (Gruneberg, 1997).

Providing infrastructure for the economy as a whole may or may not be profitable of itself, but it enables the improvement of economic welfare of society at large. World Bank (1994) views economic infrastructure as the long-lived engineered structures, equipment and facilities used in economic production and by households. The economic infrastructure includes, among others, public utilities such as power, telecommunications, piped water supply, sanitation and sewerage, solid waste collection and disposal; and transport infrastructure such as roads, railways, airports, seaports and waterways.

1.0.1 Transport Infrastructure in Kenya

An efficient and well-distributed transport system is important to an economy. Development of transport infrastructure is an important pre-requisite in creating and supporting business environment that facilitates investment, development of markets for goods and services, national economic growth and integration of various production and population centres, and job creation (Government of Kenya, 2006).

Kenya's transport system comprises five major modes, namely, roads, air, water (marine), railway, and pipeline (Government of Kenya, 2002). The value of Gross Domestic Product contribution to the economy at market prices by the entire transport sector (including communications) varied between 9.1% during 2001 and 10.9% during 2005 (Government of Kenya, 2006). Of this output, roads contributed 48.4% during 2001 and 47.3% during 2005, while air transport and water transport contributed 18.8% and 5.2% respectively during 2005. Railway and pipeline output to the economy was 1.4% and 2.4% in 2005. The rest came from services incidental to transport and communications.

1.1 Financing and Management Structure of Kenyan Road Network

Development of the road network stimulates remarkable growth of the road transport industry, both in freight and passenger carrying capacity (Government of Kenya, 1998). The management of road transport sub-sector in Kenya involves a number of government agencies. The Ministry of Roads and Public Works is responsible for inter-urban road rehabilitation, construction and maintenance; Ministry of Transport implements social aspects affecting transport as well as highway regulation and licensing; Ministry of Local Government and its different municipalities oversee urban roads; Kenya Wildlife Service Manages roads in national parks and reserves; and Kenya Roads Board oversees, co-ordinates and monitors the implementation of road maintenance programs through its designated road agencies.

The economy has a total road network of about 63,000 kilometres of classified road system and about 87, 600 kilometres of unclassified road system (Government of Kenya, 2002). The classified road system under the Ministry of Roads and Public Works comprises about 8937 kilometres of bitumen roads and about 54, 353 kilometres of gravel and earth roads in various riding surface conditions ranging from good to poor or dilapidated (Government of Kenya, 2006). In general, a classified road is that road which has been given a unique identification number and function and is managed by the Ministry of Roads and Public Works, and includes trunk roads, primary roads, secondary roads and rural access roads. The unclassified roads' do not have identification numbers and hence their management does not fall under the Ministry of Roads and Public Works.

The primary factors contributing to the deterioration of road network are inadequate funding and lack of co-ordination of road network development and maintenance (Government of Kenya, 2002). The poor state of the road infrastructure precipitates high vehicle operating costs, high fares charged for public transport, unstable delivery schedules, low productivity, non-competitive exports all of which constrain economic growth and development. Little wonder that to maintain a national average Gross Domestic Product growth rate of 10% per annum over the next 25 years, the Kenya Vision 2030 recognises the critical problems of infrastructure and high energy costs that need to addressed (Government of Kenya, 2007).

Table 1.1: Total Expenditure on Roads (KShs Million)

	2001/2002	2002/2003	2003/2004	2004/2005	2005/2006
Development (A)					
Trunk roads	1385.00	1459.50	2406.00	5946.50	8400.00
Primary roads	601.40	808.34	1260.50	3059.00	3600.00
Secondary roads	635.80	345.80	320.68	333.00	360.40
Miscellaneous roads	-	-	353.51	378.00	375.20
Sub-total (A)	2622.20	2613.64	4340.69	9716.58	12735.50
Recurrent (maintenance and repair)	8042.44	6005.17	6122	6100.00	6500.00
Total	**10,664.64**	**8,618.81**	**10462.69**	**15,816.50**	**19,235.50**

Source: Government of Kenya (2006), *Economic Survey 2006*, p. 187

Kenya Roads Board disbursed to road agencies KShs 8.4 billion in year 2003/2004 and KShs 9.6 billion. Data on recurrent and development expenditure on roads for the financial years 2001/2002 to 2005/2006 is represented in Table 1.1. If all the economy's roads were to be included in the national end-of-year financial statements as non-current assets, their current net worth considering the above investment expenditures would perhaps range between KShs 450 and KShs 550 billion. These valuable capital assets require good management to keep them in working condition in order to continue bringing in current and future streams of benefits to the national economy.

Since they are public capital goods, roads and their rehabilitation are not supplied by private firms functioning in a market environment - they are typically planned and financed by government agencies or public sector operating in a framework not strongly conditioned by economic considerations but through induced decision making (Ingram and Liu, 1999).

1.2 Overview of Construction Products Delivery

Delivery reliability is the ability to deliver products according to promised schedule, notwithstanding whether the firm may be competing on the least costly or the highest quality product (Makori, 2002). Patil and Lawrence (2003) consider that delivery reliability measures the performance of actual lead times with respect to the quoted lead times, in addition to defining delivery speed as a comparison of the expected lead time by the customer and the lead time quoted by the manufacturer. In a scheduling context for order fulfilment, Barman and Lafarge (1998) have demonstrated that delivery speed and delivery reliability, and hence customer satisfaction, are functions of due date quotation and dispatching policies.

The delivery of construction products through projects has become an issue of debate and concern, more so owing to contract time overrun which is a common problem in construction industry. The importance of completion time in construction may be viewed as two-pronged: construction projects are capital goods required for use by others; and clients desire to pay back the investment outlays and start realising income from their investment in construction. The highly fragmented nature of the construction industry has been acknowledged as a major cause of performance related problems facing the industry such as low productivity, cost and time overrun, conflicts and disputes resulting in claims and time consuming litigation (Egan, 1998). The legacy of this high level of fragmentation is that the project delivery process is considered highly inefficient in comparison with other industry sectors with fragmentation precipitating the following: fragmentation of design, fabrication and construction data not being readily used downstream; poor communication of design intent and rationale which leads to unwarranted design changes, inadequate design specifications, unnecessary liability claims and increase in project time and cost; and lack of integration, co-ordination and collaboration between various functional disciplines involved in the life cycle aspects of the project (Hampson *et al*, 2000).

The time dimension in the construction sector is all about how long the customers have to wait before receiving their product. Gitonga (2005) rightly observes that performance of a contractor in relation to time is indicated by completion period, start on site predictability, regular submission of payment invoices or statements, and claims for extension of time.

The delivery process in the sector consists of different types of specialist firms and professionals in different disciplines working together in a temporary organisation to deliver buildings and civil engineering projects (Egan, 1998). Gitonga (2005) describes the construction sector as a cocktail of business activities that includes both manufacturing and service delivery of made-to-order outputs

In their study of Australian construction industry Tucker *et al* (2001) propose that any attempt to improve the construction industry from a supply chain management approach ought to seriously concern itself with the following clusters of source uncertainties in the industry's projects:

(i.) Design: This includes selecting and developing appropriate design that meets client's requirements and communicating the final design to the main contractor (quality and completeness of technical drawings and specifications);

(ii.) Project delivery: this includes contractor selection and contractual arrangements be it competitive tendering, partnering, alliancing, incentives, time/cost penalties, etc; and

(iii.) Construction: This includes selection and relationship with subcontractors and suppliers, scheduling, site-activity co-ordination, and resource, materials and logistics management.

In their research, Kagioglou *et al* (1998) found that 85% of common performance-related problems of the construction sector are process-related, and not product related. Customer-supplier relationships are generally of the arms-length type rather than being partnerships, with competitive tendering only assuring that the contract is procured to the lowest price supplier with little or no guarantee (or even incentive) to future work (Tucker *et al*, 2001).

The industry consists of numerous parties each of which has a role to play in delivering the construction output. The performance of one party will affect the next party in the different phases of construction project which, according to Schultzel and Unruh (1996), include: feasibility, development, finance, concept development and review, estimate, detailed engineering, construction and commissioning. The client (owner or employer), consultants, contractors and subcontractors of a construction project all have a role to play in delivering a project. This is akin to a series of customer and supplier relations. The owner perceives a need to invest in a project to meet the needs of the public or the market. The owner employs consultants such as architects and engineers to design the project. A general or main contractor is then selected to construct the project according to the design. The general contractor will employ his own sub-contractors or those nominated by the client. Suppliers will deliver required materials to be fixed, installed or used in the project. The contractor, architect, engineer, among others, have profit as their goal, and the owner has the goal of minimum costs. Goals tend to conflict as different parties have different priorities.

Unlike in manufacturing industries, most products of construction cannot be standardised and are therefore one-off products, making the production processes in the construction industry to be different for each project, with excessive changes to the design of a project typical throughout the construction process (Wong and Fung, 1999).

1.3 Project as Process of Choice

A project is an activity for which money is spent in expectation of returns and which logically seems to lend itself to planning, financing and implementing as a unit (Gittinger, 1982). Projects include large-scale, one-time, unique products such as civil-engineering construction contracts, aerospace programs, among others. They are customer-specific and often too large to be moved, which practically dictates that project is the process of choice (Byron, 2006).

A process is a series of connected steps or actions with a beginning and an end that can be replicated, and involves the steps by which inputs such as people, materials, methods, machines, and environment are transformed into outputs (products and services). Howard and Fingar (2003) consider that the most successful organizations are managed from a horizontal (process) perspective, as well as from a vertical (function) perspective. This means that organisations may be viewed as a set or hierarchy of processes that produce outputs of value to a customer, as well as a set of functions such as engineering, manufacturing, accounting, and marketing. This research concentrates on the horizontal (process) perspective and adopts the business process framework developed by Brown (1996).

1.4 Statement of the Research Problem

Construction industry is often criticized for its poor performance on quality, cost, safety and speed with disputes and confrontational relationships being its defining characteristics (Kanji and Wong, 1998). Success of any construction output, like any other product, may be judged in terms of four main performance indicators: time, quality, cost and safety.

Findings from Saburi (2003) show that the general performance of the Kenyan construction industry is dissatisfying; with clients objectives of cost and time not realised by 83% and 87% respectively of the projects in the study.

Research findings by Garashie (1999) show that on average 62.5% of the water projects studied in Kenya escalated in time by more than 50% of their initial time estimates while 12.5% had their time overrun by 100%. Elton and Roe (1998) argue that many of the delays in individual projects arise from problems at the senior management level rather than from mistakes made by project managers on the site. From the above findings, it is apparent that construction projects are susceptible to cost and time overruns, with variations from planned schedules and cost estimates obviously impacting owners and contractors adversely.

Time and cost are usually critical to construction clients. Given the many contributory factors, quantitative models of time and cost may help clients to predict project outcomes at the outset, and also at different stages of the project life span (Dissanayaka and Kumaraswamy, 1999). Australian building construction has been modelled in several studies over three decades using Bromilow's time-cost formula (Ng et al, 2001). The model has been found to have good but varied forecasting abilities mainly for the developed economies such as the US, Hong Kong, Australia and the UK. In Nigeria, a developing economy, the model was found unsuitable and an alternative one developed (Ogunsemi and Jagboro, 2006). The authors claim that the reason for the model's failure was the common characteristics of the inordinate stoppages of work over extended periods owing to the client's cash flow problems and which ultimately was compounded by cost escalation of the construction inputs.

This study adapted and sought to test the ability of Bromilow's model to forecast delivery reliability in infrastructure provision, specifically road projects in Kenya. The hypothesis was that if the time-cost relationship holds true in Australian building projects, it would also holds true for the Kenyan construction industry and the road projects. The research also sought to establish the various factors responsible for delays in the sector. The research therefore addressed the following research questions:

(a) What are the factors that lead to delays in road construction projects in Kenya?

(b) Is it possible to predict whether a road construction project will be delivered on time?

1.5 Research Objectives

The study sought to:

a) Establish the main factors that lead to project delays in Kenyan road construction.

b) Determine the predictability of delivery time of road construction projects.

1.6 Importance of the Research

1.6.1 Criticality of Public Capital Goods to National Economy

The construction industry is an important sector of the economy, not least the development of economic infrastructure. World Bank (1994) estimates that developing countries invest $200 billion a year in new infrastructure, which amounts to 4% of their national output, and a fifth of their total investment. Better management of the provision of this crucial aspect of fixed capital to which the study contributes would result in savings and other multiplier benefits to an economy. Mutunga (2005) observes that the biggest proportion of our constructed project in the developing world is still being promoted by the public sector. Word Bank (1994) commends the use of contracting instruments for better monitoring and performance of operations during infrastructure development. Road transport infrastructure is indeed a critical national asset, the provision of which is the responsibility of the government.

Moreover, institutional reforms the government is currently undertaking in roads sub-sector calls for objective data to inform them and it is hoped that this study contributes to this end.

1.6.2 Forecasting by Project Managers and Estimators

Scholars have often been accused of hiding away in ivory towers. This research delves into the critical project factors of cost and time with a view to enhancing schedule estimation and forecasting, including operations improvement in the planning and delivery of road construction projects. Timely completion of projects could avoid substantial burden of cost escalation. Focussing on critical success factors in construction would help project managers a great deal. Indeed, many business undertakings do run on projects (Mutunga, 2005).

1.6.3 Contribution to Scholarship

By undertaking this research, the pervasiveness of project management concepts of time, cost and others made more apparent in the context of construction industry. It is the hope of the researcher that the study also contributes to the academic body of project management knowledge in its own right.

CHAPTER TWO: LITERATURE REVIEW

2.0 General Outline

The chapter comprises four sections. The first covers the findings on the myriad of factors contributing to construction project delays within Kenya and without. The second section attempts to place the delay factors in the business process framework by Brown (1996). The third section delves into the empirical research findings relating to Bromilow's time-cost model, including examining the common procurement processes for construction projects. The final section highlights the uniqueness of outputs from construction projects in comparison with durable goods from manufacturing sector.

2.1 Factors Contributing to Delays in Construction Projects

Construction industry is often criticised for its poor performance on quality, cost, safety and speed with disputes and confrontational relationships being its defining characteristics (Kanji and Wong, 1998).

Industry researchers and practitioners acknowledge that there are many wasteful activities during design and construction, the majority of which consume time and effort without adding value for the client (Dissanayaka and Kumaraswamy, 1999). Waste can include mistakes, working out of sequence, redundant activity and movement, delayed and premature inputs and products that that do not meet customer needs (Lo *et al*, 2006). In his study on the application of lean production techniques, Githiri (2004) found that concepts such as waste and value are not well understood by construction personnel, with waste not only being associated with materials in the construction process but also with other activities such as repair, waiting time and delays.

In their study of construction projects in Saudi Arabia, Al-Khalil and Al-Ghafly (1999) found that delays in project completion are a major problem leading to costly disputes and acrimonious relationships between the parties involved. In Nigeria, project delays were identified as the principal factors leading to the high cost of construction (Okpala and Aniekwu, 1988).

A factor analysis of 55 attributes impacting schedule performance in Indian construction projects revealed two critical success factors namely, commitment of project participant and owner's competence and one failure factor, namely conflict among project participants (Iyer and Jha, 2006). In their study of Sri Lankan construction industry Jayawardane and Gunawardena (1998) found out that the workforce consisted of 51% unskilled workers, with variables such as waiting time, idle time and travelling time affecting time performance of projects

A study conducted in Indonesia by Alwi *et al* (2001) concludes that construction supervision is one of the crucial elements in the construction projects. Further, a study of material management in Malaysia identified the critical problems such as delay in the delivery of materials, lack of planning and material variances (Abdul-Rahman and Alidrisyi, 1994).

In a study of project managers working on high-rise construction projects in two Indonesian cities of Jakarta and Yogyakarta, Kaming *et al* (1997) found out that the variables impacting construction time and cost overruns in order of their perceived importance and frequency of occurrence included inflation issues, materials cost, inaccurate materials estimating and project complexity.

Alwi *et al* (2003) further investigated the incidence of waste within Indonesian construction companies involved in non-residential building and infrastructure projects and found the key variables of waste including waiting for materials, delays to schedule, slow tradesmen, waste of raw materials on site and lack of supervision. In addition, design changes, slowness in making decisions, lack of trades' skill, inappropriate construction methods, poor co-ordination among project participants, delay of material delivery to site and poor planning and scheduling were identified as the key variables causing waste.

In his study of Kenyan power projects, Kagiri (2005) found the following factors critical in contributing to time and cost overruns: government bureaucracy, works definition, resource planning, contractors inabilities, supervision of works, improper project preparation and risk allocation.

Findings from Saburi (2003) show that the general performance of the Kenyan construction industry is equally poor in achieving client objectives, with clients objectives of cost and time not realised by 83% and 87% respectively of the projects in the study, with some of the projects stalling or being abandoned altogether.

Research findings by Garashie (1999) show that on average 62.5% of the water projects studied in Kenya escalated in time by more than 50% of their initial time estimates while 12.5% had their time overrun by 100%. Elton and Roe (1998) argue that many of the delays in individual projects arise from problems at the senior management level rather than from mistakes made by project managers on the site. Furthermore, Garashie (1999) found that the most critical factors contributing to project delays are as follows: quality of project management, operating environment, motivation of workers, infrastructure, inadequate resources, and organisation of project teams.

Mutulili (2005) demonstrates in his study that there exists a strong relationship between community participation and project success. This means that there is added benefit if government provision and management of infrastructure is done in collaboration with communities - from initiation through project design and formulation up to construction and operation stages.

Talukhaba (1988) studied time and cost overruns of construction projects in Kenya and his results showed that time performance was the poorest, whereby about 70% of the projects initiated had a chance of overruning in time with a magnitude of 53.3% compared to the possibility that about 53.7% will overrun in cost by about 20.7%.

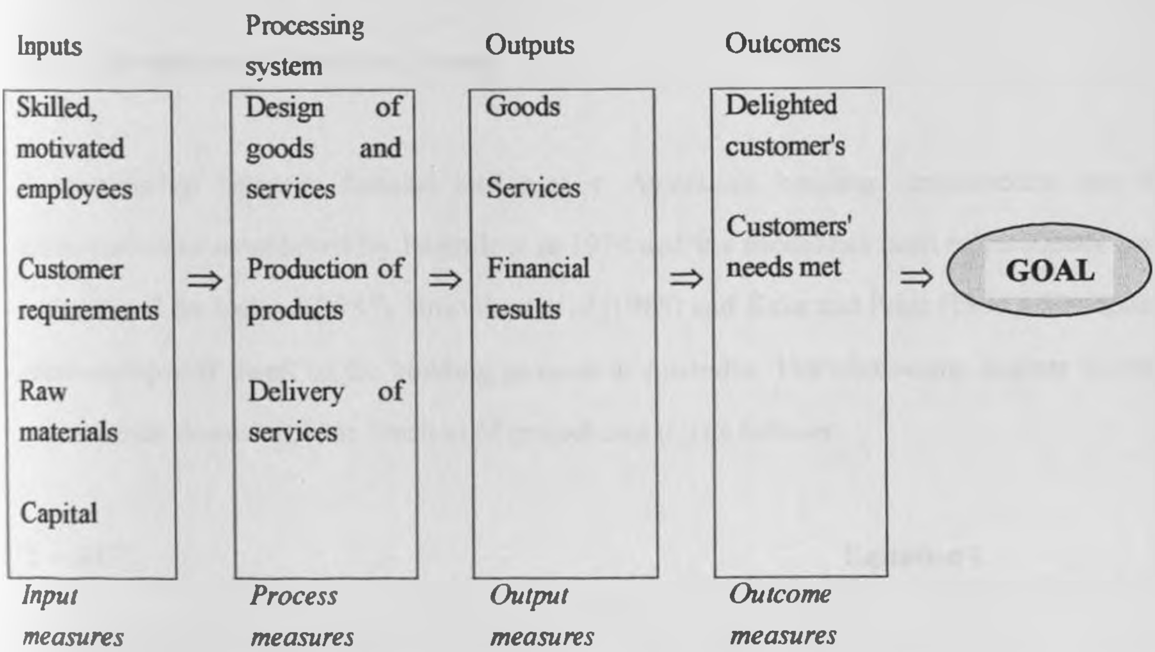
2.2 A project as viewed from Brown's business process framework

The construction industry is a cocktail of business activities that include both manufacturing and service delivery of made-to-order outputs (Gitonga, 2005). The construction process transforms and produces tangible goods in a production line - a systematic process of goods and service creation just like manufacturing. For example, to produce the capital goods, the industry requires management-cum-entrepreneurship to integrate professional skills (architects, engineers, quantity surveyors, foremen, skilled and unskilled labour); plant and equipment; financial capital; raw and processed materials; and information.

Generally, the success of any construction project can be evaluated within the traditional constraints of time, cost and quality parameters. This perception is refined by Smith *et al* (1998) and Cooke-Davies (2002) who noted that the dimensions of project success refer to efficiency and effective measures where efficiency measures correspond to strong management and internal organisational structures which means getting the project out on time, on budget and meeting a quality threshold. On the hand, the effective measures refer to the achievement of objectives, users' satisfaction and the use of the project.

A notable process framework from which to view any construction project and conceptualise the factors impacting delivery dependability is the one proposed by Brown (1996). Brown's framework as shown in the Figure 2.1 below is conceptually useful because it highlights the difference between input, process, output and outcome measures. To clarify the framework, Brown uses the analogy of baking a cake. Input measures would be concerned with the volume of flour, quality of eggs, among others. Process measures would include oven temperature and length of baking time. Output measures would focus on the quality of cake, while outcome measures would be concerned with satisfaction of the cake eaters, whether the cake was really enjoyable.

Figure 2.1: Brown's Business Process Performance Measurement Framework



Source: Brown, M.G (1996), *Keeping Score: Using Right Metrics to Drive World-Class Performance*, New York, Quality Press, p26.

From the foregoing, measuring the efficiency performance of a project means measuring the efficiency of the processes in terms of planning, management and use of resources which relates to the project outputs. Effectiveness performance measures the project 'results' in terms of accomplishing the core project objectives, users' satisfaction and the use of project which relates to project outcomes.

2.3 Project Duration and Cost Relationship

The success of any construction project, like any other industry, may be judged in terms of four main performance indicators: time, quality, cost and safety. Time and cost are usually critical to construction clients and given the many contributory factors, models of time and cost may help clients predict project outcomes at the outset and also at different stages of the project life span (Dissanayaka and Kumaraswamy, 1999).

2.3.1 Bromilow's Time-Cost Model

A relationship between duration and cost in Australia's buildings construction was first mathematically established by Bromilow in 1974 and the model has been subsequently tested and updated by Ireland (1985), Bromilow *et al* (1988) and Kaka and Price (1991). The updated relationship still dwelt on the building projects in Australia. The relationship depicts the mean construction duration (T) as function of project cost (C) as follows:

$$T = KC^B \qquad \textbf{Equation 1}$$

Where T = Duration of construction period in working days from the date of possession of site (or start of construction) to substantial (or practical) completion.

C = Completed cost of project (to client/owner) in millions of Kenya shillings, adjusted to constant labour and material prices

K = A constant characteristic of building time performance, and indicates the general level of time performance per million Kenya shillings, and

B = A constant describing sensitivity of time performance to project cost (or size of the construction project)

The two constants K and B are empirically determined by using statistic verification after linearising the above equation using logarithms as follows:

$$\ln T = \ln K + B \ln C \qquad \textbf{Equation 2}$$

Equation 2 above is in the form y = a + bx and from which K and B can be determined through linear regression of the transformed data. In this research, the proposed hypothesis is that an increase in $\log_e T$ is associated with an increase in $\log_e C$. If this hypothesis is true, then it logically follows that the time-cost relationship is also true for the Kenyan road construction projects.

2.3.2 The Predictive Ability of Bromilow's Time-Cost Model

Based on the prediction done by Bromilow, several studies have been performed to make similar predictions for either specific sector of construction or construction industries in general around the world

Ireland (1985) conducted a research to predict the construction duration of high rise commercial projects in Australia. The results gave the relationship for duration and cost with R^2 value of 0.576 and a significance level of 0.001. Kaka and Price (1991) studied relationship between value and duration of construction projects in the UK and also contribute to the similar empirical relationship. Kumaraswamy and Chan (1995) examined the relationship between the duration and cost for the Hong Kong building and civil engineering projects, and report that standardisation in public housing projects leads to more consistency in durations of projects.

Yeong (1994) reported similar study for Australian and Malaysian building construction projects. The study includes 67 Australian government projects, 20 Australian private projects and 51 Malaysian government projects. Chan (1999) did a similar study on public and private projects in Hong Kong and found that the Hong Kong private sector takes a shorter time (120 days) to complete a hypothesised project with a contract sum of HK$1 million (at December 2004 price that its government counterpart (166 days). Chan (2001) conducted a study on public sector projects in Malaysia and produced the best predictor of average construction time of $T = 269C^{0.32}$. Choudhury and Rajan (2003) indicate there is a relationship between duration and cost for the residential construction projects in Texas.

Ng et al (2001) applied the model for Australian construction projects completed between 1991 and 1998 and compared the results with the previous relationships and concluded that there is a clear improvement in construction speed over the period.

Ogunsemi and Jagboro (2006) found out that for the Nigerian situation, Bromilow's time-cost model had poor predictive abilities ($R^2 = 0.205$, $R = 0.453$). An improved model using piecewise model with good predictive abilities ($R^2 = 0.765$, $R = 0.875$) was found to be $T = 118.563 - 0.401\ C$ (where $C<408$) or $T = 603.427 + 0.610C$ (where $C>408$).

From their research that captured contract and actual cost and time, and included infrastructure projects in Malaysia, Endut *et al* (2006) conclude that not all the project parameters considered fitted the Bromilow's time-cost model and that the duration and cost relationships are almost insignificant for the different project costs. The results from the above studies are summarised in the Table 2.1 below.

Table 2.1: Summary of Findings on Bromilow's Time-Cost Model

Authors	Year	Country	Type of Project	Cost and Time model
Ireland	1985	Australia	High Rise Building Project (25)	$T = 219C^{0.47}$
Kaka and Price	1991	United Kingdom	Public Building	$T = 399C^{0.318}$
			Private building	$T = 274C^{0.212}$
			Civil Engineering (Tendered)	$T = 258C^{0.469}$
			Civil Engineering (Actual)	$T = 245C^{0.432}$
Yeong	1994	Australia And Malaysia	All projects	$T = 269C^{0.215}$
			Public housing projects (67)	$T = 287C^{0.237}$
			Public building projects (20)	$T = 161C^{0.367}$
			Public projects (51)	$T = 518C^{0.352}$
Kumaraswamy and Chan	1995	Hong Kong	Total public building projects	$T = 182.3C^{0.277}$
			Public housing projects	$T = 188.8C^{0.262}$
			Public building projects	$T = 166.4C^{0.294}$
			Total private building projects	$T = 202.6C^{0.233}$
			Private commercial projects	$T = 232.7C^{0.187}$
			Private housing project	$T = 160.2C^{0.306}$
			Civil projects	$T = 252.5C^{0.213}$
Chan	1999	Hong Kong	Building projects (110)	$T = 152C^{0.29}$
			Public projects	$T = 166C^{0.28}$
			Private projects	$T = 120C^{0.34}$
Chan	2001	Malaysia	Building projects	$T = 269C^{0.32}$
Ng et al.	2001	Australia	Overall building projects	$T = 131C^{0.31}$
			Public building projects	$T = 129C^{0.32}$
			Private building projects	$T = 132C^{0.30}$
Choudhury and Rajan	2003	Texas, US	Residential projects	$T = 18.98C^{0.39}$
Ogunsemi and Jagboro	2006	Nigeria	Building projects	$T = 63C^{0.262}$
Endut et al	2006	Malaysia	All building project (contract)	$T = 210C^{0.178}$
			All building project (actual)	$T = 303C^{0.262}$
			Public project (contract)	$T = 223C^{0.268}$
			Public project (actual)	$T = 328C^{0.246}$
			Private Project (contract)	$T = 146C^{0.249}$
			Private Project (actual)	$T = 199C^{0.228}$
			Infrastructure project (contract)	$T = 276C^{0.238}$
			Infrastructure project (actual)	$T = 375C^{0.229}$

Source: Author's compilation (2006)

The duration and cost relationship shown in the table above indicate that the values of K and B are very different for different type of projects and different contracts. Where the types of projects are the same, for example public projects, the K and B values are still very different. This implies that the relationship between project duration and cost may not be stable as one would expect and as the recent analysis of the Malaysian projects show, there is no evidence to show that all project parameters considered follow the Bromilow's time-cost model. The larger the value of R^2 (coefficient of determination) the better the indication of how well the equation resulting from the regression analysis explains the relationship among the variables.

2.3.3 Procurement Process and Time-Cost Relationship in Projects

Gruneberg (1997) observes that there are two types of tendering process: open tendering; and selective tendering. In open tendering any number of contracting firms can apply to bid for the work. In selective tendering, the client prepares a shortlist of applicants, usually about six firms. This increases the chance of any one bidder being successful. In open tendering, however, the chance of success are reduced because of the number of competing firms.

Typically, a client may achieve his objectives in the following ways:

(i) Buying a ready-made building or structure;

(ii) Commissioning a professional firm to design and prepare a project after which the client can either

a) Advertising for tender or 'open bidding'; or

b) Inviting tender from a list of selected contractors; or

c) Selecting one contractor from the outset and negotiating the contract; and

(iii) Engaging a contractor on a package deal (design and build contract) especially for specialised works. These are often called build, operate and transfer (BOT) concession contracts. As Wang, *et al* (1999) expound," A BOT concession agreement is a contract between a host government and the project promoter whereby the promoter is required to finance, design, build, operate and manage the facility and then transfer the facility free of charge to the government after a specified concession period." However, BOT contracts carry inherent risks whose order of criticality is as follows: tariff adjustment; dispatch constraint; exchange rate and convertibility; and financial closing (Wang *et al*, 2000).

Options (ii) a), (ii) b) and (iii) above constitute the major procurement processes for works where engineering is the main contract and many construction markets are characterised by these tendering processes (Andersson and Miles, 1994; Gruneberg, 1997). The employer (client) frequently appoints a construction professional as his representative to design the project, supervise the construction work, value and certify payments due to contractor and settle any disputes (Seeley, 1993).

Kaka and Price (1991) showed that the type of competition or tendering method does not affect time and cost relationship of the projects. However, findings by Endut *et al* (2006) show that tendering method does influence the time and cost relationship of the Malaysian construction projects with the selective and negotiated tendering methods associated with better contract and actual duration compared with the open tendering.

2.4 Uniqueness of Construction Outputs

The products of the construction sector - the building and civil engineering works - are unique unlike other durable goods from manufacturing sector. However, unlike in pure manufacturing industries, most products of construction cannot be standardised and are therefore one-off (prototype) products making the production processes in the construction industry different for each project.

Smith (1998), Jafaari (1996), and Brech (1971) ascribe the following unique attributes to building and civil engineering construction outputs:

(i.) Dependent on land (or site), the most important resource;

(ii.) Fixed to land since all construction works occupy a geographical area;

(iii.) Heavy and bulky in comparison to most other durable products;

(iv.) Complex since construction is an assemblage of some parts which have been through a number of stages of pre-manufacture before arrival at site;

(v.) Long cycle time: The average construction takes two years unlike hours or weeks for most durable products, thus engendering many opportunities for delays;

(vi.) Unique, with many arrangements and designs to suit different needs and tastes;

(vii.) Expensive since large capital outlays are required compared with the range of all durable products; because of the price and the tendency to uniqueness, construction products are in effect sold before they are made;

(viii.) Influence of the public, the regulatory agencies and interest groups, which will ultimately affect the functions and configuration of projects;

(ix.) Virtual lack of research and development (R&D) in the construction process;

(x.) Long lasting, a disadvantage since the process of innovation is slowed down;

(xi.) Fragmented structure of the industry with the bulk of the construction business being generated by a large number of firms, often small in size and less inclined to formal methods of work study and management;

(xii.) Diffused responsibility such that on normal construction projects typically many individual professionals and firms share the responsibility for the specification, design and construction of these projects; and

(xiii.) Transient and itinerant labour force, who are not trained to operate under the quality assurance mode of construction.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Research Design

The research design was a survey research, using both primary and secondary data. The data was collected using a structured self-administered questionnaire.

3.1 Population and Sample of the Study

The opinion data for Part I section of the questionnaire was sourced from a sample of road construction industry professionals and managers in government, consulting firms and road construction firms whose offices are in Nairobi. A survey of 75 professionals/managers was aimed at: 25 each from road construction firms, government, and consulting respectively. It was not possible to establish and quantify the actual population of managers and professionals.

For Part II of the questionnaire which answers the second objective of the study, the population of interest was completed road rehabilitation/construction projects under the jurisdiction of the jurisdiction of the Kenya Roads Board and implemented by Ministries of Roads and Public Works and Local Government. Only those completed road projects with the required information with respect to the objectives of the study were analysed.

3.2 Data Collection

The primary data comprises the opinion of professionals and managers in government, consulting firms and construction firms. The data was procured using a structured questionnaire (see Appendix 2). The questionnaire was hand-delivered appropriately with personal follow-up calls to improve response.

For the cost and time relationship which required secondary data, the respondent(s) were asked to provide information on previous projects in relation to name of the project, start and completion date, contractual and actual duration, domestic or foreign contractor, contract sum and final account cost. Specific features of the road project such as type of project (new construction or rehabilitation) and nationality of contractor (domestic or foreign) used were requested. The source of the secondary data for the time-cost model was mainly Kenya Roads Board.

3.3 Data Analysis and Presentation

Data was analysed using as appropriate, with factors impacting construction delays being categorised according to their importance or criticality using descriptive statistics. To determine whether the opinion responses are significantly different in respect of the subdivision of the respondents into the three categories, a chi-square test was carried out. The generated model was evaluated for its predictive capacity using the t-test while the Pearson Product Moment Correlation Coefficient, R, for the linearised regression equation was tested for significance. The Correlation Coefficient, R, describes the degree of relation, or the degree of closeness to a straight line or the amount of scatter that exists. The F- test was carried to establish whether the population from where two independent samples came have the same spread or variance. Content analysis was used to summarise into themes the responses on open-ended questions.

Tables were used to enhance the quality of data presentation. Some analytical interpretations and inferences concerning causal relations were made.

CHAPTER FOUR: DATA ANALYSIS, FINDINGS AND DISCUSSIONS

4.0 General Summary of Response to Questionnaire

The response to the questionnaire may be summarised as follows:

Table 4.1: Summary of Response

Strata of Managers	Sample	Respondents	
		Number	Rate (%)
Government	25	16	64
Consulting firms	25	12	48
Road construction firms	25	5	20%

Source: Research data (2006)

Table 4.2: Managers Educational Qualifications

Education Qualification	Number of respondents		
	Government	Consulting firms	Construction Firms
Ordinary Diploma	0	0	2
Higher National Diploma	0	0	2
Graduate	12	5	1
Postgraduate	4	7	0

Source: Research data (2006)

Table 4.3: Summary of Data for Time-Cost Model

Stratum of road projects	Number	Remarks
Inter-urban roads rehabilitation (gravelling)	13	Data as per questionnaire
Inter-urban rehabilitation (resealing and recarpeting)	15	Data as per questionnaire
Urban roads rehabilitation	8	Only a list of ongoing projects
Reconstruction	2	Not analysed

Source: Research data (2006)

Some of the project data in Table 4.3 above are reproduced in detail on Tables 4.6, 4.7, and 4.8 overleaf. This data answers question No. 4 of the questionnaire in which the respondents were asked to state their education qualifications. No data for new road construction was received from the respondents.

Table 4.4: Breakdown of Questionnaire Distribution

Stratum breakdown	No. of questionnaires	No of respondents
Government		
Kenya Roads Board	5	5
Ministry of Roads and Public Works (roads department)	12	7
Ministry of Local Government (Urban development department)	8	4
Consulting firms		
Runji and Partners	5	2
Wanjohi	5	1
Uniconsult	5	2
Gibb Africa	5	3
Norconsult	5	4
Construction firms		
Nyoro	5	3
Kirinyaga	5	2
Victory	5	0
G. Issaias	5	0
Intex	5	0

Source: Research data (2006)

On personal follow-up to improve questionnaire response, the road construction firms alluded to the fact that their managers were still in the projects based outside Nairobi and were yet to fill and submit the questionnaire as per question 3

Using the identified critical delay factors - both input and transformation - the following Table 4.5 comprise a summary of years of experiences of managers and professionals who responded to the question number 2 of the questionnaire.

Table 4.5: Breakdown of Experience of Managers in Years

Experience in years	Delay factor and number of respondents				
Government					
0-5	6	4	5	5	4
5-10	1	1	1	1	1
10-15	3	4	4	4	3
15-20	5	5	4	5	6
Over 20	2	2	2	2	2
Consulting firms					
0-5	1	1	1	1	1
5-10	2	2	3	2	2
10-15	2	2	1	2	2
15-20	1	1	1	1	1
Over 20	6	6	6	6	6
Construction firms					
0-5	1	1	1	1	1
5-10	1	1	1	1	1
10-15	1	1	1	1	1
15-20	2	2	2	2	2
Over 20	0	0	0	0	0

Source: Research data (2006)

Table 4.6: Urban Roads Rehabilitation Projects

Initial Sum (Kshs m)	Initial period Months	Initial Start	Initial End
630	36	May-05	May-08
217	22	Jun-05	Apr-07
193.36	24	Nov-05	Nov-07
137	12	Jul-05	Jul-06
88	18	Feb-06	Aug-07
84	18	Mar-05	Sep-06
80	15	Apr-05	Jul-06
102	20	Feb-05	Oct-06

Source: Research data (2006)

Table 4.7: Road Rehabilitation Projects (Resealing/Recarpeting)

Initial Sum (Kshs m)	Initial period (Months)	Actual start	Actual Cost (Kshs m)	Actual Period (months)	Actual end
332.63	18	Mar-99	321.44	23.5	Feb-01
47.3	12	Sep-99	46.89	16.5	Jan-01
898.56	24	Aug-99	596.22	51	Dec-03
407.08	18	Oct-96	438.99	65	Mar-02
517.24	18	Nov-96	817.97	47	Sep-00
149.98	18	Aug-97	337.93	56	Apr-02
293.67	18	Oct-00	293.67	44	Jun-04
440.58	18	Sep-00	839.77	56	Jun-04
155.69	24	Aug-99	196.64	27	Nov-01
474.17	30	May-94	675.71	87	Aug-01
327.72	18	Nov-00	1118.16	52	Mar-05
260.66	12	Oct-00	330.92	24	Oct-02
340.19	18	May-02	340.19	37	Jun-05
601.85	18	Jun-98	601.85	57	Mar-03
217.27	12	Jun-02	217.27	24	Jun-04

Source: Research data (2006)

Table 4.8: Road Rehabilitation Projects (Gravelling)

Initial Sum (Kshs m	Initial period (months)	Actual start	Actual sum (Kshs m)	Actual Period (months)	Actual End
450.38	24	Aug 02	450.38	44	Apr 06
204.71	18	Dec 02	204.71	25	Jan 05
555.13	48	Sept 98	1034.27	73	Oct 04
270.28	18	March 99	270.28	26	May 01
143.86	18	Sep 01	143.86	53	Jun 04
68.86	6	Aug 01	156.38	19	Mar 04
63.91	12	Oct 01	63.91	32	Jun 04
399.74	24	Jan 99	1022.71	65	Jun 04
270.7	24	Jan 03	270.7	36	Dec 05
332.43	18	Apr 04	332.43	24	Apr 06
27.38	6	Sep 00	27.32	12	Sep 01
124.46	12	Jun 00	124.89	12	Jun 01
35	6	Oct 00	34.8	9.4	Jul 01

Source: Research data (2006)

4.1 Rating of Factors by Respondents

For question No. 6, the respondents were asked to rate their perception of the 36 factors deemed to contribute to road project delays on a Likert scale as defined in the questionnaire. The factors had been broadly categorised as input, construction process (transformation) and environmental. Responses on matrix of 36 factors contributing to road project delays was analysed using the mode as the most applicable measure of central tendency. An attempt was made to compute the mean of respondents rating as a guide to the overall rating of factor. The mean of the factor can then be rounded off to the nearest whole number in order to establish the respondents consensus on the few factors considered critical to precipitating project delays. Tables comprise a summary of mean rating of factors:

Table 4.9: Mean Rating of Input Factors

Factors	Mean rating (score) as perceived by managers/engineers in:		
	Government	Consulting Firms	Road Contractors
(i) Failure to learn from past mistakes	3.44	2.33	2.00
(ii) Labour disputes (go-slows) on site	2.06	2.00	1.40
(iii) Underestimation of project duration	3.44	3.58	3.60
(iv) Contractor's cash flow (budget) problems	4.39	4.17	4.60
(v) Contractor's cash flow (budget) problems	3.56	3.50	4.00
(vi) inadequate contractor experience	3.27	3.08	3.20
(vii) Construction equipment breakdowns	3.44	3.17	3.20
(viii) Unqualified staff of contractor's team	3.69	3.08	2.40
(ix) Late delivery of project inputs	3.25	3.08	3.00
(x) Poor supplier-contractor relations	3.25	2.58	2.20
(xi) Delayed payment to contractor	3.81	4.17	4.80
(xii) Inappropriate duration estimate	2.75	3.67	3.00
(xiii) Poor motivation of contractor's workers	3.20	2.80	3.20
(xiv) Others (please add)			

Source: Research data (2006)

4.1.1 Contribution of Input Factors to Road Projects Delay

On four of the input factors causing delays in road projects, there appears to be consensus among the respondents that they are critical as summarised in the following table:

Table 4.10: Critical Delay Factors (Input)

Input Factor	Mean Rating (score) as perceived by managers/engineers in:		
	Government	Consulting Firms	Road Contractors
(iii) Underestimation of project duration	3.44	3.58	3.60
(iv) Contractor's cash flow problems	4.39	4.17	3.60
(v) Client's cash flow problems	3.56	3.50	4.00
(xi) Delayed payment to contractor	3.81	4.17	4.18

Source: Research data (2006)

Table 4.11: Mean Rating of Construction (Transformation) Process Factors

Factors	Government	Consulting Firms	Road Contractors
(xv) Design changes by supervision team	3.25	3.00	3.20
(xvi) Poor relations between engineer and contractor	2.31	2.46	3.60
(xvii) Inappropriate project organisation structure	2.59	2.69	3.60
(xviii) Corrupt or fraudulent practices within the project	2.50	2.33	2.40
(xix) Inadequate supervision of works	2.69	2.92	3.60
(xx) Increase in scope of works	3.52	3.50	4.00
(xxi) Lack of commitment to project duration	3.82	3.58	4.00
(xxii) Rework (work repeats) owing to defects	2.13	3.00	2.40
(xxiii) Poor co-ordination among the project team (Contractor's and Engineer's staff)	2.50	3.00	3.00
(xxiv) Delayed certification (approval) of finished work by the Engineer	2.19	2.25	3.20

(Table continues overleaf)

Table 4.11: Mean Rating of Construction (Transformation) Process Factors - Continued

Factors	Government	Consulting Firms	Road Contractors
(xxv) Slowness in making project decisions by the Engineer	3.00	2.67	3.20
(xxvi) Time waste in the project (idle time, travelling time and waiting time)	2.38	2.33	3.00
(xxvii) Poor scheduling of site activities	3.13	3.33	3.40
(xxviii) Inappropriate construction methods	2.56	3.00	3.20
(xxix) Others (please add)			

Table 4.12: Mean Rating of Environmental Factors

Factors	Government	Consulting Firms	Road Contractors
(xxx) National economic factors (inflation, price changes of inputs, etc)	3.00	2.58	2.80
(xxxi) Bad relations with project financiers (for donor-financed projects)	2.81	2.15	2.60
(xxxii) Political interference	2.94	2.00	2.60
(xxxiii) Project complexity (non-standardisation)	2.40	2.17	3.40
(xxxiv) Adverse/unpredictable weather conditions	2.47	2.42	2.00
(xxxv) Ownership (management structure) of road construction firms	2.63	3.00	2.80
(xxxvi) Bureaucracy of government departments and complexity of the payment process	3.39	3.33	3.20
(xxxvii) Lack of project support from client's top managers	2.59	2.25	3.20
(xxxviii) Contractor's head-office support to site management team and operations	3.00	2.67	3.40
(xxxix) Others (please add)			

Source: Research data (2006)

4.1.2 Contribution of Construction Process Factors to Road Projects Delay

There was a consensus of opinion among the three strata of respondents that two factors in construction process management (Table 4.13) are critical in precipitating delays. These form part of the factors Alwi *et al* (2003) investigated as some of the variables resulting in waste in Indonesian construction companies. If addressed would inevitably ameliorate project implementation delays in road sub-sector.

Table 4.13: Critical Delay Factors (Transformation Process)

Factors	Mean Rating (score) as perceived by managers/engineers in:		
	Government	Consulting Firms	Road Contractors
(xx) Inadequate supervision of works	3.52	3.50	3.60
(xxi) Increase in scope of works	3.82	3.58	4.00

Source: Research data (2006)

However, the respondents from the construction firms also felt that fraudulent practices (factor xix with a mean rating of 3.6), design changes by the supervision team (factor xvi with a mean rating of 3.6) and poor relations between Engineer and the Contractor team (factor No. xvii with a rating of 3.6) contributed to project delays whereas the respondents from government and consulting firms strata rated them as of less than average influence in road projects delay.

4.1.3 Contribution of Environmental Factors to Road Projects Delay

None of the respondents considered the nine listed factors in the questionnaire as critical in engendering project time overruns, generally rating them around average or less. Table 4.14 overleaf shows the rating of two factors considered as the 'most critical' among the listed environmental factors. Yet their rating is indeed average or less in their impact on road production delays. These finding appear to contradict those of Garashie (1999) among which was the operating environment as a major cause of project delays in water projects.

Table 4.14: Critical Delay Factors (Environmental)

Factor	Mean Rating (score) as perceived by managers/engineers in:		
	Government	Consulting Firms	Road Contractors
(xxxvi) Ownership (management) structure of road construction firm	3.39	3.33	3.20
(xxxviii) Contractor's head-office support to site management team and operations	3.00	2.67	3.40

Source: Research data (2006)

4.2 Perceptions on Construction Process Cycle Efficiency

An attempt was made to establish the perceptions of process efficiency for the 30-day working cycle of a typical domestic contractors as compared to a foreign contractor based in Kenya. The data answers question 7 of the questionnaire where managers were asked to rate performance perceptions. The response on performance perceptions by respondents were as follows:

Table 4.15: Government Project Managers/Engineers Perceptions

Time (days)	26-30	21-25	16-20	11-15	10 or less
Domestic contractor	0	3	9	1	2
Foreign contractor	5	8	2	0	0

Source: Research data (2006)

Table 4.16: Consulting Firms Engineers/Project Managers

Time (days)	26-30	21-25	16-20	11-15	10 or less
Domestic contractor	0	2	5	4	1
Foreign contractor	2	9	1	0	0

Source: Research data (2006)

Table 4.17: Construction Firms Project Managers/Engineers Perceptions

Time (days)	26-30	21-25	16-20	11-15	10 or less
Domestic contractor	0	0	5	1	0
Foreign contractor	2	3	0	0	0

Source: Research data (2006)

Table 4.18: Data analysis on Construction Process Cycle Time

Contractor	Process cycle performance								
	Government			Consulting Firms			Road Contractors		
	$\bar{X}$	$X\sigma_n$	$X\sigma_{n-1}$	$\bar{X}$	$X\sigma_n$	$X\sigma_{n-1}$	$\bar{X}$	$X\sigma_n$	$X\sigma_{n-1}$
Domestic contractor	17.33	4.42	4.58	16.33	4.25	4.44	17	2.00	2.24
Foreign contractor	24	3.27	3.38	23.42	2.47	2.57	25	2.45	2.74

Source: Research data (2006)

From the data above, it would appear that Kenyan domestic road construction firms would benefit from learning and benchmarking their site planning and operations management from their foreign counterparts based in Kenya as the latter are perceived to display higher process cycle efficiency.

4.2.1 F-Test: Two-Sample Test of Independence in Variance

An F-test was carried out on the samples, using the process cycle efficiency data (especially the sample variance, s) on domestic contractors to establish how independent the populations were in their variances.

$$\text{F-ratio} = \frac{\text{Larger } s^2}{\text{Smaller } s^2}$$

4.2.1.1 Government and Consulting Firms' Managers/Engineers

F-Ratio = $4.58^2/4.44^2 = 1.04$

F-Critical, P=0.95, one-tailed test from Tables ($f_1 = n_1 - 1 = 15$ while $f_2 = n_2 - 1 = 11$) is 2.72. Since test statistic is less than the F-limit statistic the hypothesis that there is no significant difference in spread or variability in the two populations from where the samples came is accepted. The population variances are the same.

4.2.1.2 Consulting and Construction Firms' Managers/Engineers

F-ratio = 3.93

F-Critical value, P=0.95, one-tailed test from Tables ($f_1 = n_1 - 1 = 11$ while $f_2 = n_2 - 1 = 4$) is 5.94.

F-critical>F-ratio.

Therefore, there is no difference in the population variability. The population variances are the same.

It can be inferred that the three categories of data came from populations with no significant difference in variability or spread and thus pooled variance can be used for any further statistical analyses after averaging the individual variances together into a single estimate of population variance, σ.

4.2.2 Chi-Square Test: One Sample Test of Population Variance

A chi-square test was carried out on each of the three samples of engineers and managers to establish whether there was a significant difference in their variances vis-à-vis the theoretical variance of the population from which they were drawn.

$$\chi^2 \text{ - distribution} = \frac{(\text{Sample variance})^2}{(\text{Theoretical population variance})^2}(n-1)$$

Where n is the number of samples drawn from that population

4.2.2.1 Government Managers/Engineers

Test statistic = $4.58^2/4.42^2\,(16-1) = 16.11$

Critical value of χ^2 for which there is 5% chance of being lower, $\chi^2_{0.95} = 25$.

The test statistic is less than the upper limit, hence there is no significant difference in variability of this sample and the theoretical variance of the population of government engineers

4.2.2.2 Managers/Engineers in Consulting Firms

Test statistic = $4.44^2/4.25^2\,(12-1) = 12.01$

Critical value of χ^2 for which there is 5% chance of being lower, $\chi^2_{0.95} = 19.7$.

The test statistic is less than the upper limit statistic read from tables, hence there is no significant difference in variability of this sample and the theoretical variance of the population of consulting firms engineers and project managers

4.2.2.3 Construction Firms' Project Managers/Engineers

Test statistic = $2.24^2/2.00^2$ (5-1) = 5.02

Critical value of χ^2 for which there is 5% chance of being lower, $\chi^2_{0.95}$ = 9.94.

Again, the test statistic is less than the upper limit. Hence, there is no significant difference in spread of this sample and the theoretical variance of the population of engineers and project managers from road construction firms.

4.3 Influence of Liquidated Damages Clause in Contract Performance

The respondents were asked to rate the impact of liquidated damages in motivating timely project completion in question 8. On the impact of this clause in reducing the problem of project delays in Kenya, the following were the perceptions from strata of managers in the sub-sector.

Table 4.19: Rating by Government Project Managers/Engineers

Rating	5	4	3	2	1
Number of respondents	0	0	6	5	4

Source: Research data (2006)

Table 4.20: Rating by Consulting Firms Project Managers/Engineers

Rating	5	4	3	2	1
Number of respondents	0	0	0	7	5

Source: Research data (2006)

Table 4.21: Rating by Construction Firms Project Managers/Engineers

Rating	5	4	3	2	1
Number of respondents	0	0	2	2	1

Source: Research data (2006)

On the impact of this clause in reducing the problem of project delays in Kenya, the following were the mean computed perceptions from strata of managers in the sub-sector with a mode of 2.

Table 4.22: Mean Rating of the Impact of Liquidated Damages Clause

Mean rating of impact of the clause		
Government	Consulting Firms	Road Contractors
2.13	2.17	2.2

Source: Research data (2006)

All the road construction projects in Kenya have a clause in the conditions of contract stipulating the amount payable to the Client should the contractor fail to complete the project in the stipulated time for reasons of his own making. The full amount of liquidated damages represents a genuine attempt by both parties to the contract in pre-estimating damages or losses an injured party would suffer in the event of a breach by the defaulting party (Williams, 1992). The general principle behind the payment of breach-related damages is compensation for losses or restitution in full, and not a penalty. The innocent party must be restored to the financial position in which he would have been had the offending party discharged his contractual obligations in full. The Contractor, when entering into a contract, agrees to pay to the Employer the stipulated amounts if the same become due on account of delayed completion of the works without the need of the Employer to prove his actual damage or loss.

From the summary of findings in table 4.22, there appears to be a general consensus across the strata of respondents that the liquidated damages clause has been of little consequence in motivating construction companies into timely completion of road projects, even though it is always part and parcel of the conditions of contract. The clause then calls for a rethink.

4.4 Stakeholder Priorities of Action to Ameliorate Project Delays

On exactly what various stakeholders needs to be do to reduce road project delays and increase delivery dependability of construction industry in Kenya, the following comprise the thematic summaries of mass of views expressed by the respondents on this open-ended question. The data answers question number 9 of the questionnaire.

Table 4.23: Priorities by Government Project Managers/Engineers

(a) For Client/Employer	No of respondents	%
Timely payments of interim payments	11	68.75
Good financial planning or budgetary allocation	9	56.25
Adequate remuneration of engineers/managers	8	50.00
Non-interference with project management	2	12.25

(b) For Engineer	No of respondents	%
Timely decisions and instructions	12	75.00
Well-designed contract document	6	37.50
Skilled/adequate project supervision	5	31.25
Ethics and professionalism	5	31.25
No influence by contractors	3	18.75

Table continues overleaf

(c) For Contractor	No of respondents	%
Qualified and motivated site personnel or technical capacity	9	56.25
Adequate and serviceable equipment	7	43.75
Ethical behaviour	6	37.50
Stop diversion of project funds after payment	5	31.25
Commitment to project duration	3	18.75

Source: Research data (2006)

Table 4.24: Priorities by Consulting Firms Engineers/Project Managers

(a) For the Client	No of respondents	%
Timely payments to contractor	10	83.33
Non-interference with engineer in the project	4	33.33
Support to engineer	2	16.67

(b) For Engineer	No of respondents	%
Decisiveness or timely issuance of correct instructions	8	66.67
Impartiality in construction management	4	33.33
Proper contract documentation	4	33.33
Timely work certification	2	16.67
Professional ethics	2	16.67

(c) For Contractor	No of respondents	%
Proper equipment/plant	6	50.00
Skilled and knowledgeable site staff	5	41.67
Experienced site agent	3	25.00
Full delegate site of site responsibility	2	16.67

Source: Research data (2006)

Table 4.25: Priorities by Construction Firms Managers/Engineers

(a) For Client	No of respondents	%
Prompt or timely payments to contractor	3	60.00
Project ownership	2	40.00

(b) For Engineer	No of respondents	%
Prompt decision-making	4	80.00
Impartiality in judgement	2	40.00
Facilitate contractor, and do not obstruct	2	40.00

For Contractor	No of respondents	%
(c) Dependable plant	3	60.00
Fair remuneration of the staff	3	60.00
Commitment to project	2	40.00

Source: Research data (2006)

The principal stakeholders in road projects implementation are the employer or client who sponsors the project, the contractor who is charged with responsibility to deliver the project and the engineer who is an impartial manager of the project on behalf of the employer and who instructs and certifies the output of the contractor. The above findings corroborate the critical factors causing delays and demands regular stakeholders forum for dialogue to minimise road project delays.

4.5 Tripartite Responsibility in Ameliorating Project Delivery

From the mass of responses to question 9, the employers (clients) who are always government departments need to endeavour to process -reengineer the payment of interim certificates so as to promptly be able to honour monies due to contractor, do good financial planning or adequate budgetary allocation for each and every project, provide a realistic project duration, adequately remunerate his project managers and engineers and give the managers a free hand the project.

For project managers and engineers to contribute in reducing project delays, they are obligated to make timely decisions and give concise instructions on site, provide comprehensive contract documentation with proper quantities covering the envisaged scope of work, and show impeccable impartiality in contract administration and supervision of works.

For the contractor, the critical contractual obligations in minimising project delivery delays include providing qualified and experienced site agent and staff, availing serviceable and dependable construction equipment and plant, managing his project finances prudently, among other necessary resources for timely project execution. As Schleifer (1990) observes,

> "Many contractors believe that they lose money or fail because of weather conditions, labour problems, inflation, unexpected rise in interest rates, the high costs of equipment, a tightening or shrinking of the market, or simple bad luck. Actually none of these has ever been the primary reason for contractor failure. They may have contributed to failure once a bad management decision was made. But they were not the basic cause of failure.... We, as contractors, often attribute our failure to survive to conditions over which we have no control. Actually that is not the case... The recurrent and industry wide risk to potential profit or failure broadly include company's business strategies or practical considerations on the one hand and fiscal or accounting considerations on the other. In fact the failure causes include increase in project size, changes in key personnel, lack of managerial maturity in expanding organisations, poor accounting systems, failure to evaluate project profitability, lack of equipment cost control, poor billing procedures, and unfamiliarity with new geographical area" (pp. ix, 16).

The above findings are corroborated by the observations of Elton and Roe (1998) that many of the delays in individual projects arise from problems at the senior management level rather than from mistakes made by project managers. It thus appears that project performance is often less a matter of understanding the constraints of project, such as the critical path and the scarce resources, and more a function of personal skills and capabilities of the potential leaders of the project. Project leadership may be the larger constraint to focus on if project performance in Kenya is to be improved.

The factors causing delay in construction sector are process-related just as Kagioglou *et al* (1998) observed that 85% of the commonly associated problems in construction sector are process related, not product related. Each of the principal actors in project realisation process have some obligations to reduce project delays and thus engender delivery reliability of the road projects as briefly described hereunder

4.6 Relationship Between Road Contracts Duration and Cost

4.6.1 Bromilow's Model

From the scatter graphs of various types of road projects and the regression results on the Bromilow's model, there exists a clear relationship between project duration and cost. The regression analysis of the log linear time-cost data with time converted into days are as follows:

Table 4.26: Model Data on Inter-Urban Roads Rehabilitation (Gravelling)

Regression results	Initial contract duration and cost	Actual contract duration and actual cost
Ln K	5.659	6.637
K	287	763
B	0.5937	0.4628
R	0.927	0.7935
R^2	0.860	0.630
Critical $t_{0.95}$	1.782	1.782
Computed t	8.20	4.33
Critical $R_{0.95}$	0.4762	0.4762

Source: Research data (2006)

Table 4.27: Model Data on Inter-Urban Roads Rehabilitation (Resealing/Recarpeting)

Regression results	Initial contract duration and cost at signing of agreement	Actual contract duration and actual cost at contract completion
Ln K	7.697	6.709
K	2026	820
B	0.1897	0.4718
R	0.5165	0.7770
R^2	0.2668	0.604
Critical $t_{0.95}$	1.761	1.761
Computed t	2.17	4.45
Critical $R_{0.95}$	0.4409	0.4409

Source: Research data (2006)

4.6.2 Normal Linear Regression Model

Using the normal linear regression with project duration in months (expressed as X in the equation) and costs in millions of Kenya Shillings (expressed as C in the equation), the above data was analysed to provide a possible comparison with Bromilow's time-cost model. The following are the regression results

Table 4.28: Model Data on Inter-Urban Roads Rehabilitation (Gravelling Projects)

Regression results	Initial contract duration and cost at signing of agreement	Actual contract duration and actual cost at contract completion
R	0.9006	0.8418
R^2	0.811	0.709
Critical $t_{0.95}$	1.782	1.782
Computed t	15.81	9.59
Critical $R_{0.95}$	0.4762	0.4762
Slope	13.67	13.95
Y-Intercept	-19.44	-143.51
Proposed model	$C = 13.67X-19.44$	$C = 13.95X-143.51$

Source: Research data (2006)

Table 4.29: Model Data on Inter-Urban Roads Rehabilitation (Resealing/Recarpeting)

Regression results	Initial contract duration and cost at signing of agreement	Actual contract duration and actual cost at contract completion
R	0.4748	0.6131
R^2	0.2254	0.376
Critical $t_{0.95}$	1.761	1.761
Computed t	1.945	2.798
Critical $R_{0.95}$	0.4409	0.4409
Slope	20.77	9.245
Y-Intercept	9.245	67.17
Proposed model	C = 20.77X+9.245	C = 9.245X+ 67.17

Source: Research data (2006)

Except for gravelling projects which display marked consistency in output per unit of time at contract signing and at project completion, the resealing/recarpeting projects promise more than double what they are able to deliver, implying speculation during tendering and cost overrun before actual project commencement. On the other hand, there more output consistency in estimating and executing gravelling works.

4.6.3 Adjusted Initial Contract Price Versus Actual Period

An attempt was made to develop a linear model for the above projects using the initial adjusted costs (to December 2004 prices using civil engineering cost indices) and actual period of the projects. It is envisaged that the model could be more practical for purposes of estimating and planning. The results of the Bromilow's time-cost model and the linear regression model are as tabulated overleaf

Table 4.30: Adjusted Data on Inter-Urban Roads Rehabilitation (Gravelling)

Regression results	Adjusted initial price and actual duration
Ln K	6.528
K	684.3
R	0.776
R^2	0.602
Critical $t_{0.95}$	1.761
Computed t	4.229
Critical $R_{0.95}$	0 4762
Slope	0.513
Model	$T = 684.3C^{0.513}$

Source: Research data (2006)

Table 4.31: Adjusted Data on Inter-Urban Roads Rehabilitation (Resealing/Recarpeting)

Regression results	Adjusted initial price and actual duration
Ln K	6.781
K	880.9
R	0.752
R^2	0.566
Critical $t_{0.95}$	1.771
Computed t	4.407
Critical $R_{0.95}$	0.4409
Slope	0.464
Model	$T = 880.9C^{0.464}$

Source: Research data (2006)

The above models have reasonable estimating and predictive capabilities.

A normal linear regression model was fitted onto the same project data above in order to provide a comparison with Bromilow's time-cost model. The table overleaf gives the results.

Table 4.32: Inter-Urban Roads Rehabilitation (Gravelling)

Regression results	Actual contract duration and adjusted initial price
R	0.8119
R2	0.6591
Critical $t_{0.95}$	1.782
Computed t	9.59
Critical $R_{0.95}$	0.4762
Slope	9.382
Y-Intercept	-21.913
Proposed model	Cost =9.382X - 21.913

Source: Research data (2006)

Table 4.33: Inter-Urban Roads Rehabilitation (Resealing/Recarpeting)

Regression results	Actual contract duration vs adjusted initial price
R	0.703
R^2	0.494
Critical $t_{0.95}$	1.761
Computed t	3.462
Critical $R_{0.95}$	0.4409
Slope	13.041
Y-Intercept	-33.718
Proposed model	Cost = 13.04X-33.72

Source: Research data (2006)

It would appear that the gravelling projects model have better estimating capabilities than the resealing/recarpeting regression function.

4.6.4 Urban Roads Rehabilitation Projects

For urban roads rehabilitation projects, only data for 8 ongoing projects could be availed at the time of data collection. For Bromilow's time-cost model the following are the results

Table 4.34: Urban Roads Rehabilitation Project (Bromilow's Model)

Regression results	Initial price vs Initial duration
Ln K	7.118
K	1235
R	0.7891
R^2	0.6227
Critical $t_{0.95}$	1.895
Computed t	2.4495
Critical $R_{0.95}$	0.6215
Slope	0.3693
Model	$T = 1235C^{0.3693}$

Source: Research data (2006)

For tender purposes, the Bromilow's time-cost model for urban road projects rehabilitation has a reasonably good estimating capacities.

For the above data on urban roads rehabilitation projects, a normal linear regression model was fitted using initial duration in months and Initial contract price in millions of Kenya Shillings. The results are as follows

Table 4.35: Urban Road Rehabilitation Project Model (Normal Regression)

Regression results	Initial contract duration vs initial price
R	0.9037
R^2	0.8168
Critical $t_{0.95}$	1.895
Computed t	5.8170
Critical $R_{0.95}$	0.6215
Slope	22.955
Y-Intercept	-282.02
Proposed Model	Cost = 22.955X-282

Source: Research data (2006)

For bidding purposes, the normal linear regression model for urban road projects rehabilitation has strong predictive capacities.

4.6.5 Summary Discussions and Implications of the Findings on Time-Cost models

In spite of their various estimating abilities, the functions show that there exists a relationship between project duration and cost. There is no evidence to show that all the project parameters considered follow the Bromilow's time-cost model. It would appear that road contractors in Kenya always promise to undertake projects that will almost always be delivered late.

As data from respondents in the three strata confirm, there is underestimation of project duration as well as scope change during implementation. The conclusion for the project planning during pre-contract stage is this: the managers need to carry out exhaustive design and make accurate quantities estimates and thus improve the construction industry's delivery reliability. Moreover, the current practice of the client's project managers fixing the duration and steamrollering the contractors to tender and fit their resources into a time schedule without any option is demonstrably outmoded, ineffective and unrealistic for all practical project management purposes. Indeed, the consequence of this practice in part is projects having pervasive time overruns.

The predictive abilities of the models are varied and may be summarised as follows using the coefficient of determination (R^2) and its conceptual legend outlined in the table below.

Table 4.36: Categorisation of R^2

R^2 Value	0.2-0.4	0.4-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	Over 0.9
Remarks	v. poor	poor	moderate	good	v. good	strong	v. strong

Source: Author's conceptual taxonomy (2006)

Table 4.37: Summary of Time-Cost Models' Predictive Abilities

(a) Bromilow's time-cost models			
Road project type	Model	R^2	Model's predictive ability
Rehabilitation (Gravelling)			
At contract signing	$T = 287C^{0.594}$	0.860	Strong
At contract completion	$T = 763C^{0.463}$	0.630	Good
Actual duration vs adjusted initial price	$T = 684.3C^{0.513}$	0.602	Good
Rehabilitation (resealing/recarpeting)			
At contract signing	$T = 2026C^{0.190}$	0.267	Very poor
At contract completion	$T = 820C^{0.472}$	0.604	Good
Actual duration vs adjusted initial price	$T = 880.9C^{0.464}$	0.566	Moderate
Overall (roads rehabilitation projects)			
At contract signing	$T = 630C^{0.418}$	0.636	Good
At contract completion	$T = 846C^{0.476}$	0.660	Good
Urban roads rehabilitation			
At contract signing	$T = 1235C^{0.367}$	0.623	Good

Source: Research data (2006)

(b) Linear regression models			
Road project type	Model	R^2	Model's predictive ability
Rehabilitation (Gravelling)			
At contract signing	C = 13.67X-19.44	0.811	Strong
At contract completion	C = 13.95X-143.51	0.709	Very good
Actual duration vs adjusted initial price	C = 9.38X-29.91	0.659	Good
Rehabilitation (resealing/recarpeting)			
At contract signing	C = 20.77X + 9.245	0.225	Very poor
At contract completion	C = 9.245X + 67.17	0.376	Very poor
Actual duration vs adjusted initial price	C = 13.04X - 33.72	0.494	Poor
Urban roads rehabilitation			
At contract signing	C = 22.95X - 282.02	0.817	Strong

Source: Research data (2006)

An analysis of road projects in Kenya has confirmed that the contract time and cost have a relationship in the form of $T = KC^B$. The best predictor of average construction time in road gravelling projects in Kenya is of $T_{start} = 287C^{0.5937}$ and $T_{end} = 763C^{0.4628}$. This means that to complete a hypothesized road gravelling project with a contract sum of KSh 1 million takes 763 days as opposed to the 287 days the contractor initially agrees to deliver when entering the contract, suggesting inordinate delay in the project completion.

Another case in point is B, a constant indicating the sensitivity of time perfomance to project cost (or size of the construction project) for resealing/recarpeting road projects. The sensitivity is very low at the time of entering into agreement while the same B is almost three times at project completion stage. Moreover the K value, a constant indicating the general level of construction time performance per million Kenya shillings, is abnormally large at contract signing stage. In spite of the model's poor estimating capabilities, the conclusion is that there are pervasive speculative practices and poor time estimates at tender stage for resealing/recarpeting projects, among other underlying influences. This practice calls for thorough review and managerial redress. The normal regression model attests to this inference in that at project initial stage the output rate averages at Kshs 20.77 million per month while at completion stage the mean contract output is actually KShs 9.24 million per month.

A hypothesized infrastructure project in Malaysia worth one million Malaysian rupees is delivered in 276 days at the contract signing and actually delivered in 375 days. One million worth of a hypothetic road resealing and recarpeting project in Kenya is actually delivered in 820 days. This suggests gross time overruns in road sub-sector projects just as Garashie (1999), Saburi (2003) and Kagiri (2005) have already found out in their research on economic infrastructure projects. Indeed all road projects initiated are in a state of time overrun even before the commencement date. These findings further corroborate those of the performance of the building construction sub-sector (Talukhaba, 1988).

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Critical Factors Causing Road Project Delay in Kenya - Objective 1.5(a)

Delays are common in civil engineering projects in Kenya, inevitably resulting in increased project cost. The perceptions of the civil construction practitioners on how critical a list of factors are in precipitating delay were gathered and analysed using the basic mean score in pursuit of research objective 1.5 (a).

In summary, the factors that cause road project delays in Kenya are many and varied. But the few crucial delay factors identified through analysis of the respondents data obtained in this research are contractor's and client's cash flow problems, delayed payment to contractor, underestimation of project duration, unqualified staff of contractor's project team, inadequate supervision of works and increase in scope of works. These input and transformational process factors are attributable to the core stakeholders in any project (Engineer, Client and Contractor) and are within their respective abilities to prudently manage and control.

Environmental factors were found to be of moderate or of no discernible impact in precipitating road project delays.

5.2 Predictability of Delivery Time of Road Rehabilitation Projects - Objective 1.5(b)

It is possible to predict delivery time of road projects. There is a significant time-cost relationship as identified in this research as outlined research objective 1.5 (b). Certainly, attempts to predict construction durations represent a problem of continual concern and interest to both researchers and project managers (Nkado, 1992, 1995; Chan and Kumaraswamy, 1995; Kumaraswamy and Chan, 1995; Walker, 1996). Bromilow's model may serve as a convenient and useful tool for project managers and clients to predict the reasonable time required for the delivery of a construction project in Kenya. The derived time-cost relationship, expressed in the form, $T = KC^B$, provides an alternative and objective method of estimating construction time to supplement the current practice of estimation based largely on the individual project manager's and engineer's subjective experience. The identified models could also provide important benchmarks for future research on the time performance of construction projects in Kenya and facilitate international comparison, or possible benchmarking, of time performance.

5.3 Recommendations for Managerial Action

The following issues arise from this study and may need consideration:

(a) The contract periods as initially set and agreed at contract signing are inordinately inadequate and a crucial factor affecting time overruns in projects. The time estimating practice need to be reviewed with a view to developing a realistic basis for estimating project duration, taking into account the effect of many others factors that affect time performance as discussed previously. Perhaps, as a start the employer may need to ask the bidders to indicate their proposed period for undertaking any contract after the client gives a range of indicative periods. This will obviously call for a new method of evaluating the tender cost and adjusting them to bring them to parity as far as time factor is concerned, particularly where project duration is more than a year. The criteria of net present cost using a pre-set discount rate during bidding may be tried to evaluate and compare various bid prices with different periods.

(b) Having a realistic and attainable project schedule guarantees successful delivery of any project. Project success does not depend on having a project schedule for the sake of it. It has been demonstrated that the initially set contract periods are woefully inadequate and an important factor contributing to time overruns of the project. In estimating the contract period, there need to be proper identification of tasks and sub-tasks through the work-breakdown structure, accurate examination of relationship and sequencing between tasks and optimisation of the schedule by use of the critical path of activities to derive realistic time estimates, in addition to the assessing impact of other factors that affect the time performance. The obvious implication from this study is that more emphasis should be given to project time control than has been given so far, from project conception through to implementation. This means that the project leadership must always have few strategic control points, the critical or the most significant elements in the project or any system at which monitoring or collecting information should occur (Stoner, et al, 2003). After all, in as much as construction projects require different trades and knowledge and multitudes of professionals from various disciplines, their management including scheduling and control utilize the same tools and techniques and are subject to the common constraints or objectives of time, cost, quality, scope and organisation.

(c) In as much as the Contractor is deemed a business entity in its own right, the clients of road projects may need to demand that contractors employ experienced and qualified staff for each project including giving written delegation of authority to their site agents.

(d) The sub-sector lacks a project information centre for storing information related to contract performance data that can be used by interested parties in the construction industry as Talukhaba (1988) had earlier observed. This needs to be established to enhance the research and further improvements in the industry.

(e) There is need for structured training of practitioners in road sub-sector on the principles of leadership, basics of project management such as resource planning and optimisation and process management, among others. Moreover, there is need for the main stakeholders in road sub-sector - clients (employers), engineers, and contractors - to hold regular dialogues in an acceptable forum to freely discuss and resolve the pervasive problem of project delays, among other managerial issues affecting infrastructure projects in Kenya.

(f) In addition to re-engineering the payment process so as to make it efficient and minimise delays, the employer may need to develop and include a new clause in future conditions of contract exclusively intended to motivate contractor to early project completion. The clause could work along side the liquidated damages clause, which has so far proved to be of little impact in the industry.

5.4 Limitations of the Study

This study suffers the following limitations:

(a) The study was, in part, carried out exclusively among a sample of those project managers and engineers based in Nairobi. Another study on perceptions should be carried out incorporating much larger samples of project managers/engineers, including those supervising projects outside Nairobi. This is especially important for the construction firms' stratum which, in the opinion of the researcher, evinced poor response to the questionnaire for this study.

(b) Respondents' data for testing Bromilow's model did not include precise start and completion time in terms of days but instead it incorporated months. The researcher made some minor adjustment with assumptions to derive project duration. This could have resulted in errors in the findings.

(c) The respondents did not give any data for modelling the new road construction and gave only two sets of data for reconstruction projects. This is a shortcoming in the study since Bromilow's model was originally developed for new building projects and should also have been of interest to see how it can be tested in new road construction projects as well.

5.5 Suggestions for Further Research

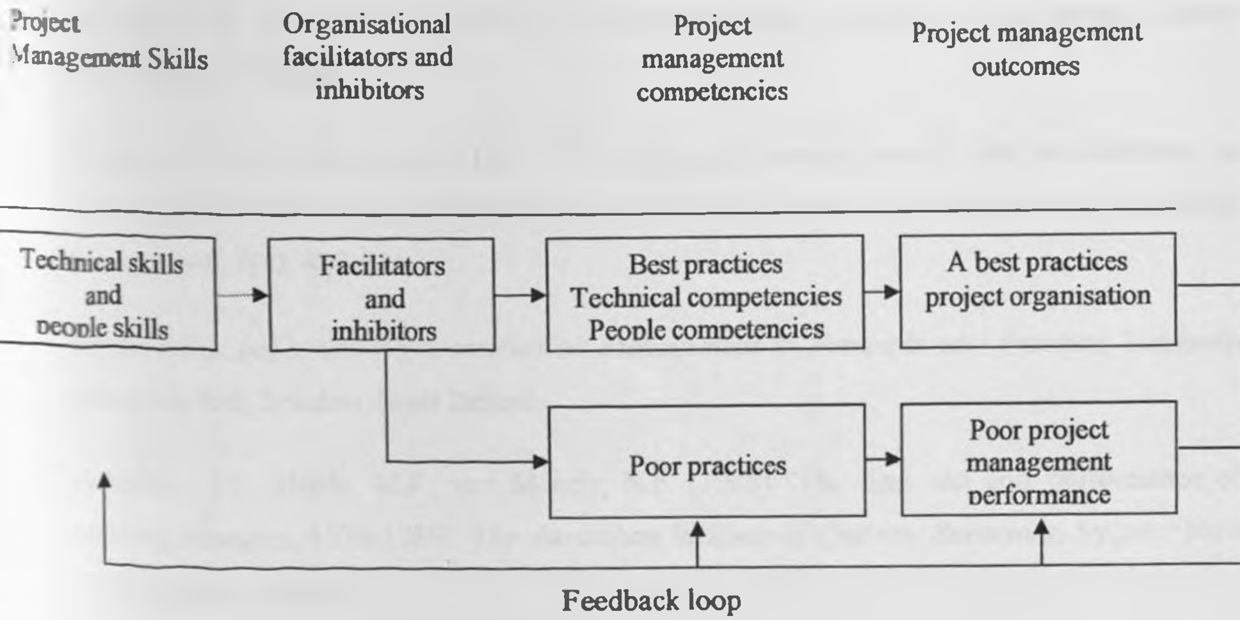
(a) Time is related to contract cost as this research shows. This means that estimated cost can be used to estimate the contract period, taking into consideration other intervening factors. This research was limited to investigating the predictive ability of Bromilow's time-cost relationship in the Kenya road projects, and therefore does not incorporate the effects of other factors suggested by researchers cited in this study and included in the research questionnaire. The road sub-sector has many factors that influence the time performance of projects. Even with Bromilow's models, the problem of time and cost performance is far from complete until all the other factors are addressed including geographical differences of project sites, construction materials markets, labour force market, construction disputes, organisational structure, communication, motivation, national economic factors, government policies affecting the industry (especially taxation), among others. Future research work may be directed to the testing of the models' sensitivities to these factors and incorporate coefficients or weightings as appropriate.

(b) In their comparative search for quantitative models for improved project time-cost estimation in Hong Kong, Dissanayaka and Kumaraswamy (1999) investigated the Artificial Neural Networks (ANN) and found that the ANN had better prediction capabilities than multiple linear regression (MLR). An investigation may need to be carried out on how best the ANN may be applied to time-cost estimation in the Kenyan construction sector.

(c) A commonly used measure of goodness of fit of a linear model is R^2, or the coefficient of determination. The R^2 value is widely accepted to be an indicator of how well the model fits the population. However, the model usually does not fit the population as well as it fits the sample from which it is derived (Chan, 1999). The author recommends that the statistically adjusted R^2 be used in future research to realistically reflect the goodness of fit of the Bromilow's model in the population of projects.

(g) In his study on the major variables contributing to best practices in construction project management, Loo (2003) organised them into a causal model as illustrated in Figure 5.1 below. Further analytical research may need to be carried out to establish the actual linkages between these variables and an empirical relationship developed to guide decision making among practitioners of project management in Kenya.

Figure 5.1: A Model of Best Practices in Project Management



Source: Loo, R. (2003) "A Multi-Level Causal Model for Best Practices in Project Management", *Benchmarking: An International Journal*, 10(1), p32

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Appendix 1

RESEARCH QUESTIONNAIRE

Part I (tick in the appropriate box)

1. Have you ever worked in a road construction site (equipment-intensive)? ❑ Yes ❑ No

2. If 'Yes' for 1 above, for how long have you been in road construction sub-sector?
   ❑ Less than 5 years ❑ 5-10 years ❑ 10-15 years ❑ 15 -20 years ❑ over 20 years

3. Which type of organisation are you currently working in?
   ❑ Government (also state corporations) ❑ consulting firm ❑ road construction firm

4. What are your education qualifications?
   ❑ Ordinary Diploma ❑ Higher National Diploma ❑ Graduate ❑ Post-Graduate

5. Have you worked with a foreign road construction company in Kenya? ❑ Yes ❑ No

6. Factors contributing to road project delays (time overruns)
Please rank/rate as shown here the extent you consider each of the factors listed in the table below actually contribute to the problem of road projects delays in Kenya:

[5. Very much; 4. Much; 3. Average; 2. Little; 1. Not all]

Factors	Ranking (Rating)				
A. Input factors					
(i) Failure to learn from past mistakes	5	4	3	2	1
(ii) Labour disputes (go-slows) on site	5	4	3	2	1
(iii) Underestimation of project duration	5	4	3	2	1
(iv) Contractor's cash flow (budget) problems	5	4	3	2	1
(v) Client's cash flow (budget) problems	5	4	3	2	1
(vi) Inadequate contractor experience	5	4	3	2	1
(vii) Construction equipment breakdowns	5	4	3	2	1
(viii) Unqualified staff of the contractor's team	5	4	3	2	1
(ix) Late delivery of project inputs/supplies	5	4	3	2	1
(x) Poor supplier-contractor relations	5	4	3	2	1
(xi) Delayed payment to contractor	5	4	3	2	1
(xii) Inappropriate project duration estimate	5	4	3	2	1
(xiii) Poor motivation of contractor's workers	5	4	3	2	1

(xiv) Others (please add)	5	4	3	2	1
	5	4	3	2	1
	5	4	3	2	1
B. Construction (transformation) process factors					
(xv) Design changes by supervision team	5	4	3	2	1
(xvi) Poor relations between Engineer and Contractor	5	4	3	2	1
(xvii) Inappropriate project organisation structure	5	4	3	2	1
(xviii) Corrupt or fraudulent practices within the project	5	4	3	2	1
(xix) Inadequate supervision of works	5	4	3	2	1
(xx) Increase in scope of works	5	4	3	2	1
(xxi) Lack of commitment to project duration	5	4	3	2	1
(xxii) Rework (work repeats) owing to defects	5	4	3	2	1
(xxiii) Poor co-ordination among the project team [Contractor's and Engineer's staff]	5	4	3	2	1
(xxiv) Delayed certification (approval) of finished work by the Engineer	5	4	3	2	1
(xxv) Slowness in making project decisions by the Engineer	5	4	3	2	1
(xxvi) Time waste in the project (idle time, travelling time and waiting time)	5	4	3	2	1
(xxvii) Poor scheduling of site activities	5	4	3	2	1
(xxviii)Inappropriate construction methods	5	4	3	2	1
(xxix) Others (please add)	5	4	3	2	1
	5	4	3	2	1
C. Environmental factors					
(xxx) National economic factors (inflation, price changes of inputs, etc)	5	4	3	2	1
(xxxi) Bad relations with project financiers (for donor-financed projects)	5	4	3	2	1
(xxxii) Political interference	5	4	3	2	1
(xxxiii)Project complexity (non-standardisation}	5	4	3	2	1
(xxxiv) Adverse/unpredictable weather conditions	5	4	3	2	1

(xxxv) Ownership (management) structure of the road construction firm	5	4	3	2	1
(xxxvi) Bureaucracy of government departments and complexity of payment process	5	4	3	2	1
(xxxvii) Lack of project support from client's top managers	5	4	3	2	1
(xxxviii) Contractor's head-office support to site management team and operations	5	4	3	2	1
(xxxix) Others (please add)	5	4	3	2	1
	5	4	3	2	1
	5	4	3	2	1

7. Construction process efficiency
Given a 30-day cycle time of continuous site operations (assume no weekends and holidays), indicate the most likely time spent on actual or real output by a contractor

Time (days)	26-30	21-25	16-20	11-15	10 or less
Domestic contractor					
Foreign contractor					

8. To what extent has liquidated damages clause in our construction contracts motivated or spurred timely completion of projects (Tick in appropriate box)

5. Very much	4. Much	3. Moderately	2. Very little	1. No impact

9. Please indicate three (3) of the most critical (important) factors for each of the following project stakeholders that if well addressed would reduce construction delays and greatly improve delivery dependability of road construction projects in Kenyan.

	For Employer (Client)	For Engineer	For Contractor
1			
2			
3			

Part II

10. Please fill the following details regarding completed road contracts (projects)

Road project title/description		Contract details (As initially agreed)			Contract data at completion		Nationality of Contractor (Domestic /Forcign)
		Contract Sum	Start date	Period (Months)	Substantial completion date	Actual (Final) Cost	
Rehabilitation projects							
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
Reconstruction projects							
1							
2							
3							
4							
5							
New construction projects							
1							
2							
3							
4							

Appendix 2

DATA ANALYSIS FOR TIME-COST MODELS

Gravelling (Rehabilitation)_

Initial Sum (Kshs m	Initial period Months	Initial period Days	Actual sum (Kshs m	Actual Period months	Actual Period (Days)	
450 38	24	8760	450 38	44	16060	
204 71	18	6570	204 71	25	9125	
555.13	48	17520	1034 27	73	26645	
270 28	18	6570	270 28	26	9490	
143 86	18	6570	143 86	53	19345	
68 86	6	2190	156 38	19	6935	
63 91	12	4380	63 91	32	11680	
399 74	24	8760	1022 71	65	23725	
270.7	24	8760	270.7	36	13140	
332 43	18	6570	332 43	24	8760	
27 38	6	2190	27 32	12	4380	D - EL
124 46	12	4380	124 89	12	4380	F-EL
35	6	2190	34 8	9.4	3431	D - EL

Computed t

$$t = \frac{R\,(n-2)^{1/2}}{(1-R^2)^{1/2}}$$

Where n-2 are the degrees of freedom, and
R is Pearson Product Moment Correlation Coefficient

Conclusion:

Rehabilitation (Includes Resealing/Recarpeting)

Initial Sum (Kshs m	Initial period Months	Initial period Days	Actual sum (Kshs m	Actual Period months	Actual Period Days	
332 63	18	6570	321 44	23 5	8577.5	F-EL
47.3	12	4380	46 89	16 5	6022 5	D - EL
898 56	24	8760	596 22	51	18615	
407 08	18	6570	438 99	65	23725	
517 24	18	6570	817 97	47	17155	
149 98	18	6570	337 93	56	20440	
293 67	18	6570	293 67	44	16060	
440 58	18	6570	839 77	56	20440	
155 69	24	8760	198 64	27	9855	FB
474.17	30	10950	675 71	87	31755	
327 72	18	6570	1118 16	52	18980	
260 66	12	4380	330 92	24	8760	FB
340 19	18	6570	340 19	37	13505	
601 85	18	6570	601 85	57	20805	
217 27	12	4380	217.27	24	8760	

Conclusion:

Natural Logs (For Bromilow's Time-Cost Model)

Initial period	Initial sum	Actual period	Actual Sum		
9.07	6.11	9.68	6.11		
8.79	5.32	9.12	5.32	0.5937131	Slope (Initial)
9.77	6.32	10.19	6.94		
8.79	5.6	9.16	5.6		
8.79	4.97	9.87	4.97		
7.69	4.23	8.84	5.05	5.6594	Y-Intercept (Initial)
8.38	4.16	9.37	4.16		
9.08	5.99	10.07	6.93	0.4627589	Slope (Actual)
9.08	5.6	9.48	5.6		
8.79	5.81	9.08	5.81	6.637	Y-Intercept (Actual)
7.69	3.31	8.38	3.31		
8.38	4.82	8.38	4.83		
7.69	3.58	8.14	3.55		

$Y = 5.6595 + 0.593713X$ $Y = 6.637 + 0.462759X$

$R_i = 0.9273482$ $R_a = 0.79347$ Pearson Product Moment Correlation Coefft

$R_i^2 = 0.860$ $R_a^2 = 0.630$

Critical $t_{0.95} = 1.782$

Critical $R_{0.95} = 0.4762$

Computed $t = 8.20$ Computed $t = 4.33$

Cost plays a statistically significant role in the explanation of time in road projects

$T_i = 287C^{0.5937}$ $T_a = 763C^{0.4628}$

Natural Logs (For Bromilow's Time-Cost Model)

Initial period	Initial sum	Actual period	Actual Sum		
8.79	5.81	9.06	5.77		
8.38	3.88	8.7	3.85		
9.08	6.8	9.83	6.39	0.1897176	Slope (Initial)
8.79	6.01	10.07	6.08		
8.79	6.25	9.75	6.71		
8.79	5.01	9.93	5.82		
8.79	5.68	9.68	5.68	7.6969997	Y-Intercept (Initial)
8.79	6.09	9.93	6.73		
9.08	5.05	9.2	5.28	0.4718447	Slope (Actual)
9.3	6.16	10.37	6.52		
8.79	5.79	9.85	7.02	6.7093	Y-Intercept (Actual)
8.38	5.56	9.08	5.8		
8.79	5.83	9.51	5.83		
8.79	6.4	9.94	6.4		
8.38	5.38	9.08	5.38		

$Y = 0.1897X + 7.614$ $Y = 0.472X + 6.7083$

$R_i = 0.5165469$ $R_a = 0.77700142$

$R_i^2 = 0.2668$ $R_a^2 = 0.604$

Critical $t_{0.95} = 1.761$

Critical $R_{0.95} = 0.4409$

Computed $t = 2.17$ Computed $t = 4.45$

Cost plays a statistically significant role in the explanation of time in road projects

$T_i = 2026C^{0.190}$ $T_a = 820C^{0.4718}$

Road Rehabilitation (Gravelling Projects)

Initial Sum (Kshs m	Initial period Months	Initial period	Actual sum (Kshs m	Actual Period months	
450 38	24		450 38	44	Slope (Initial)
204 71	18		204 71	25	Y-Intercept
555 13	48		1034 27	73	Ri
270 28	18		270 28	26	
143 86	18		143 86	53	Slope (Actual)
68 86	6		156.38	19	Y-Intercept
63 91	12		63 91	32	Ra
399 74	24		1022 71	65	
270 7	24		270 7	36	
332 43	18		332 43	24	
27 38	6		27 32	12	
124 46	12		124 89	12	
35	6		34 8	9.4	

Yi =13 67X - 19 44

Ya =13 95X - 143 51

Critical t 0 95 = 1 782

Critical R 0.95 = 0 4762

Computed t = 15 81

Computed t = 9 59

Road Rehabilitation Projects (Resealing/Recarpeting)

Initial Sum (Kshs m	Initial period Months	Actual sum (Kshs m	Actual Period months	
332.63	18	321 44	23.5	
47.3	12	46 89	16.5	Slope (initial)
898 56	24	596 22	51	Y-Intercept
407 08	18	438 99	65	RI
517 24	18	817 97	47	
149 98	18	337 93	56	Slope (Atual)
293 67	18	293 67	44	Y-Intercept
440 58	18	839 77	56	Ra
155 69	24	196 64	27	Y
474 17	30	675 71	87	
327 72	18	1118 16	52	
260 66	12	330 92	24	
340.19	18	340 19	37	
601 85	18	601 85	57	
217.27	12	217.27	24	

13.67309524
-19.43571429
0.900559625 Ra2 = 0.811

13.94577571
-143.5093741
0.841825749 Ra2 = 0.709

20.766
9.245
0.4748

Y = 20.77X +9.245

Critical t 0.95 = 1.761
Critical R 0.95 = 0.4409

Computed tl = 1.945

9.245
67.168
0.613058193

Computed ta = 2.798

Y = 9.245X + 67.168

Road Rehabilitation Projects (Resealing/Recarpeting)

Initial Sum (Kshs m	Initial period Months	Actual start	Actual sum (Kshs m	Actual Period months	Actual end	Adjusted Initail Price* (Dec 04 Prices)
332 63	18	Mar-99	321.44	23 5	Feb-01	**469.4**
47.3	12	Sep-99	46 89	16 5	Jan-01	**66.15**
898 56	24	Aug-99	596.22	51	Dec-03	**1257.36**
407 08	18	Oct-96	438 99	65	Mar-02	**659.12**
517 24	18	Nov-96	817 97	47	Sep-00	**837.52**
149 98	18	Aug-97	337.93	56	Apr-02	**233.8**
293 67	18	Oct-00	293 67	44	Jun-04	**378.76**
440 58	18	Sep-00	839 77	56	Jun-04	**568.81**
155 69	24	Aug-99	196 64	27	Nov-01	**217.93**
474 17	30	May-94	675 71	87	Aug-01	**1192.86**
327.72	18	Nov-00	1118.16	52	Mar-05	**422.03**
260 66	12	Oct-00	330 92	24	Oct-02	**336.39**
340 19	18	May-02	340 19	37	Jun-05	**403.68**
601 85	18	Jun-98	601 85	57	Mar-03	**897.09**
217.27	12	Jun-02	217.27	24	Jun-04	**251.89**

Road Rehabilitation (Gravelling Projects)

Initial Sum (Kshs m	Initial period Months	Duration Days	Adjusted Price* (Dec 04 Prices)	Actual sum (Kshs m	Actual Period months	Actual End	Adj Prices* Dec 04)
450 38	24	8760	**533.92**	450 38	44	16060	**450.38**
204 71	18	6570	**260.16**	204 71	25	9125	**204.71**
555 13	48	17520	**826.4**	1034 27	73	26645	**1031.67**
270 28	18	6570	**363**	270 28	26	9490	**339.34**
143 86	18	6570	**176.3**	143 86	53	19345	**143.75**
68 86	6	2190	**84.39**	156 38	19	6935	**156.35**
63 91	12	4380	**78.32**	63 91	32	11680	**63.86**
399 74	24	8760	**551.12**	1022.71	65	23725	**1009.43**
270 7	24	8760	**325.76**	270 7	36	13140	**270.7**
332 43	18	6570	**332.37**	332 43	24	8760	**332.43**
27 38	6	2190	**35.35**	27 32	12	4380	**33.6**
124 46	12	4380	**160.78**	124 89	12	4380	**156.8**
35	6	2190	**45.14**	34 8	9 4	3431	**43.65**

Adjusted Initial Price (Millions) versus Actual Period (Months)

Slope	13 041
Y-Intercept	-33.718
R	0.703

Y = 13 041X - 33.718

Critical $t_{0.95}$ = 1.761

Critical $R_{0.95}$ = 0.4409

Computed t= 3.564

Normal Linear Regression

Adj. Initial Price vs Actual Period

Slope	9.3817086
Y-Intercept	-21 91364
R	0 8118581
R2	0 6591135

Critical t0.95 = 1.782

Critical R 0 95 = 0 4762

Computec t = 4 612

Y = 9 38X - 21.91

Natural Logs (For Bromilow's Time-Cost Model)

Actual period	Adj. Initial Price
9 68	6.280246
9 12	5 5221007
10 19	6 7170789
9 16	5 8664681
9 87	5 1721871
8 84	4 4354489
9 37	4 360803
10 07	6.3119526
9 48	5 7861609
9 08	5 8062488
8 38	3 5652984
8 38	5 080037
8 14	3 8097688

Slope	0 513
Y-Intercept	6 528
R	0.776

Y = 0 513X + 6 528

Critical $t_{0.95}$ = 1 761

Critical $R_{0.95}$ = 0 4762

Computed t =4 229

Road Rehabilitation Projects (Resealing/Recarpeting)

Initial Sum (Kshs m	Initial period Months	Actual start	Adj'd Price* (Dec 04 Prices)	Actual sum (Kshs m	Actual Period months	Actual end	Adjusted Price* (Dec 04 Prices)
332.63	18	Mar-99	**469.4**	321 44	23 5	Feb-01	**411.53**
47.3	12	Sep-99	**66.15**	46 89	16.5	Jan-01	**60.03**
898 56	24	Aug-99	**1257.36**	598 22	51	Dec-03	**630.95**
407 08	18	Oct-98	**659.12**	438.99	65	Mar-02	**520.69**
517.24	18	Nov-96	**837.52**	817 97	47	Sep-00	**1056.03**
149 98	18	Aug-97	**233.8**	337.93	56	Apr-02	**400.9**
293 67	18	Oct-00	**378.76**	293 67	44	Jun-04	**293.45**
440 58	18	Sep-00	**568.81**	839 77	56	Jun-04	**839.14**
155 69	24	Aug-99	**217.93**	198 64	27	Nov-01	**241.43**
474.17	30	May-94	**1192.86**	675.71	87	Aug-01	**838.42**
327.72	18	Nov-00	**422.03**	1118 16	52	Mar-05	**1118.16**
260.66	12	Oct-00	**336.39**	330 92	24	Oct-02	**394.75**
340 19	18	May-02	**403.68**	340 19	37	Jun-05	**340.19**
601 85	18	Jun-98	**897.09**	601 85	57	Mar-03	**657.31**
217.27	12	Jun-02	**251.89**	217.27	24	Jun-04	**217.11**

Natural Logs (For Bromilow's Time-Cost Model)

Initial Period	Inital Price	Actual period	Adj Initial Price
8.79	5.8070308	9 06	6 1514553
8 38	3 8565103	8 7	4.1919249
9.08	6 8007935	9 83	7.1367616
8.79	6.0090097	10.07	6 4909056
8.79	6.248507	9.75	6.7304451
8.79	5 010502	9 93	5 454466
8 79	5.6824567	9 68	5 9369028
8 79	6 088092	9 93	6 3435465
9 08	5 0478669	9 2	5.3841739
9 3	6 1615659	10 37	7 0841091
8.79	5.7921596	9 85	6.0450764
8 38	5.5632169	9.08	5.8182712
8.79	5 8295043	9.51	6.0006225
8.79	6 4000082	9.94	6.7991562
8 38	5.3811408	9 08	5.5289925

Slope	0.189	Slope	0 464
Y-Intercept	7.699	Y-Intercept	6 781
R	0.516	R	0.752

Y = 0.189X + 7.699

Y = 0 464X + 6 781

$T = 880.9C^{0.464}$

Critical $t_{0.95}$ = 1.771

Critical $R_{0.95}$ = 0.4409

Computed t= 2.172

$T = 2206C^{0.189}$

Computed t = 4.407

Natural Logs (For Bromilow's Time-Cost Model)

Initial period	Initial Sum
9 483416292	6 445719819
8 990939807	5.379897354
9 077951184	5 264553736
8 384804003	4 919980926
8.790269111	4 477336814
8 790269111	4 430816799
8 607947565	4 382026635
8 895629627	4 624972813

Slope	0 369282572
Y-Intercept	7.118
R	0 789102591

Critical $t_{0.95}$ = 1 895

Critical $R_{0.95}$ = 0 6215

Computed t= 2 4495

Y = 0 37X + 7 56

R2 0 623

$T = 1234C^{0.188}$

Urban Roads Rehabilitation Project

Initial Sum (Kshs m	Initial period Months	Duration (days)	Initial Start	Initial End
630	36	13140	May-05	May-08
217	22	8030	Jun-05	Apr-07
193 36	24	8760	Nov-05	Nov-07
137	12	4380	Jul-05	Jul-06
88	18	6570	Feb-06	Aug-07
84	18	6570	Mar-05	Sep-06
80	15	5475	Apr-05	Jul-06
102	20	7300	Feb-05	Oct-06

Initial Cost versus Initial Period in Months

Slope	22 9546198
Y-Intercept	-282 0190335
R	0 90374677
R2	0.816758225

Y = 22 95X - 282

Critical $t_{0.95}$ = 1.895

Critical $R_{0.95}$ = 0 6215

Computed t = 5.170

Overall (Inter-Urban Roads Rehabilitation) - both gravelling and resealing/recarpeting

Natural Logs (For Bromilow's Time-Cost Model)

Initial period	Initial sum	Actual period	Actual Sum
9.07	6.11	9.68	6.11
8.79	5.32	9.12	5.32
9.77	6.32	10.18	6.94
8.79	5.6	9.16	5.6
8.79	4.97	9.87	4.97
7.69	4.23	8.84	5.05
8.38	4.16	9.37	4.16
9.08	5.99	10.07	6.93
9.08	5.6	9.48	5.6
8.79	5.81	9.08	5.81
7.69	3.31	8.38	3.31
8.38	4.82	8.38	4.83
7.69	3.56	8.14	3.55
8.79	5.81	9.06	5.77
8.38	3.86	8.7	3.85
9.08	6.8	9.83	6.39
8.79	6.01	10.07	6.08
8.79	6.25	9.75	6.71
8.79	5.01	9.93	5.82
8.79	5.68	9.68	5.68
8.79	6.09	9.93	6.73
9.08	5.05	9.2	5.28
9.3	6.16	10.37	6.52
8.79	5.79	9.85	7.02
8.38	5.56	9.08	5.8
8.79	5.83	8.51	5.83
8.79	6.4	9.94	6.4
8.38	5.38	9.08	5.38

0.41756894 slope (initial)
6.44451803 Y- intercept

0.47644811 Slope (actual)
6.74028605 Y-Intercept (Actual)
Ri 0.797268701
Ra 0.812548022 } Pearson Product Moment Correlation Coefficient

Critical $t_{0.95}$ = 1.314
Critical $R_{0.95}$ = 0.3207
Computed ti = 6.73 Computed ta = 7.12
Cost plays a statistically significant role in the explanation of time in road projects
$Ti = 630C^{0.4176}$ $Ta = 846C^{0.4764}$