Time and cost performance in construction

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One of the most essential problems confronting the water and sanitation sector in the northern region of Ghana is performance of cost and time. In most cases time overruns occur in the donor-funded projects and in the extreme cases cost overruns. Time and cost overruns occur in almost all related water and sanitation construction projects in the northern region of Ghana. It is therefore essential to define the actual performance difficulties in order to make light of and avoid the delays and increasing cost in any donor-funded water and sanitation project. In the ESAs funded water and sanitation projects, the aim of project control is to ensure the projects finish on time, within budget and achieving other project objectives. It is a complex task undertaken by project managers in practice, which involves constantly measuring progress; evaluating plans; and taking corrective actions when required (Kerzner, 2003). During the last few decades, numerous project control methods, such as Gantt Bar Chart, Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM), have been developed (Nicholas, 2001) (Lester, 2000). A variety of software packages have become available to support the application of these project control methods, for example Microsoft Project, Asta Power Project, Primavera, etc. Despite the wide use of these methods and software packages in practice, many of these donor-funded projects in the north still suffer time and cost overruns. This chapter reviews literature concerning the major issues of and cost and time performance in order to recognize the related information regarding those issues.

Definition of Time and Cost Performance

Time Performance

Time performance is defined as meeting the duration baseline in the initial planning process of the project. Time overruns occurs when there is an extension of time beyond planned completion dates traceable to the major stakeholders (Kaming et al., 1997). Delays are incidents that impact a project’s progress and postpone project activities; delay causing incidents may include unavailability of resources, communication problems, slowness in decision making, design delays, etc. In general, project delays occur as a result of project activities that have both external and internal cause and effect relationship (Vidalis and Najafi, 2002). (Choudhury and Phatak, 2004) and (Chan-Albert, 2001) defined the time overruns as the differentiation between the actual completion time and the estimated completion time. Project delays are those that cause the project completion date to be delayed (Al-Gahtani and Mohan, 2007).

Cost Performance

Cost performance is defined as the zero difference between the budgeted/original cost estimate of the project and in some cases spending below the estimated cost of the project. Cost variance occurs when there is an excess of actual cost over budget or below budget. Cost variance in construction projects often result in an overrun which is also occasionally called “ cost escalation,” “ cost increase,” or “ budget overrun.” (Zhu and Lin, 2004). Cost overrun is defined as the change in contract amount divided by the original contract award amount . This calculation can be converted to a percentage for ease of comparison (Jackson, 1999).

(Choudhury and Phatak, 2004), defined the cost overruns as the differentiation amid the original cost estimate of project and actual cost on completion of works of a commercial sector construction project.

“ Cost is among the major consideration throughout the project management life cycle and can be regarded as one of the most important parameters of a project and the driving force of project success” (Azhar et al., 2008, p. 7). (Gido and Clement, 2003), mentioned that cost performance is an effective technique in project management effort expended and it is widely accepted in the literature and industry. Earned Value Analysis (EVA) is used to evaluate cost performance of different types of projects. Cost control, cost estimating, and cost budgeting are three cost related processes that interact among each other and with other scopes of construction projects.

Time variance for water and sanitation projects

Time variance (Tv) is the time between the scheduled contract time and the completion time in undertaking the projects.

Bromilow’s Time-Cost Model

Bromilow was the first to develop an empirical model for the prediction of construction time using the project cost. The model known as Bromilow’s time-cost (BTC) model, developed and published in Australia in 1969, was developed for giving a fast and construction schedule estimate using project cost. The model provides a forecast of construction schedule using the estimated final cost of the project. Bromilow’s model disclosed that the construction duration was highly correlated with the project cost (Bromilow, 1969). The model was developed by the use of a linear regression model. (Hoffman et al, 2007), confirmed that, Bromilow was triumphant in providing

a point estimate as well as upper and lower quartile limits of construction duration using past project data. (Ameyaw et al, 2012).

The correlation was re-tested by (Bromilow, 1988) collaborated with the Australian Institute of Quantity Surveyors (AIQS) in two transcribe contract time performance studies, in 1976 and 1988. (Bromilow, 1988), investigated 408 projects built between 1970 and 1976 and establish that despite indication of superior disparity between the time performance of projects of comparable value, ‘ the correlation between construction duration and project cost revealed in the 1960s is pertinent.’ Even though project time is influenced by many other factors including cost, some success has been chalked in an attempt to model project time. The model as first developed by (Bromilow, 1969) is expressed as T = KCB. T represents project duration, C actual cost of the project including fluctuations and variations, K is a constant showing the level of time performance for a unit of C, and B is a constant describing how the time performance was affected by project size as measured by the cost. (Long et al, 2009), argued that the application of Bromilow’s time-cost model in estimating and benchmarking the project duration has been vigorous while some studies have suggested that the application of this model is unsuitable. More importantly, (Mensah, 2010), adopted the Bromilow’s time cost model to estimate project duration on donor funded feeder roads in Ghana and found it applicable.

Auxiliary analysis showed the original Bromilow time-cost model is not the best fit regression form, and alternative models were proposed. All the researchers identified cost was a poor forecaster of time performance, and further proposed an alternative model to that proposed by Bromilow (1969).

(Kaka and Price, 1991), used the time-cost model for both civil and building projects and indicated that the original model, as introduced by (Bromilow, 1969), remained unchanged but the coefficient of the equation changed with the project type.

(Al-Momani, 2000), stated that the owner satisfaction for performance can be defined as the gap between what the owner expects and the level of performance they believe is being delivered by the contractors. (Lehtonen, 2001), stated that performance measurement is a basis for progressive improvement and monitoring of company productivity. (Chan and Kumaraswamy, 2002) remarked that project performance measurement include time, budget, safety, quality and overall client satisfaction. (Thomas et al., 2002), defined performance measurement as monitoring and controlling of projects according to regular basis. (Kuprenas, 2003), stated that project performance measurement means an improvement of cost, schedule, and quality for design and construction stages. (Long et al, 2004), stated that a project performance measurement is related to many indicators such as time, budget, quality, specifications and stakeholders' satisfaction. (Navon, 2005), defined performance measurement as a comparison between the desired and the actual performances.

Problem of Performance in Construction Industry

The failure of any construction project is mainly related to the problems and failure in performance. Moreover, there are many reasons and factors which attribute to such problem. (Ogunlana et al., 1996), stated that the construction industry performance problems in developing economies can be classified in three layers: inadequacies in industry infrastructure (resources

supply), clients and consultants caused problems and contractor incompetence/inadequacies. (Okuwoga, 1998), identified that the performance problem is related to poor budgetary and time control. (Long et al, 2004), remarked that performance problems arise in large construction projects due to many reasons such as: incompetent designers/contractors, poor estimation and change management, social and technological issues, site related issues and improper techniques and tools. (Navon, 2005), stated that the main performance problem can be divided into two groups: (a) unrealistic target setting (i. e., planning) or (b) causes originating from the actual construction (in many cases the causes for deviation originate from both sources).

(Samson and Lema, 2002), found that the traditional performance measurement systems have problems because of large and complex amount of information with absence of approaches to assist decision maker understand, organize and use such information to manage organizational performance. (Navon, 2005), remarked that traditional project performance control is usually generic (e. g., cost control techniques). It relies on manual data collection, which means that it is done at low frequency (normally once a month) and quite some time after the controlled event occurred (i. e., not in real-time). Moreover, manual data collection normally gives low quality data.

(Ling et al., 2007), remarked that architectural, engineering and construction (AEC) firms may encounter challenges managing construction projects performance in China because of unfamiliarity with this new operating environment. (Kim et al., 2008), stated that international construction

projects performance is affected by more complex and dynamic factors than domestic projects; frequently being exposed to serious external uncertainties such as political, economical, social, and cultural risks, as well as internal risks from within the project.

Project Management and Performance

There is a strong relation between project management and project performance. Management in construction industry is considered as one of the most important factors affecting performance of works. (Brown and Adams, 2000) studied a new approach to the measurement of the effect of Building Project Management (BPM) on time, cost and quality outputs using 15 `cases' derived from UK data. The evaluation undertaken demonstrates that BPM as it is presently implemented in the UK fails to perform as expected in relation to the three predominant performance evaluation criteria; time, cost and quality. (Lehtonen, 2001), obtained a model for performance measurement which assist both firms' top management and operational managers for continuous feedback on operational activities. (Thomas et al., 2002), stated that documenting and archiving performance data could be useful for future reference, such as for settling disputes on claims, and in maintenance and repair works. (Kuprenas, 2003), remarked that quantification of the impacts of the project management processes are identified through three steps of analysis: comparison of summary statistics of design performance, proof of statistical significance of any differences and calculation of a least squares regression line of a plot of design performance measurement versus amount/application of project management as a means to quantify management influence to design phase cost performance.

(Cheung et al., 2004), studied the project performance related to project managers and remarked that development of a Web-based construction Project Performance Monitoring System (PPMS) can assist project managers in exercising construction project performance indicators and can help senior project management practitioners, etc., in monitoring and assessing project performance. (Pheng and Chaun, 2006), stated that while project management is only one of the many criteria upon which project performance is contingent, it is also arguably the most significant as people formulating the processes and systems who deliver the projects. (Ugwu and Haupt, 2007), stated that an adequate understanding and knowledge of performance are desirable for archiving managerial goals such as improvement of institutional transformations, and efficient decision making in design, specification and construction, at various project-level interfaces, using appropriate decision-support tools. (Ling et al., 2007), investigated Project Management (PM) practices adopted by Singaporean construction firms and dogged the level of performance of their projects in China; they identified PM practices that led to better performance; and recommended key PM practices that could be adopted by overseas construction firms in China to improve project performance.

Water and Sanitation Projects and Performance

Success of projects depends mainly on success of performance. Many previous researches had studied performance of construction projects. (Dissanayaka and Kumaraswamy, 1999), remarked that one of the principal reasons for the construction industry’s poor performance has been attributed to the inappropriateness of the chosen procurement system. (Reichelt and

Lyneis, 1999), remarked three important structures underlying the dynamic of a project performance which are: the work accomplishment structure, feedback effects on productivity and work quality and effects from upstream phases to downstream phases. (Thomas et al., 2002), identified the main performance criteria of construction projects as financial stability, progress of work, standard of quality, health and safety, resources, relationship with clients, relationship with consultants, management capabilities, claim and contractual disputes, relationship with subcontractors, reputation and amount of subcontracting. (Chan and Kumaraswamy, 2002), stated that construction time is increasingly important because it often serves as a crucial benchmarking for assessing the performance of a project and the efficiency of the project organization.

(Cheung et al., 2004), identified project performance categories such as people, cost, time, quality, safety and health, environment, client satisfaction, and communication. It was obtained by (Navon, 2005), that a control system is an important element to identify factors affecting construction project effort. For each of the project goals, one or more Project Performance Indicators (PPI) is needed. (Pheng and Chaun, 2006), obtained that human factors played an important role in determining the performance of a project. (Ugwu and Haupt, 2007) remarked that both early contractor involvement (ECI) and early supplier involvement (ESI) would minimize constructability-related performance problems including costs associated with delays, claims, wastages and rework, etc. (Ling et al., 2007), obtained that the most important of practices relating to scope management are controlling the quality of the contract document, excellence of reaction to

perceived variations and extent of changes to the contract. It was recommended for foreign firms to adopt some of the project management practices highlighted to help them to achieve better project performance in China.

Information Technology and Water and Sanitation Projects Performance

Information technology technique is very important in the entire world. Information technology (IT) opens new visions in the businesses and industries performance of the world. The construction industry is considered as one of the industries using IT technique such as software management systems, database and communications. For many years, many processes, functions, operations were done difficulty because of absence of IT field. In addition, most of the work was done manually which lead to more cost, time and poor performance. Furthermore, IT usage in the construction industry leads to many changes, innovations and developing in many aspects which lead finally to good and strong performance. There are many benefits and relations of using IT in the construction projects such as: greater use of IT correlates with better project performance, owners and contractors realize meaningful benefits, IT affects schedule compression beneficially, and overall project cost savings which lead to a success performance of project (Schwegler et al., 2001).

(Nitithamyong et al., 2004), remarked that information Technology (IT) is now routinely used in the construction industry as a tool to reduce some of the problems generated by fragmentation. The use of IT improves coordination and collaboration between firms participating in a construction

project, leading to better communication practices and so good performance. Its benefits include an increase in the quality of documents and the speed of the work, better financial control and communications, and simpler and faster access to common data as well as a decrease in documentation errors.

(Thomas et al., 2002), proposed contractor Performance Appraisal and Reporting (PAR) system for reviewing contractor performance at an organizational level. Advancements in World Wide Web techniques provide enhanced capacities to collect compile and disseminate performance-related information to various construction stakeholders in a timely and cost-effective manner. (Becerik, 2004), stated that the rapid advances of web-based project management and collaboration technology offer new opportunities to improve existing construction project performance. (Cheung et al., 2004) obtained framework software to measure project performance based on project performance measurement system (PPMS). The system contains four stages which are data entry, database, reporting and action. This system has eight categories to measure performance which are people, cost, time, quality, safety and health, environment, client satisfaction, and communication. (Goh, 2005), remarked that information technology management leads to performance improvement in the construction industries. For instance, in Singapore 2003, general administration, design, project management and site management were enhanced by using of IT. In addition, there were more advantages as quick working, good quality of work and fast access of information.

Factors Affecting Performance of Managers

(Ogunlana et al., 1996), recommended the need for focused effort by economy managers and construction industry associations to provide the infrastructure needed for efficient project management and performance. (Dissanayaka and Kumaraswamy, 1999), stated that the knowledge that would influence potential performance enables project managers to pay special attention to control performance more effectively. (Chan and Kumaraswamy, 2002), remarked that effective communication and fast information transfer between managers and participants help to accelerate the building construction process and performance. (Kuprenas, 2003), studied the impact of the use of a project management based organizational structure, project manager training, frequency of design meetings, and frequency of design reports on design phase cost performance. The process of a design team meeting frequency and the process of written reporting of design phase progress were found to be statistically significant in reducing design phase costs.

(Navon, 2005), stated that data are collected and used for construction managers as a basis to evaluate the Project Performance Indicators (PPI) actual value to compare it with the planned value and forecast its future value based on past performance. (Pheng and Chaun, 2006), identified the importance of the working environment variables for the performance of a project manager in the private and public sectors according to three main groups which are job condition, project characteristic and organizational related categories. The result revealed that working hours, physical condition of project site, complexity of project, material and supplies, project size,

duration of project and time availability were viewed differently in terms of importance by the contractors and consultants groups. Team relationship was ranked as the most important variable affecting the performance of a project manager. It is obtained that project managers experiences do not have much effect on how they perceive their working environment.

Time Impact Analysis

Time is an essential part of every plan organisations develop for performing contract work. There is a relationship between the schedule, the scope of work, and the project conditions. According to (Anabari, 2003), Time Impact Analysis is typically associated with the modeling of the effects of a single delay. It requires a CPM schedule that is able to show the pure CPM calculation differences between a schedule that does not include a delay and one that does include an activity modeling a delay. The difference for project completion between the non-impacted schedule and that of the schedule with the impact is considered to be the impact of the delay for time duration considerations.

Project Cost – Time Relationship

Total project costs include both direct costs and indirect costs of performing the activities of the project. Direct costs for the project include the costs of doing work related to some specific activities of the project. Indirect costs, on the other hand, are the necessary costs of doing work which cannot be related to a particular activity, and in some cases cannot be related to a specific project (Davison, 2003),.

If each activity was scheduled for the duration that resulted in the minimum direct cost in this way, the time to complete the entire project might be too

long and substantial penalties associated with the late project completion might be incurred (Dlakwa and Culpin, 1990). Thus, planners perform what is called time-cost trade-off analysis to shorten the project duration. This can be done by selecting some activities on the critical path to shorten their duration. As the direct cost for the project equals the sum of the direct costs of its activities, then the project direct cost will increase by decreasing its duration. On the other hand, the indirect cost will decrease by decreasing the project duration, as the indirect cost are almost a linear function with the project duration (Al-Khalil and AL-Ghafly, 1999).

Factors Affecting Cost and Time Performance

(Chan and Kumaraswamy, 2002), remarked that studies in various countries appear to have contributed significantly to the body of knowledge relating to time performance in construction projects over the past three decades, while (Iyer and Jha, 2005), remarked that project performance in term of cost is studied since 1960s. These studies range from theoretical work based on experience of researcher on one end to structured research work on the other end. Moreover, (Pheng and Chaun, 2006), stated that there have been many past studies on project performance according to cost and time factors.

(Chan and Kumaraswamy, 1996) stated that a number of unexpected problems and changes from original design arise during the construction phase, leading to problems in cost and time performance. It is found that poor site management, unforeseen ground conditions and low speed of decision making involving all project teams are the three most significant factors causing delays and problems of time performance in local building

works. (Okuwoga, 1998), stated that cost and time performance has been identified as general problems in the construction industry worldwide. (Dissanayaka and Kumaraswamy, 1999), remarked that project complexity, client type, experience of team and communication are highly correlated with the time performance; whilst project complexity, client characteristics and contractor characteristics are highly correlated with the cost performance. (Reichelt and Lyneis, 1999), obtained that project schedule and budget performance are controlled by the dynamic feedback process. Those processes include the rework cycle, feedback loops creating changes in productivity and quality, and effects between work phases.

(Chan-Albert, 2001), identified that the best predictor of average construction time performance of public sector projects in Malaysia is T = 269 C 0. 32. This relationship can serve as a convenient tool for both project managers and clients to predict the average time required for delivery of a construction project. (Kuprenas, 2003), stated that process of a design team meeting frequency and the process of written reporting of design phase progress were found to be statistically significant in reducing design phase costs. Otherwise, the use of project manager training and a project management based organizational structure were found to be processes that do not create a statistically significant in reducing design phase costs.

(Iyer and Jha, 2005), remarked that the factors affecting cost performance are: the competence of project manager’s; support of top management; coordinating and leadership skills of project manager’s; monitoring and feedback by the participants; decision making; coordination among project participants; owners’ competence; social condition, economical condition

and climatic condition. Coordination among the various participants of the project was as the most considerable of all the factors having utmost influence on cost performance of projects. (Love et al., 2005), studied project time-cost performance relationships by using project scope factors for 161 construction projects that were completed in various Australian States. It was noticed that gross floor area and the number of floors in a building are key determinants of time performance in projects. Besides, the findings indicate that cost is a pitiable forecaster of time performance.

(Chan and Kumaraswamy, 2002), proposed specific technological and managerial strategies to increase speed of construction and so to upgrade the construction time performance. It is remarked that effective communication, fast information transfer between project participants, the better selection and training of managers, and detailed construction programs with advanced available software can help to accelerate the performance. (Jouini et al., 2004): stated that managing speed in engineering, procurement and construction projects is a key factor in the competition between innovative firms. It is found that customers can consider time as a resource and, in that case, they will encourage the contractor to improve the time performance.

Identifying factors that influence cost performance

Previous research has attempted to establish reasons for the difference between the tender sum and the final account. This segment identifies the factors that influence cost performance. Four factors were identified from the obtainable research findings, (Morris, 1990), (Kaming et al., 1997) and (Chimwaso, 2001). These are; design changes, inadequate planning,

irregular weather conditions; and fluctuations in the cost of building materials.

To expand the research it was decided to synchronize the above list of factors with other factors gleaned from the final account reports. These were compared with the factors from the existing research findings, and a final list of 18 factors was prepared. These were then separated into two groups of seven significant factors and nine other factors, which are usually ignored, but perceived to be of equal significance (Chimwaso, 2001).

Measurement of Project Performance

(Karim and Marosszeky, 1999), stated that performance measurement systems have been one of the primary tools used by the manufacturing sector for business process re-engineering in order to monitor the outcomes and effectiveness of implementation. (Brown and Adams, 2000), obtained an evaluation framework to measure the efficiency of building project management (BPM) by using conventional economic analysis tools such as time, cost and quality. (Lehtonen, 2001), stated that performance measurement systems are imminent in the construction firms. (Samson and Lema, 2002), stated that effective and efficient management of contractors' organizational performance requires commitment to effective performance measurement in order to evaluate, control, and improve performance today and in the future.

(Tangen, 2004), obtained that performance measurement is a complex issue that normally incorporates at least three different disciplines: economics, management and accounting. Measurement of performance has garnered

significant interest recently among both academics and practitioners. (Tangen, 2004), remarked the choice of a suitable measurement technique depends on a number of factors, including the purpose of the measurement; the level of detail required; the time available for the measurement; the existence of available predetermined data; and the cost of measurement.

(Navon, 2005), defined performance measurement as a comparison between the desired and the actual performances. For example, when a deviation is detected, the construction management analyzes the reasons for it. The reasons for deviation can be schematically divided into two groups: (a) unrealistic target setting (i. e., planning) or (b) causes originating from the actual construction (in many cases the causes for deviation originate from both sources). (Navon, 2005), stated that performance measurement is needed not only to control current projects but also to update the historic database. Such updates enable better planning of future projects in terms of costs, schedules, labor allocation, etc. (Pheng and Chaun, 2006), stated that the measurement of project performance can no longer be restricted to the traditional criteria, which consist of time, cost and quality. There are other measurement criteria such as project management and products.

(Cheung et al., 2004), stated that New South Wales Public Works Department in Australia launched a Project Performance Evaluation (PPE) framework, which covers an extensive array of performance parameters. PPE parameters are communication, time, cost, quality, safety, claims and issues resolution, environment, contract relations. PPEs’ purpose is to broaden project performance procedures to envelop soft parameters also, such as communication and resolution of dispute. In the UK, a performance

measurement tool for project referred to as the Key Performance Indicators (KPIs) was developed by the KPI working group under the UK Construction Industry Best Practice Programme to include time, cost, quality, client satisfaction, change orders, business performance, health and safety. The implementation steps of KPIs are as follows: Decide what to measure, Collect data and calculate the KPIs. That notwithstanding, both the PPE and KPIs are valuable tools for measuring performance of a project over a period of time. Anyway, it is obtained from previous study that both methods PPE and KPIs can be used for measuring of performance as the indicators are similar in two methods. In this study KPIs method will be used to measure performance.

(Iyer and Jha, 2005), stated that measuring the performance of any construction project is a very complex process because modern construction projects are generally multidisciplinary in nature and they involve participation of designers, contractors, subcontractors, specialists, construction managers, and consultants. With the increasing size of the project, number of participants in the project also increases. The objectives or goals of all participants need not be same even in a given project. Hence to measure performance of a project witho