Time-Cost Optimization of Kenya Government Construction Projects Delivery: The Case of Kenya Roads Board

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Abstract Every human activity utilizes time, but time is limited in. This means that the supply of time is perfectly inelastic and due to its nature, need for optimal utilization of time is imperative. Therefore, the timely completion of construction projects is considered one of the most important factors referring to project success. The literature reviewed in this paper is on time-cost optimization of Kenya government construction projects delivery by the Kenya Roads Board. The objectives of the literature review include finding out the time-cost optimization techniques used by Kenya Roads Board for the delivery of the government construction projects, examining how the construction time and Cost Management affects the delivery of Kenya government construction projects by the Kenya Roads Board, establishing the relationship between time and cost on the delivery of Kenya government construction projects by the Kenya Roads Board and identifying the time-cost optimization challenges affecting the delivery of Kenya government construction projects by the Kenya Roads Board. The theories that inform this study include system theory, Pareto Principle and the Triple Constraint Theory. The proposed study will apply a descriptive survey design which is deemed appropriate for this research because it can be used to obtain information concerning the current status of events and to describe what exists with respect to variables or conditions in a unique situation. The findings literature review established that the common causes of time and cost overruns in government construction projects is the incompetence of contractors before, lack of client's commitment to finance projects in timely manner, owing to the outdated procurement processes utilized and corruption on the part of officers involved. The common techniques used in the time-cost optimization for construction projects include PERT, genetic algorithm, Critical Path Method. There are little attempts which have been made with regards to the time-cost optimization in Kenyan government road construction projects. Hence, there is need for a study to be done to examine the time-cost optimization in Kenyan government road construction projects.

Keywords: time management, Kenya Roads Board, KERRA, KURA, Kenya government, Gross Domestic Product (GDP)

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1. Introduction

Construction project is a major industry throughout the world accounting for a sizeable proportion of most countries' Gross Domestic Product (GDP) and Gross National Product (GNP). According to an observation made by [1]. the importance of the construction sector is not only related to its size but also to its role in economic growth. An industry sector this big could not but have an impact on the economy. Reference [2] reinforces this statement by stating that the construction industry is an economic investment and its relationship with economic development is well posited, with many studies having highlighted the significant contribution of the construction industry to national economic development. Although some argue that the extent of its contribution is not always clear, others have argued that the construction industry can be used to regulate the economy.

Reference [3] state that with regard to the relationship of the construction industry to economic growth, it does not in any way invalidate the importance of the construction industry in providing the necessary infrastructures that stimulate economic development. As such, the industry is required for national development. It has been argued that for a country to have meaningful and sustained development, it urgently requires to stabilize its construction industry, because if the construction industry is inefficient, it will be difficult for such a country to attain meaningful development.

Within the construction process, time and cost are critical resources which cannot be overlooked. Time is the most precious asset available to man which cannot be

stored, recovered or transferred. Every human activity utilizes time, but time is limited in supply since we only have 24 hours in a day, 7 days a week etc. This means that the supply of time is perfectly inelastic and due to its nature, need for optimal utilization of time is imperative. According to [4], time is money, and delay in a certain construction project affects time and thus money, which is the lifeblood of any economy. Therefore, the timely completion of highway construction projects is considered one of the most important factors referring to project success.

Time being one of critical resources, and one of vital determinants of project success has huge importance in the modern business world. To be first in the market, to gain competitive advantage and to reduce time dependent costs can be motivational factors for companies trying to compress their schedules. Need to reduce project duration is leading firms to continuously search for tools and techniques to do so. There are many scheduling techniques available as well as many tools for reducing project duration which are being put to practice today. However, available data shows that there are a significant number of projects which exceed their planned schedules.

The cost effective scheduling is one of the most important aspects of the construction project management. Traditionally used methods for the cost effective project scheduling in construction management include either the Critical path method (CPM) or the program evaluation and review technique (PERT) combined with trial-and-error procedure. In this way, the cost effective project schedules are achieved in a time-consuming cost-duration analysis of various alternatives for start times and durations of construction project activities. However, doubt always exists as to whether or not the obtained project schedule is optimal.

In Kenya, Infrastructure development is a central pillar of Kenya's Vision 2030 and in 2015 the US$3bn construction sector contributed 4.8% to the Kenyan economy. The Economic Survey 2016 published by the Kenya National Bureau of Statistics as reported by [4], 2016) reported that approximately 148,000 people are formally employed in the domestic building and construction industry. Currently 11 of the 43 major infrastructure projects in East Africa are in Kenya. These mega-projects include the US$3.8bn Mombasa - Nairobi Railway Project, the US$2.1bn Tatu City Project, the US$1bn Lamu Port Berths Project and the US$900m Lake Turkana Wind Power Project. According to [5], demand for housing continues to grow with role players estimating that more than 210,000 new residential units need to be built annually to keep pace with Kenya's expanding population. With crude oil production in the Great Rift Valley set to commence in the first half of 2017, many analysts predict that the country is on the cusp of an unprecedented construction boom.

Kenya Roads Board (KRB) is a statutory body established by the Kenya Roads Board Act No. 7 of 1999 in accordance with Chapter 446 (State Corporations Act) of the Laws of Kenya. Kenya Roads Board is a State Corporation under the Ministry of Transport, Infrastructure, Housing, and Urban Development. As stipulated in the Kenya Roads Board Act of 1999, the object and purpose for which the Board was established is "to oversee the road network in Kenya and coordinate the maintenance, rehabilitation and development funded by the Fund and to advise the Minister on all matters related thereto."

According to [6], ninety three percent (93%) of all freight and passenger traffic in Kenya is carried by road. The road network is extensive, consisting of approximately 161,451.4 kilometers out of which 10% is paved, while the rest of the network is either gravel or earth roads. It is estimated that about 30% of the paved roads are in good condition while only about 20% of the unpaved roads is in maintainable condition. Hence a large portion of the network is in either poor or failed condition and requires urgent rehabilitation to restore it to a maintainable condition.

According to the latest data from the Road Inventory and Condition Survey as cited by [7], the condition of paved roads is - 19% good, 22% fair and 59% poor; while the condition of unpaved roads is - 12% good, 22% fair and 66% failed. During 2016, the Board allocated and released funds in accordance with the published Annual Public Roads Programme (APRP) to the Road Agencies who have reported an expenditure of Kshs. 29.07 Billion for maintenance of 36,689km of roads, against the target of Kshs 29.18 Billion for maintenance of 49,350km. The Board will continue to evaluate the delivery of road works to assure value for money. As such, this study examines the time-cost optimization as a factor in relation to the delivery of government construction projects by the Kenya Roads Board.

The delays on the delivery of construction projects are seen as one of the most frequent problems in the construction industry. The aftermath of delays affects all people and organizations involved in the project. This is especially true for the owner's business since delaying the startup of the project will impede obtaining the expected project revenue and will increase financial costs. In addition, the owner may face several other difficulties resulting from the commitments delivery date established in the contract.

On the other hand, prolonging the project execution time usually results in contractors who have to deal with cost overruns due mostly to the extra expenses on management personnel, cost escalations of materials, increase of financial cost, paying contract penalties, and so forth. Moreover, given the usual competitive environment in the construction industry, contractors who fail to complete projects on time may get their reputation harmed and become impeded to obtain new contracts. Project quality can also be affected due to construction delays since the construction team usually dedicates less time to quality control when the main concern is completing the project on time. When this is the case, workers are usually pushed to work overtime and to increase the production rate, which very often entails failures and reworks. In developing countries, delays during the construction of public assets, such as schools, could also result in social harm given the fact that this kind of infrastructure is usually urgently needed. Therefore, the sooner those projects are completed, the better for satisfying the social needs in those countries.

By nature, government and private projects bear different characteristics which influence their performance. Government projects have more complex and longer

bureaucracy which in turn impact on contractor performance and delivery. Government contractors undertake government funded projects, which could be in local or central government undertaking public facilities, such as public buildings, roads, bridges, and dams. Ultimate decisions on the implementation of the schedules lie with the contractor. However, governments have a nonlinear decision process and this impedes the desired execution on the part of the contractor for success. This study concerns itself with the time-cost optimization of Kenya government projects, specifically in Kenya Roads Board

2. Literature Review

2.1. Systems Theory

The general systems theory as an approach to knowledge was first developed by [8], a well-known biologist, in the 1920s. According to [8], it seems legitimate to ask for a theory, not of systems of a more or less special kind, but of universal principles applying to systems in general, which until now was considered a vague, hazy, and semi-metaphysical concept. Social science is one area where systems theory has been applied. In this study, for example, all institutions undertaking a project do so within a time frame, expecting to make returns on investment. However, projects are a conglomeration of processes and stages which have to be observed in sequence to reach completion. Project processes are interdependent components making a whole system. A system is a set of objects or entities that interrelate with one another to make a whole. Reference [9] view a system as "a set of interacting units that endure through time within an established boundary by responding and adjusting to change pressures from the environment to achieve and maintain goal states. In the case of projects, the set of interacting units includes the client and the contractors with whom they will have relationships. Systems theory is therefore about interdependence and gives a way of looking at relationships by looking at parts and wholes, enabling us to look at how parts are related.

In the context of the study, the system theory finds its application. This is whereby the delivery of government construction projects requires various parts to be put in place and to operate uniformly. For instance, there is need for the time to be scheduled and the cost for covering that time be calculated so as to project on the period that may be taken in delivering the construction projects.

2.2. The Pareto Principle

The Pareto Principle is also commonly referred to as the 80-20 rule. This principle was formulated by an Italian economist and philosopher known as Vilfredo Pareto. In coming up with the principle, Pareto indicated that the vast majority of impact in anything comes from a small proportion of activities, people or effort. The observation was based on demographic data in Italy. 80% of the land was owned by 20% of the population. And 80% of productivity from these lands came from 20% of those

working on it. The 20% who made things happen were generally more efficient, managed time better, and streamlined operations for the highest leverage. Based on this theory, time management guides and coaches advice people to focus on the 20% of activities or tasks which are more important to the overall success. The effort and time that one devotes to this creamy layer will more than outweigh the investments into the rest.

The focus of the Pareto principle is that by analyzing the problem sources, usually few causes appear more frequently than others. This principle serves as a general reminder to prove the relationship between inputs and outputs is usually not balanced. For instance, a lower fraction of efforts could drive firm's profits and vice versa, most of managers' time is often inadequately spent in activities that have a poor contribution in achieving company results [10]. These Pareto-type observations are not necessarily bad, or good. A good example in the context of road construction is whereby if only 20% of the roads in a town handle 80% of the traffic, then that could be good for a maintenance crew who can concentrate mainly on the fewer roads; but it could be bad for commuters who take the busy roads. Such Pareto observations could lead to strategies; road crews could try to move commuters off of the busy roads, or commuters could move off on their own. As such, this theory finds its application in the current study.

2.3. The Triple Constraint Theory of Projects

This theory was created in the mid-1980s by Dr. Martin Barnes. The triangle was created to demonstrate that the quality (scope), cost and time interrelated. According to an observation made by [11], focusing or fixing one point of the triangle impacts the other two points. The theory argues that these three main constraints need to be adequately managed so as to enhance project delivery. It can be noted that each constraint in the triangle is connected and moving one point of the triangle will impact the other two points. Figure 1 shows a diagram representing the triangle.

Figure 1. The Triple Constraint Model (Source: Reference [12])

The triangle comes into play when something affects one of its "legs." If that happens, one may need to adjust

one or both of the other elements to accommodate the change. For example, if a client suddenly shortens a time frame, then a project will likely need more resources, or perhaps a scope reduction. Every project needs guardrails. Even on a basic level, these guardrails are all concepts everyone should be able to agree upon before the first day of any project. The triangle provides a clear way to signal to stakeholders scope creep.

It also demonstrates what tradeoffs can and should be weighed and made. The triangle model also empowers project managers to measure external factors and forces and their effect on one or more "legs." In the context of the study, government construction projects require proper optimization of time and cost so as to facilitate it delivery. The model creates a pathway for the researcher in better understanding the importance and relationship between the time and cost in the delivery of construction projects.

2.4. Empirical Studies

Reference [13] carried out an evaluation on the time-cost optimization of construction projects with generalized activity constraints, the results indicated that both methods effectively simulated the structure of construction projects, and their application could provide time and cost savings. In a study carried out by [14], there were various techniques in cost optimization of construction projects that were suggested. Some of these techniques included the Critical Path Method and the Program evaluation and review technique (PERT). Critical Path Method (CPM) was developed to optimize the organization of complex procedures of an activity network and also to identify critical activities in a network critical path. Because activities in the network can be carried out in parallel, the critical path is the length of the longest path from the start of project to its finish

Reference [15], in their study established that utilization of the model was effective especially in improving the decision making process. A good example may be the study by [16] which developed a simplified spreadsheet-based model for TCT problem using integer programming. Other studies such as those done by [17,18] and [19] utilized the heuristic methods for solving the TCT problem. On the other hand, the traditional trade-off has been extended in the modern studies to include various components such as quality, resources, and environmental issues. A study by [20] for example came up with a time-cost-quality trade-off optimization model for highway construction.

There are various studies which have been done regarding the techniques of time and cost optimization in the construction projects. For instance, [21] in their study introduced an approach for modeling and optimization of an overall construction schedule presented on a spreadsheet using Genetic Alogarithm. The model integrated time-cost trade-off (TCT), resource allocation, resource leveling, and cash flow simultaneously. They optimized the time, cost, resource, and cash flow via an aggregated cost objective function. Additionally, [22] presented a GA model for resource-constrained scheduling and TCT.

They used the quadratic penalty function to transform the constrained resource scheduling problem to an unconstrained one. Also, [23] introduced an optimization model which integrates resource constraints and cash flow management issues, and maximizes net cash flow to

optimize project profit from the contractors' perspective. Despite the contribution of these studies on the techniques they fail to show how the optimization techniques influence the delivery of the projects. This current study on the other intends to establish the techniques used by the KRB and how it affects the delivery of government construction projects in Kenya

It is one of the most critical resources in any project. Reference [24] opine that it is also one of vital success criteria for every kind of project. Time management in projects involves processes required to accomplish timely completion of projects. According to [25] project scheduling represents the conversion of project goals into an achievable methodology for their completion. He further elaborates; it creates a timetable and reveals the network logic that relates project activities to each other in a coherent fashion [25] Scheduling according to [24], determines when every single activity should be undertaken in order to finish the project on time

A project is a temporary endeavor undertaken to create a unique product, service, or result. Projects by definition are time bound activities, meaning they have a definite beginning and definite end point. For undertaking any tasks, there are certain activities to be performed, and certain steps to be followed, and these activities should be performed sequentially. According to [26], eight hundred and forty five of Kick starter top projects in the USA missed their targeted delivery dates. Reference [27] studied 50 most funded projects around the USA and found that out of the studied projects; only 8 out of the 50 met their set deadlines. Successful execution of projects and keeping them on time and within budget depends on effective planning and scheduling right from the beginning. This statement is supported by [28] and [29] who observe that high levels of experience and accurate time and cost estimation are necessary to plan a project effectively.

Reference [30] and [31] found that delayed payments, slow delivery of payments, coordination problems and poor communication were important causes of delay in construction projects in Egypt. Reference [32] found that poor planning, poor site management, inadequate supervisory skills on the part of the contractor, delayed payments, material shortages, labour supply shortages, equipment availability and failure, poor communication and rework were the most important causes of delays in the Malaysian construction industry.

The independent variable on the other hand is the time-cost optimization. The relationship between the variables is as presented by the figure below.
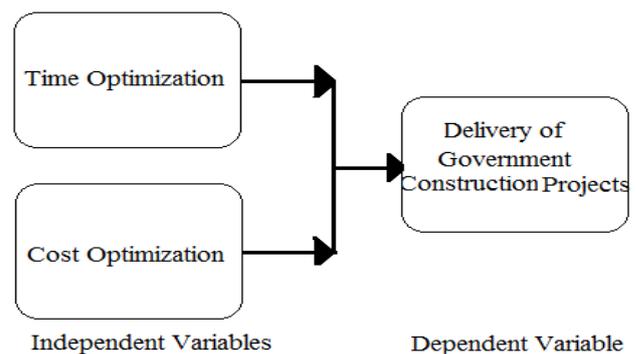
Figure 2. Conceptual Framework

3. Methodology

The adopted literature review methodology. The literature reviewed in this paper is on time-cost optimization of Kenya government construction projects delivery by the Kenya Roads Board. The objectives of the literature review included finding out the time-cost optimization techniques used by Kenya Roads Board for the delivery of the government construction projects, examining how the construction time and Cost Management affects the delivery of Kenya government construction projects by the Kenya Roads Board, establishing the relationship between time and cost on the delivery of Kenya government construction projects by the Kenya Roads Board and identifying the time-cost optimization challenges affecting the delivery of Kenya government construction projects by the Kenya Roads Board. The theories that inform this study include system theory, Pareto Principle and the Triple Constraint Theory.

4. Conclusion and Recommendation

As it has been reviewed in this study, construction projects play an important role in the overall development of a country and its economy. Government projects are always huge and they may take a lot of money and time to be completed. However, over the years, there have always been delays in the completion of the projects. The reviewed literature has also been able to show the different techniques that are used in time-cost optimization for the construction projects. Some of the techniques that have been pointed out in the review of literature include the Critical Path Method and the Program evaluation and review technique (PERT) [14], the standard set up by estimator method, Subdivision by detail method, particle swarm method [15], dynamic, integer, and linear programming [16] among many others. All these techniques have their unique roles that they play in the time-cost optimization processes. Delays in project delivery were largely influenced by the presence of cost overruns. The major causes of such overruns which affect the delivery of government projects as pointed out in the literature include delayed payments, financial deficiencies on the part of the client or the contractor, contract modifications, economic problems, material procurement problems, changes in design drawings, staffing problems, unavailability of equipment, poor supervision, construction mistakes, poor coordination on site, changes in specifications, labour disputes and strikes [32,33].

Acknowledgements

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