UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

INVESTIGATING PROJECT COST ESTIMATION PRACTICES IN EMERGING CONSTRUCTION FIRMS TO REDUCE PROJECT COST VARIANCE IN GHANA: A CASE STUDY OF THE KUMASI METROPOLITAN

BY

PEREZ ANSAH AWUAH

JULY, 2021

UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCTION, KUMASI

INVESTIGATING PROJECT COST ESTIMATION PRACTICES IN EMERGING CONSTRUCTION FIRMS TO REDUCE PROJECT COST VARIANCE IN GHANA: A CASE STUDY OF THE KUMASI METROPOLITAN

BY

PEREZ ANSAH AWUAH

(190010631)

A DISSERTATION PRESENTED TO THE DEPARTMENT OF CONSTRUCTION AND WOOD TECHNOLOGY EDUCATION, FACULTY OF TECHNICAL EDUCATION, UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE REWARD OF A MASTER OF TECHNOLOGY DEGREE IN CONSTRUCTION TECHNOLOGY.

JULY, 2021

DECLARATION

I,**PEREZ ANSAH AWUAH hereby** declare that this submission is my own work towards the MTech. and that, to the best of my knowledge, it contains no material previously published by another person or material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

Signature:…… **Date:**……..

NAME: ING. DR. EMMANUEL APPIAH-KUBI (SUPERVISOR)

Signature: ……... **Date:** ……

ACKNOWLEDGEMENT

I want to give the biggest thanks to my supervisor Ing. Dr. Emmanuel Appiah-Kubi for guiding me throughout my research work. I would like to also thank Mr. Boye Joshua Kumi, Dr. Justice Wiredu and Mr. Richard Abbey for their inspirations and other supports rendered to me as I carried out my research work.

And finally, I give all thanks to the Lord God almighty for His abundant grace.

DEDICATION

I dedicate this project to my father Mr. R. R. Awuah, my mother Philomena Gyamfuah, my brother Fred Asiedu Awuah and my sister Nancy Awuah Kyei for their generous support and other contributions made towards this dissertation. Finally, to all my friends who in diverse ways encouraged me to come out successfully with this dissertation. To all, I say God richly bless you.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Improving cost estimation practices in emerging building construction firms continue to be a major feature of construction projects in an attempt to deal effectively with uncertainty and to achieve project success. The dissertation was conducted to investigate project cost estimation practices in emerging construction firms to reduce project cost variance in Ghana. The researcher employed the survey research design in the study with an accessible population of ten (10) construction companies, and five (5) consultancy firms operating in the Kumasi Metropolis. However, the study used purposive sampling technique to sample ninety (90) respondents to answer a set of structured questionnaires. Statistical package for the social science (SPSS) and MicrosftEcel (M.s Excel) were used to analyze the data and the results were presented in charts and tables showing their frequencies and percentages. In practice, according to the respondents the study found that, parametric, detailed/bottom-up, computer aided cost estimation methods and others are the major project cost estimation methods and techniques utilized by emerging construction firms to reduce project cost variance in the Kumasi metropolis. The study concluded that, emerging construction firm managers at Kumasi metropolis must critically examine and utilized the most appropriate project cost estimation method and technique applicable to each construction project to help reduce cost variance. The study therefore recommended that, building professionals (contractors, consultants, construction managers and quantity surveyors) are to ensure that all the effective cost estimation methods and techniques are fully adhered to in the construction of domestic buildings, public and industrial buildings as well. The study also recommended that, building professionals should ensure that they are well informed of the significant risk factors affecting cost estimation of construction works in order to make the right estimation required.

CHAPTER ONE

1.0 Introduction

The chapter comprises background to the study, statement of the problem, aim of the study, objectives of the study, research questions, significance of the study, scope of the study and end with the organization of the study.

1.1 Background of the Study

According to Holm *et al*. (2005) cost estimation is the procedure of examining a specific scope of work and forecasting the cost of completing the work. Cost is the riskiest variable (Becker, Jaselkis, & El-gafy, 2014) within the standard success criteria of cost, schedule, and performance targets often called the "iron triangle" (Williams, 2016) when it comes to managing projects. Therefore, it is imperative that the specific scope of work and the time obtainable to the estimator is distinct to achieve precision in the estimation hence, cost estimating entails gathering, investigating and summarizing the data pertaining to a project. Cost estimation in building construction is one of the most critical tasks in the stages of a building project. According to Sung-Hoon An, *et al.* (2010), estimators must deal with numerous uncertainties in the project. One of the dimensions of assessing a project's success is completing the project within the assigned budget (Kerzner & Kerzner, 2013).

Project budgets are funds estimated during the planning phase based on what the project is expected to cost at completion. It is very difficult to estimate project budgets accurately before executing the projects due to lack of information and risks. Thus, a project management plan including cost estimation are developed at an early stage before projects are constructed. So, it is very difficult to accurately estimate the

project budget due to lack of information or data (Creedy, Skitmore, & Wong, 2010), and is needed for justification of projects on economic grounds and for efficient capital planning and financing (Caron, Ruggen, & Merli, 2013). Cost variance is a concept used to describe project cost deviations between the planned and the actual costs and describe whether the project spend exceeded the estimated costs.

According to Valtanen (2020), cost variance is calculated by subtracting the actual costs from the budgeted costs, meaning that the positive cost variance implies cost savings, and negative being cost overruns. Broyles and Lay (1982) discuss that there are favorable and unfavorable cost variances, favorable being the cost savings and unfavorable cost overruns. However, the cost deviations occur as a result of inadequate planning, and a project can be completed within the assigned budget only if the cost estimate is of a high quality (Shane *et al.,* 2009). Coupled with the implications of the cost overestimation and underestimation, it can be concluded that in the context of project business there are no favorable cost variances, and to sustain the business operations, the seller must be able to produce a high-quality precise cost estimate. Unfortunately, cost overruns are a prevalent and often-times encountered issue that hinders project success (Shehu *et al.,* 2014). Kaplan (1975) states that the actual project costs will rarely be the same as the planned budget costs. Due to project complexity, implying numerous interactions between the elements within a project system, it is challenging to identify the root cause leading to impaired performance (Munier, 2014). One of the oftentimes recognized major causes of cost overruns is inadequate planning (Havranek, 2017).

Cost overruns are a major problem in both developed and developing countries (Angelo & Reina, 2002). Cost and time overruns tend to be norm with construction projects. Flyvbjerg (2002) established that it is common to find 9 out of every 10

construction projects globally with cost overruns of 50 to 100 percent. According to Dubai Architecture (2014), a typical example of global project that was not spared from cost and time overruns is the famous Burj Khalifa completed in 2009, which was constructed with the most advanced construction technology and project management techniques, yet took nine months longer to complete and costs 71% higher than anticipated. The inherent problem of cost overruns of construction projects has been a major concern for all construction industry stakeholders especially emerging construction firms, hence, the numerous studies on the problem to help alleviate these recurring in the future.

Leading nations use significant estimation methods which the emerging construction sector in developing countries do not use (Seeletse and Ladzani, 2012) it is evident that this sector does not meet global best practice standards. Besides, the prices that deviate far from the reasonable limits, indicates that, emerging contractors seem to be using outdated project costing methods (i.e., methods no longer used by emerging contractors of developed worlds and large contractors) in business. The majority of emerging contractors make use of the Gantt chart programming and scheduling technique (Seeletse and Ladzani, 2012). Fewer emerging contractors use the WBS method. The more complex CPM and PERT methods are virtually not used, i.e., they are used to an insignificant extent relative to the use of other methods. Generally, though, relative to the methods applied in the construction industry in developing countries, project costs estimate developed by emerging contractors are questionable. (Seeletse and Ladzani, 2012).

Therefore, this study investigates project cost estimation practices of emerging construction firms in Ghana to reduce project cost variance. The principal aim is to project cost estimation methods and techniques that can be utilized by emerging

construction firms to reduce cost variance, identify significant risk factors affecting cost estimation of construction works and ultimately establish internal organizational processes and method techniques used by the majority of emerging construction firms to reduce cost variances.

1.2 Statement of the Problem

Emerging construction companies worldwide are faced with issues of cost estimation and controlling methods that contributes woefully to their collapse. Most emerging companies don't take into account the fact that costs are dependent on time factor which has quite a remarkable impact on projects total costs (Keisala, 2009). Cost and time overruns are common in infrastructure and building construction projects. Researches on construction projects in some developing countries indicate that by the time a project is completed, the actual cost exceeds the original contract price by about 30 % according to Al-Momani (1996).

A global study on cost overrun issues in construction infrastructure projects covering 258 projects in 20 nations, (Flyvbjerg *et al.,* 2003), concluded that 9 out 10 projects face cost overruns ranging from 50 to 100 %. Studies of construction projects in UK, for example, found that 73% of construction projects executed by the UK government departments and agencies had cost overruns whiles 70% had time overruns (Cooke & William, 2009). According to (Frimpong *et al.,* 2003), 33 out of 47 representing 70% of projects in Ghana were delayed due to cost overruns. According to the World Bank Report on Ghana (2012), about 13 out of 26 World Bank funded projects in Ghana which should have completed within three to five years, have run far beyond their completion dates, with some running for eight to nine years. This has

resulted in over US$1.5 billion of funds out of US$2.3 billion approved in total remaining in the World Banks chest due to cost overruns.

Fugar and Agyakwah-Baah (2010) and Danso and Antwi (2012), also suggests that the issues of cost overruns of construction projects are common and are major problems facing emerging construction industry in Ghana. According to Sunjka and Jacob (2013), dispute and claims becomes a major outcome due to losses incurred through cost overruns. They also suggest that disputed projects would have extra costs and time consequences related to the engagement of professional arbitrators in cases of disputes that go through arbitration. Sunjka and Jacob (2013) further highlighted that, most construction projects by emerging construction firms faces total abandonment due to cost overruns. The study of Haseeb *et al.* (2011) refers to the total abandonment of the construction project as stopping every work or suspending the project for a long time.

It is imperative that, attention is seen to be given to the challenge of cost overruns of construction projects in Ghana. It is therefore noteworthy that, studies which have resulted in some few published literatures on the cost and time overruns of construction projects in Ghana exist. These literatures, dealt with the causes and mitigating measure of delays in building construction projects (Fugar and Agyakwah-Baah, 2010), causes of delays and cost overruns in groundwater construction projects in developing countries (Frimpong et al.,2003) as well as factors influencing time and cost overruns of telecom tower construction projects in Ghana (Danso and Antwi, 2012). So far, however, there is no reliable evidence of project cost estimation practices in emerging construction firms to reduce project cost variance in Ghana. This study therefore sought to investigate and validate this knowledge gap.

1.3 Purpose of the Study

The purpose of this study was to investigate project cost estimation practices in emerging construction firms to reduce project cost variance in Ghana.

1.4 Objectives of the Study

1. To determine project cost estimation methods and techniques that can be utilized by emerging construction firms to reduce project cost variance at Kumasi Metropolis.
2. To identify significant risk factors affecting cost estimation of construction works at Kumasi Metropolis.
3. To establish internal organizational processes and method for reducing project cost variances at Kumasi Metropolis.

1.5 Research Questions

1. What are the project cost estimation practices, methods and processes that can be utilised by emerging construction firms to reduce project cost variance at Kumasi Metropolis?
2. What significant risk factors affects cost estimation of construction works at Kumasi Metropolis?
3. What internal organizational processes and method could help to reduce project cost variances at Kumasi Metropolis?

1.6 Significance of the Study

Cost estimation in building construction is one of the main elements of the building industry. It is an important aspect of building construction and as such extensive research needs to be carried out on this element. There are many groups inside and outside of the building industry that will benefit from this study. Among these groups are: owners, consultants, designers, and academicians. Some of the benefits that this research offers include: Provide possible improvement of consulting cost estimation system and its benefits to clients, consulting firms and the constructor of the project; Clients will benefit tremendously from unnecessary risk; by avoiding or reducing the risk. Contractors can use the knowledge to forecast or hedge cost estimates, that is in pricing, protecting against exchange rate and inflation. Finally, the study will also assist lecturers, students and individuals from different works of life as a basis for further research into the subject area of project cost estimation.

1.7 Scope of the Study

The scope of the research is limited to the emerging construction companies and consultancy firms operating within Kumasi Metropolis. The scope of the investigation is narrowed down even further to construction managers, contractors, quantity surveyors and consultants in the Metropolis. The study is focused on finding out project cost estimation practices, methods and processes utilised by developed construction firms to reduce project cost variance, significant risk factors affecting cost estimation of construction works and to establish internal organizational processes and method for reducing project cost variances at Kumasi Metropolis.

1.8 Organization of the Study

The study will be organized into five chapters. Chapter one will deal with the introduction which will cover the background to the study, statement of the problem, aim and objectives of the study, research questions, significance of the study, the scope of the study, and organization of the study. Chapter two will concentrate on the review of related literature, based on the research objectives and other areas to cover construction cost estimate practices to reduce project cost variances in Ghanaian construction industries. Chapter three will present the description of the procedures and methods used in investigating and collecting data for the study. It covers the research design, the population, sample and sampling techniques, data collection instrument, validity and reliability, data collection procedures, and data analysis techniques. In chapter four, presentation, analysis and discussion of results are presented. Finally, the summary of findings, conclusions, recommendations and suggestions for further research are catered for by chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The success of every research work depends greatly on the already existing data or information about the research topic. Based on that fact, this research work depended on the number of studies that have been done to investigate project cost estimation practices in emerging construction firms to reduce project cost variance in Ghana. The review has been organized around these main themes: project lifecycle and structure, cost estimation, qualities of a good estimate, challenges in cost estimation and budgeting, importance of historical information in cost estimation, cost variance, cost estimation methods and techniques, risk factors affecting cost estimation of construction works, and internal organizational processes and method for reducing project cost variances.

2.1 Project Lifecycle and Structure

A project is a temporary entity oriented at producing and delivering a unique product or service to the customer (PMI PMBOK, 2001). Other characteristics of project business are defined by the nature of projects – they are finite with a clearly established beginning and end date, must be completed within the agreed time frame and within the allocated budget (Kerzner and Kerzner, 2013). The project lifecycle can be viewed from the perspectives of the supplier and of the customer. From the customer's point of view, projects are termed as investment projects, and from the supplier's point of view – delivery project. In this study, the projects are perceived rather from

the supplier's point of view, although, in customer centric organizations, the investment and delivery projects tend to mirror each other (Venkataraman and Pinto, 2008). The project's lifecycle is schematically represented in Figure 2.1.

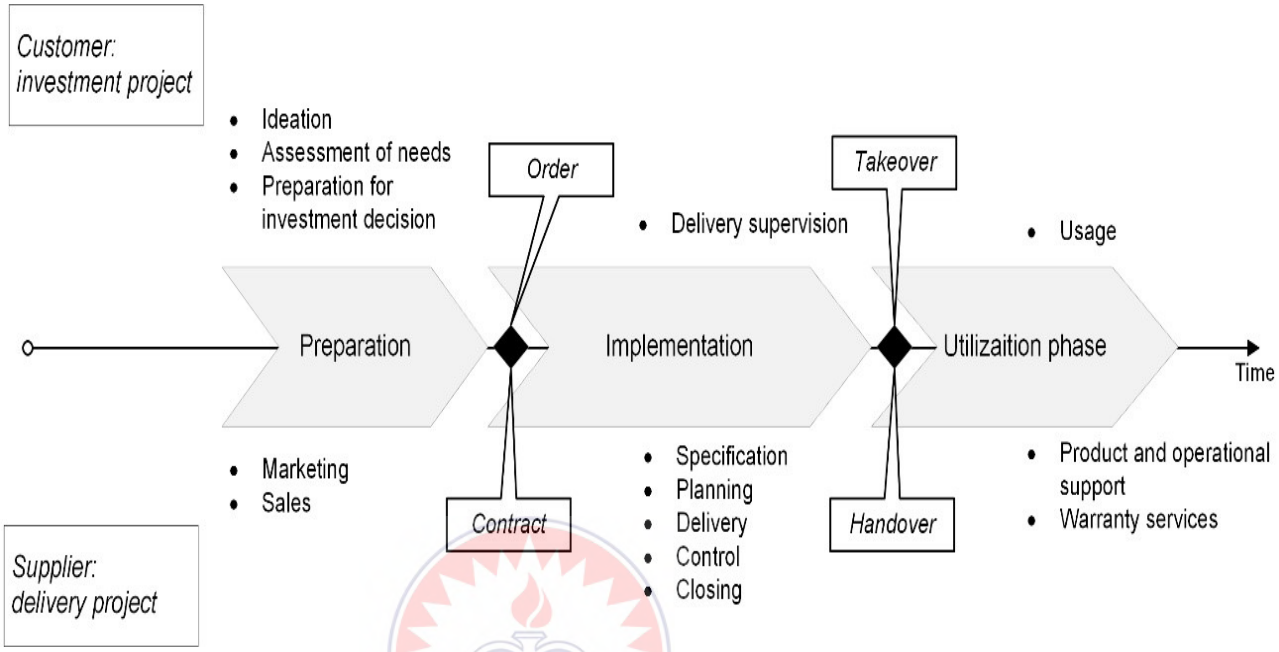

Figure 2. 1: Project lifecycle. (Source: Venkataraman and Pinto, 2008)

The lifecycle can be subdivided into three general categories: preparation, implementation and utilization phase (Kerzner and Kerzner, 2013). The terms may differ source by source, but the category descriptions remain consistent. Kerzner and Kerzner (2013) discuss the subcategories of the project preparation phase and identify four partitions: strategic, conceptual, planning and design phases. From the supplier's perspective, the sales and marketing efforts occur during the pre-contractual phase, placing the cost estimation and budgeting processes on the same timeline. While the supplier is carrying out the sales efforts, the customer is preparing for a decision to invest. Cost estimation and budgeting happen during the preparation phase of the project lifecycle; hence, the project preparation phase is the main focus of this study. Nevertheless, a delivery project as a whole is to be considered, since the cost and

schedule variances become apparent only as the project is being implemented, thus, the project implementation phase is of some relevance to this work.

Taking into account the definition of a project, the entity may be viewed in terms of product or work breakdown structure. The concept of work breakdown structure (WBS) was introduced by the US Department of Defense (DoD) in the 1960s and NASA for the purpose of effective control of large projects (Norman *et al.,* 2008). NASA (2018) states that WBS defines the work that needs to be completed throughout the project as well as enhances the understanding of the project's objectives, scope, and deliverables. Additionally, WBS is said to provide guidelines for the internal organization and communication needed for the successful achievement of project objectives. Work breakdown structure is available at different levels of detail, providing an opportunity to plan and evaluate the project's performance in terms of technical requirements, schedule and costs (NASA, 2018), which are coincidentally the three project objectives according to the classic triple constraint. Thus, WBS is a key element when it comes to project planning and execution (Norman *et al.,* 2008). Work breakdown structure is a hierarchy of work tasks, which are typically subdivided into up to four layers. PMI PMBOK (2017) describes WBS as a task-oriented tree of activities with a deliverable-oriented decomposition of work into work packages. According to PMI (2006), one of the core principles of a WBS is 100% rule, which states that the work breakdown structure should represent an entire scope of the deliverables, them being internal, external or of another type. In the context of project business, the first WBS level is typically a headline of the project. The second level represents major work elements, either physical or functional (Stewart and Wyskida, 1987), which are the major work packages. The third level of the WBS is comprised of minor subdivisions or activities followed by the fourth layer of specific tasks. It is rare

that organizational WBS extends to more than 4 levels (Stewart and Wyskida, 1987), however, NASA's handbook of WBS (2006) illustrates a seven-level WBS.

2.2 Cost Estimation

The International Cost Estimating & Analysis Association defines cost estimation as a process of collecting and analyzing historical data and using that data to estimate future costs of deliverables with the help of quantitative models. Cost estimation is a forecasting technique, in contrast to cost analysis, which is based on organizing and processing historical data (Stewart and Wyskida, 1987). A successful cost estimate can be effectively used in bidding, negotiations, cost tracking, and cost analysis. The information requirement of the cost estimation process can be broken down into two categories: historical data and organizational operations. Historical data may include any archival data in a form of previous cost estimates or statistics, as well as published re-ports about similar work either from within the organization or external sources. Few companies, besides public organizations, disclose their cost structure and detailed financial figures, so obtaining the information from external sources may not always be possible. As an alternative, some scientific and research publications can be followed to trace the best available practices regarding cost estimation in a specific industry. In a sense, without cost analysis, cost estimation would not be possible. Simply storing the data is insufficient for the purpose of effective cost estimation. Indeed, the literature confirms that as a best practice for cost estimation, the data should be analyzed, reported and systematically archived for the ease of retrieval and interpretation (PMI PMBOK, 2001). Interestingly, when it comes to archives in public and industrial organizations, usually the ones in public organizations are more traceable

and more systematic in contrast to those kept by industrial organizations (Stenberg and Rajan, 2016).

There are a variety of identified requirements for cost estimation available in the existing literature. According to Stewart and Wyskida (1987), the required inputs for computation of a successful cost estimate are (1) information, (2) method, (3) plan for the estimate and (4) a set of necessary skills. The researchers identify twelve steps of cost estimation according to the previously mentioned requirements. Cost estimate adjustment is an iterative process and is based on recalculating the estimate due to the availability of new information or technical specifications. Additionally, the estimate adjustment is used in design-to-cost (DTC) cost management, meaning that the cost estimate, as well as the product design, are iterated to meet the target cost requirement. At the end of the cost estimating process, the estimate together with all the assumptions and relevant remarks should be recorded and presented for the purpose of organizational learning and process enhancement. Stewart and Wyskida (1987) propose a structure for a cost estimate report, which is shown in Table 2.1. A well-reported cost estimate information is invaluable as a part of future sales cases acting as reference material for analogous projects.

Table 2. 1: Contents of the published cost estimate

S/N	Title	Content
I	Introduction	Case with background information, date
II	Specifics	Ground rules and assumptions
III	Description of the work activity	Schedule, specification, quantities, location and other applicable factors
IV	Detailed cost breakdown	By work element, by cost element, by schedule element
V	Summary of the estimate	-
VI	Pricing factors	Labor rates including skill categories, inflation rates, material prices, overhead, SG&A costs, fee rates
VII	Estimating team details	Names and contact information
VIII	Rationale	Material backing up the cost estimate: an explanation of reasoning.

Source: (Stewart and Wyskida, 1987)

The table shows that the researchers identify eight sections as a guideline for a decent cost estimate report. The sections include an introduction, ground rules, and assumptions, description of work, cost breakdown, summary, pricing factors, estimating team details and rationale. The researchers emphasize, that the enlisted content is just a recommendation and a successful cost estimate should include as many case-specific details as possible. It is noteworthy, that the authors emphasize the need for clarity of the report, as it must be accessed and understood by the management and sales staff as well as those, who typically carry out the cost

estimation tasks. Other literature sources provide further variations of cost estimation procedures. For example, the Project Management Institute in their guidelines subdivides the process of cost estimation into three constituents – inputs, tools and techniques, and outputs. PMI PMBOK (2001) defines the information and procedures of cost estimating as shown in Figure 2.2.

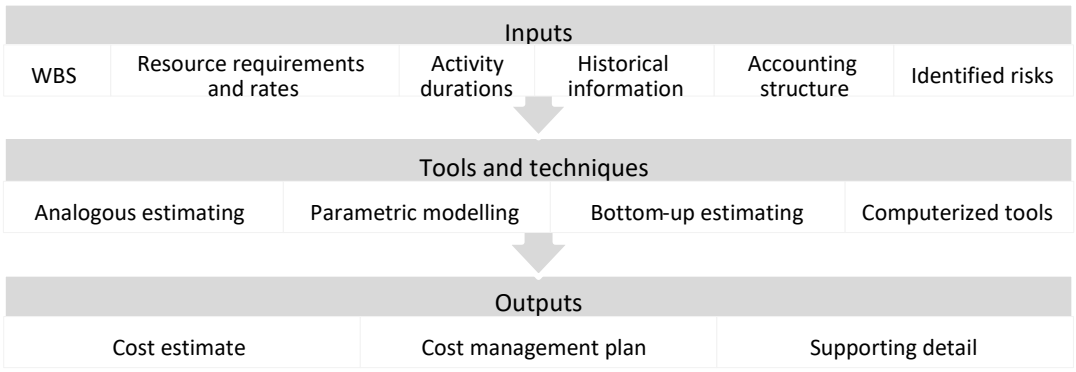

Figure 2. 2: Cost estimation process (Source: PMI PMBOK (2001).

The cost estimation process shown in the figure defines the necessary inputs as the information requirements and separates the methods of cost estimation into categories. The tools and techniques of cost estimating include analogous estimating, parametric modeling, bottom-up estimating and computerized tools. Finally, an output of the cost estimate is not simply a number, which is the aggregated estimate, it also includes a cost management plan and a supporting detail. A cost management plan is an action plan originating from the risk evaluation that dictates how the unforeseen circumstances are to be managed in order to maintain the costs in check. Supporting detail includes the pricing factors, established rules, and assumptions, description of the scope of the work as well as the range of the expected costs. Both PMI PMBOK (2001), and Stewart and Wyskida (1987) provide different takes on systematic approaches for cost estimation. In general, the process of cost estimation is commercially privileged information when it comes to private companies since a good cost estimating practice may be an important source of competitive advantage.

Successful cost estimation and cost management plan ensure a target profit level for a company. Public and governmental companies, however, disclose their cost estimating procedures, as their finances and expenditures should be transparent and traceable (OECD/OAS, 2002). NASA (2015) provides a good example of a cost estimation procedure in their cost estimating handbook. NASA's cost estimation process is built according to the best available practice guidelines from the US Government Accountability Office (GAO, 2009). Interestingly, the most abundant cost estimation documentation comes from the construction and transportation industries. Another example of a cost estimate process is provided by the Queensland Government, the Ministry of Transport and Main Roads (2017). The cost estimation processes are illustrated side-by-side in Table 2.2.

Table 2. 2: Cost estimation process examples.

1	Receive customer request	Define the estimate's purpose	Define project scope
2	Construct WBS	Develop estimating plan	Collect project information
3	Define technical specifications	Identify program characteristics	Become familiar with the project site
4	State ground rules and assumptions	Determine estimating structure	Gather estimating information
5	Select a cost estimating methodology	Ground rules and assumptions	Develop base estimate
6	Select cost model/tool	Obtain data (including historical data)	Conduct a reality check (reference and historical data)
7	Gather data (including historical	Develop point estimate and	Assess risk

	data)	compare to the independent estimate	
8	Develop the estimate	Carry out sensitivity analysis	Calculate contingency
9	Carry out a risk assessment and incorporate into the estimate	Carry out risk and uncertainty analysis	Determine escalation
10	Document the estimate	Document the estimate	Complete and document the estimate
11	Present the results	Present the estimate to be approved	Review the estimate
12	Update the estimate when required	Update the estimate according to the actual costs and changes	Present for approval

Source: Ministry of Transport and Main Roads (2017)

The table shows the three cost estimation processes side by side. Overall, due to the fact that NASA follows the best practice guidelines established by GAO, the cost estimation procedures from these sources are alike. The procedure established by the ministry of transport differs from the first glance, emphasizing transparency and bureaucratic process of a meticulous review of the cost estimate. Nevertheless, all the processes have functional similarities, namely developing scope and technical specification, gathering and reviewing pricing factors and cost data, surveying reference and historical material, risk review, rigorous documentation, specified information requirements, identifying ground rules and assumptions, and reviewing and updating cost estimates to be stored and easily retrieved and interpreted in the future. The commonality between the reviewed cost estimation processes is illustrated in Figure 2.3.

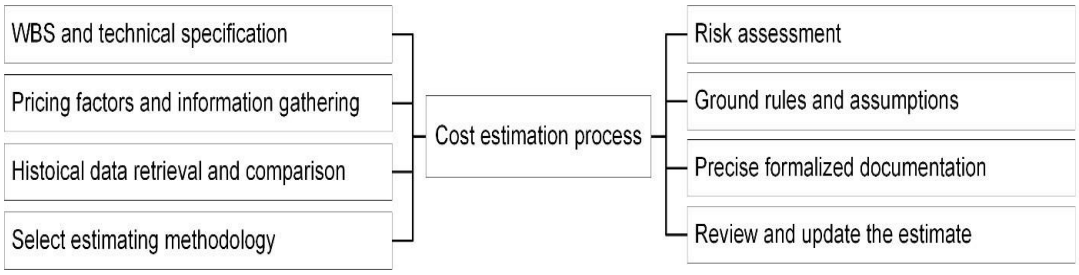

Figure 2. 3: Commonality in various cost estimation processes. (Source: GAO, 2009).

The figure shows the most frequently mentioned elements of the compared procedures of cost estimation (NASA, 2015; Queensland Government, 2017). All the sources additionally emphasize the iterative nature of the cost estimation process. The cost estimate should be updated, revised and adjusted based on the incoming change requests and most recent information. The updated estimates are an effective and helpful tool for the companies during the initial estimation phases, as the estimate computation can be expedited with the data gathered from the previous equivalent projects (Taylor, 2007). Cost estimation requires a set of skills for the estimate to be reliable. The skills and competencies required for a cost estimator are mathematical, statistical, engineering, production planning, communication, writing, and industrial engineering skills in addition to some specialty skills necessary to decimate and understand the company's operations (Stewart and Wyskida, 1987, p.3). Understanding of organizational operations is fundamental for cost estimating, and depending on the method of estimating, different levels of detail of technical expertise may be required. Dagostino and Peterson (2011) explain that a good estimator, in addition to possessing the aforementioned skills, should be experienced in the industry, organized to be able to meet deadlines and be able to deal with stress. Such a set of skills is rarely present in one cost estimator, especially if the company's portfolio is complex and diverse.

Additionally, when it comes to project business, in order to estimate the subcontractors' costs, the cost estimator should have an understandingof the subcontractors' processes as well as company-specific processes. Hence, cost

estimation is often carried out in teams rather than individually. In some organizations, the whole cost estimating department is established in order to cover the necessary skill requirements (Kesavan *et al.,* 2009). In some companies, a reporting relationship is established between a cost estimator and the departments responsible for the work packages and activities to provide the data and capabilities necessary for a comprehensive cost estimate. Cost estimation requires information input regarding resources, schedule, materials, and facility requirements, as well as the company's cost account structure and historical data for reference (Artto *et al.,* 2011). Taylor (2007) defines reports from earlier projects and expertise of experienced employees as appropriate sources of information for cost estimation. Additionally, having a database of historical cost estimates is an invaluable source of information, if upkept and processed accordingly (Taylor, 2007). Sometimes, a database of standard data is available, most often in the manufacturing and construction industries (Kesavan, *et al.,* 2009). The databases may include manufacturing throughput times, machinery-related information and predetermined standards for time requirements, for instance in public construction projects. DoD (2010) utilizes the cost data from the Cost Book, which is a Tri-Service cost database for the construction industry, in addition to their own historical cost data archive.

2.3 Qualities of a Good Estimate

Taylor (2007) discusses the successful cost estimation practices and infers on the steps that are to be undertaken to create a quality estimate. The first steps according to the author are to determine the purpose of the estimate and assess the available information and resources for the estimation process. It is also emphasized that when sharing the estimate within the organization, the accuracy and the detail level of the

estimate should be clearly stated and understood by the user of the estimate (Taylor, 2007). If the estimate is rough and unprecise and it is misused in customer negotiations, the seller organization may encounter financial losses or dismantle its reputation in the eyes of the customer by revoking the offer and altering the contract price. Taylor (2007) proposes a set of recommendations for carrying out a successful cost estimation. The recommendations include: using the most accurate method and a combination of methods if possible, involving internal project stakeholders and experienced employees in the estimating process, recording all assumptions, basing the estimates on the evaluation and assessment of previously conducted estimates, communicating the level of precision to the party, who is using the estimate, and provide estimates based on the available information and do not pad them. GAO (2009) identifies their requirements for a credible estimate. The requirements include clear task identification, internal stakeholder involvement in the estimation process, reliable data, standardized estimating procedure, identification and accounting for uncertainties, considering inflation, and reviewing, adjusting and revising the estimates throughout the project's lifecycle (GAO, 2009). If the recommendations are followed, the estimates that are obtained in the end is comprehensive, accurate, credible and well documented. GAO's complete list of recommendations for attaining a high-quality cost estimate is attached in Appendix A. Kerzner and Kerzner (2013) specify that a good estimate is based on the recent experiences from similar work, is supported by reference material and market surveys as well as is carried out by a knowledgeable person. Ideally, the estimate should be supported by data from a database accumulated from previous cases and computerized software (Kerzner and Kerzner, 2013). The role of the computerized software could, for example, be data fitting into probability density or distribution functions, as well as running statistical simulations.

2.4 Challenges in Cost Estimation and Budgeting

Cost estimation and cost budgeting are a part of project planning, which means that both are carried out prior to the project's implementation and produce more of a forecast rather than a definitive output. Accurate cost estimation, based on which the sales and implementation budgets are set, is vital for the project's success (Love et *al.,* 2013). An accurate budget ensures that the company will attain target profitability as well as serves as a performance control baseline for the project. Additionally, an accurate cost estimate establishes a valid ground for decision-making, and cost and schedule management within an organization (Doloi, 2013). However, project business is notorious for changes and it is known that cost and schedule variances are inevitable. Nonetheless, identifying and managing variance, as well as creating realistic and attainable estimates are instrumental in attempting to reduce the controllable variance. Venkataraman and Pinto (2008) conclude that in project business cost estimation is by default more difficult due to the unique nature of each project. That, coupled with the unpredictable changes in scope and other circumstances, make variance at completion almost inevitable. Analogous estimating is a widely-used technique in cost estimating, however, since no two projects are identical, the estimate obtained by analogous estimating is merely a rough guideline. Venkataraman and Pinto (2008) and Taylor (2007) additionally emphasize that the estimation is even more challenging in "multi-year projects", as the scope of the project, external and internal environment, and resource requirement and availability are subject to change over the years.

Artto *et al.* (2011) and PMI PMBOK (2001) bring up a managerial technique called the rolling wave principle, which is an iterative planning technique. The general principle of the rolling wave is to make use of the new, more accurate information as the project progresses and conduct cost estimation at a more detailed itemization level.

The activities that are barely specified and are described on a highly general level are estimated at the cost account level. Other challenges in cost estimation exist when it comes to itemization and timely cost allocation to a correct work package in the correct cost account (Venkataraman and Pinto, 2008). Accurate cost tracking and being able to trace the costs related to a specific cost item or work package is vital in earned value management, variance analysis at completion as well as future estimation. Taylor (2007) discusses the novelty of technology and technological requirements characteristic to project business as a reason for difficulties in cost estimation. As each project is unique in scope, the solutions provided to the customers are most likely also unique and tailored to the customer's needs. This makes the availability of historical data a challenge, as it is highly unlikely to find a project with comparable parameters. Another variable that affects cost estimation is the size of the project. Jørgensen *et al.* (2012) found a correlation between the project size and the planning accuracy in projects. The researchers conclude that the larger and more complex the project is, the more likely cost overruns are to occur. The researchers were able to definitively state that the size affects the project no matter how rational the cost estimation procedures are, although, the patterns of the most and least successful cost estimating techniques were not clear. Shane *et al*. (2009) concur on the likelihood of cost overruns in larger projects. The researchers additionally state that the projects can be delivered within the assigned budget, however, that requires an extreme awareness of cost-incurring factors as well as a good cost estimate.

Love *et al.* (2013) confirms that cost estimating is more challenging in larger projects due to increased complexity and the likelihood of change orders throughout project implementation. Doloi (2010) elaborates on the particular aspects brought by increased project complexity and modern reliance on the supply chain. One of the

features of the modern industrial environment is increased reliance on the supply chain and, hence, increased tendency to outsource some activities (Kujala *et al.,* 2010). Outsourcing is a strategy that companies use to differentiate their offerings in the market place by acquiring extra capabilities or capacity without investing in their development and differentiation. Outsourcing can be regarded as a survival tool for manufacturers in modern competitive and developed industrial environment. The firm acquiring cost estimates from the contractors relies on the estimates being accurate, however, deviations often occur due to factors affecting contractors' performance or inaccuracies in the initial cost estimation on their behalf (Doloi, 2010). The researcher points out that contractors' documentation quality and efficiency are sometimes inappropriate for setting a budgetary baseline. Shane *et al.* (2009) additionally bring up the challenge of misinterpretation and reporting, in other words, impaired and incomplete information flow.

Ferris (1976) attributes human personality as a challenge to cost estimation processes. The researcher states that the personality traits have a positive correlation to certain estimating tendencies, namely that there is a positive correlation between the optimistic personality and overestimation as well as pessimistic personality and underestimation. Challenges in cost estimation that are attributed to human factors are typically difficult to interpret. Shane *et al.* (2009) investigate the concept of optimism bias, which is associated with unrealistic schedules and budget baseline setting during the project planning phase. The effect of human factors on the estimate is unclear and cannot be easily mitigated with de-escalation factors, thus indicating that a degree of formalization and standardization is required to be applied to the process to eliminate the effect of personality bias. Tanaka *et al.* (1993) discuss another challenging issue associated with cost estimation. Due to the estimating process being so time- and

resource-consuming, it may be challenging to evaluate and compare design alternatives from the economic perspective. The uncertainty involved in the conceptual stage of project planning adds to the difficulty of reliable cost estimation. Additionally, the individual producing the cost estimation is of relevance. Tanaka *et al.* (1993) see it as a problem if the solution engineers and designers are responsible for the cost estimate. Taylor (2007) collaborates the previously mentioned and concludes that cost estimation should not be assigned to technical employees as an extra duty to avoid problems. Coupled with Stewart's and Wyskida's(1987) identified skill requirements for cost estimation, it follows that the estimator should possess expertise in finance and industrial management, as well as a technical understanding of the product portfolio. The challenges involved in the cost estimating procedure are summarized in Table 2.3.

Table 2. 3: Challenges in cost estimation: summary.

Challenges in cost estimation	The nature of project business
	Lack of historical information
	Itemization and allocating costs to cost accounts
	Novelty of technology and custom -made solutions
	Project's size
	Reliance on supply chain
	Human factor
	Resource -consuming - costly to compare alternatives
	Assigning the task of cost estimation to technical staff

Source: Stewart's andWyskida's(1987)

The table provides a summary of the challenges involved in cost estimation. Some of the challenges are of the controllable character and some, such as the nature of the project business cannot be controlled. Some methods, however, can be identified to mitigate the overall inaccuracy or other effects resulting from the uncontrollable challenge factors.

2.5 Importance of Historical Information in Cost Estimation

The literature emphasizes the need for organized and retrievable historical information for obtaining a more precise cost estimate, however, sometimes the information is not available. The lack of information may be based on the novelty of the product or incomplete cost estimating procedures. The cost estimate process is completed with the supporting detail, including the cost analysis and the lessons learned from the estimating process. Processing and accumulating the cost estimate and cost variance data at the end of the project are the necessary constituents for the cost database, which is an invaluable tool in cost estimation (Stewart and Wyskida, 1987). Without historical data, most of the estimation techniques would not be possible. Historical data is used in analogous estimating, parametric estimating, deterministic estimating, learning curve and detailed estimating (Venkataraman and Pinto, 2008). Thus, it follows that not a single one of the estimation bundles would be complete without the reliance on historical data. The importance of historical data to the cost estimation process was brought up as one of the elements of commonality in various cost estimation processes employed across different industries (see Figure 16). The quality and reliability of the data must be ensured in order for the historical data to be a prerequisite for excellence. Historical data is a key component for the basis of estimate, which is an integral step of the cost estimation process. In project business, especially, the internal cost estimate information is crucial, since the offerings that the project-based firms provide to their customers are never unique and are most often tailored to a specific case and customer.

Rush and Roy (2000) discuss an approach to project comparison technique solely based on historical data – case-based reasoning (CBR). This technique is based on forming a case and comparing and adapting the solution in accordance with

observed historical trends. The previous cases and the information obtained and processed from the previous cases serve as a knowledge database, according to which the new solution is developed. Moreover, the information stored in the knowledge database is being continuously verified through application to the new cases. The researchers call this utilization of historical data as a learning process. CBR is an approach that is related to a projection technique widely applied in industry, called the learning curve (Stewart and Wyskida, 1987; Venkataraman and Pinto, 2008). There are two schools of learning curve theories - a cumulative average theory and a unit theory. A cumulative average learning curve was developed by Wright (1936) and the incremental (unit) learning curve was developed by Crawford in 1947 (Stewart and Wyskida, 1987). Both theories are based on the assumption that the organization learns from the tasks performed and the more times a task was performed in the past, the less time it will require in the future. The repeatedly incurred costs in the organizational context are recurring costs, thus it can be concluded that the learning curve concerns only the processes which incur recurring costs. Unfortunately, learning curves are applicable only to direct labor (DOE, 2011). For a project-based firm, the manufacturing learning curve may not be as instrumental, based on the degree of outsourcing. However, the idea of experiential learning and standardization may be useful in terms of evaluating the uncertainty involved in project planning. Lowe and Skitmore (1994) investigate the effect of experience and learning on the quality and effectiveness of task completion when it comes to cost estimation. The researchers found that if the individual is reflecting on their experiences and are able to convey their experience and identify development needs, the accuracy of their estimation work is higher. Thus, it is imperative for the cost estimator to follow through the whole process of cost estimation, including the estimation review and lessons learned from

estimating. Portfolio standardization and repetition of the tasks serves also as a mechanism for decreasing uncertainty, caused by the novelty or custom-made nature of the offering (Lorenz *et al.,* 2019). Ulonska and Welo (2014) address the same issue from a different perspective, stating that the organizations, whose operations are based on custom-made solutions must be able to increase their learning capabilities. In other words, it is imperative for the organization to be able to convert the acquired tacit knowledge into explicit form, which required a systematic approach to collecting, processing and archiving data. Clear and systematic organization of product portfolio and project deliveries enables a clear overview of variances and unifies all the experience and tacit knowledge into one holistic database (Ulonska and Welo, 2014). It follows, that the learning curve phenomenon cannot be completely discarded when it comes to indirect work, although the application of the learning curve is not as literal as outlined by Wright or Crawford. The systemization of acquired knowledge is a pathway to deal with the uncertainties in a project-based business, where the projects and the offerings are unique.

2.6 Cost Variance

Cost variances are expected in project business since the projects are rarely implemented according to the established plan (GAO, 2009). Additionally, Pinto (2016) remarks that the planned conditions are rarely encountered throughout project implementation and the project's scope is subject to change. Cost variances, however, cannot be attributed solely to the unforeseen circumstances. Unrealistic planning and budget setting may lead to financial deviations between the cost baseline and the actual costs. GAO (2009) clarifies that variances are a signal of unrealistic or incomplete planning, lack of change management and control during the project, and/or the quality

of project execution. Cost estimates are used for bidding and tendering. Realistic cost estimates, thus, become imperative to the project's success and the overall organizational success. Cost variance can be classified into favorable and unfavorable, signifying costs overrun and underrun respectively (Broyles and Lay, 1982). The standard of performance, in this case, is the project's sales budget. The favorable and unfavorable variances may further be subdivided into controllable and uncontrollable. Although, one might ask whether there is such a thing as a favorable variance. A favorable variance may entail cost savings as well as overestimation. Overestimates may lead to higher bidding prices compared to those of the competitors, leading to potential loss of business and customers. Underestimates may lead to the firm's inability to execute the scope of deliverables within the designated budget, thus, leading to financial losses on the company level (Kesavan *et al.,* 2009). Additionally, a tighter budget may imply compromised quality of the execution subsequently leading to customer dissatisfaction and causing reputational hazards. Thus, before concluding whether the variance is favorable, the root cause of the cost savings is to be determined.

The triple constraint of project management can be used to demonstrate the effect of abnormal performance in one aspect on the other constituents of the project's success. The relationship is demonstrated in Figure 2.4

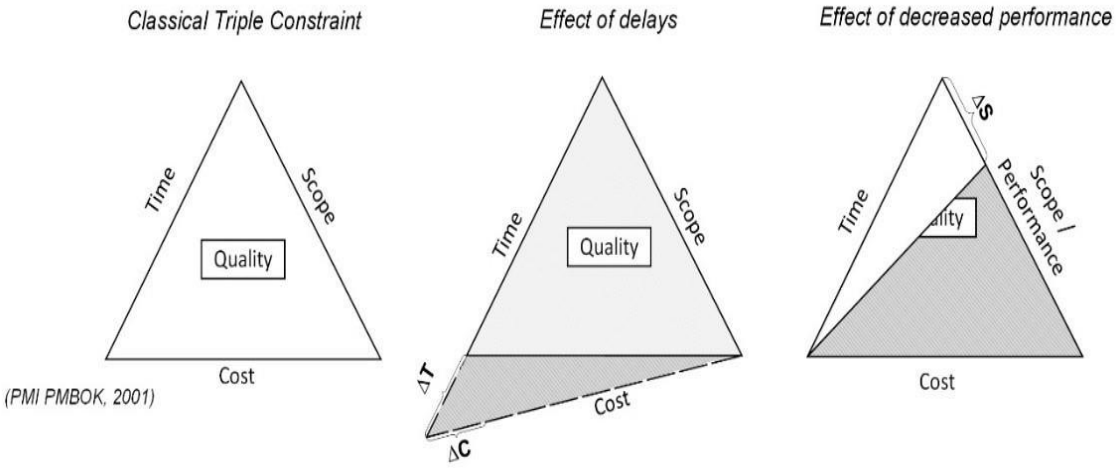

Figure 2. 4: The effect of deviations from the project plan. (Source: Kesavan et al., 2009).

The figure demonstrates that the schedule and costs are interconnected. In the event of delays, additional costs are likely to be incurred assuming that quality is to remain unchanged. The scope in the triple constraint represents the tasks associated with the execution of the project scope (PMI PMBOK, 2001), and, can be thought of as performance. In case of lower than planned performance levels, the quality of the deliverables will suffer if the project is ordered to be completed within the schedule and cost baselines. Other variations of the CTC model may be used to illustrate the effect of change of one or more of the variables and their impact on the project's success. It follows that the variance monitoring and control is a vital part of project management and ensuring the project's success in terms of customer satisfaction and profitability. Cost variances are a standard occurrence in project business, as in reality, the actual expenditure will rarely be equivalent to the planned budget (Kaplan, 1975). As a reference, about 35 per-cent of the software projects are completed within the schedule baseline (Goh and Hall, 2011), meaning that 65% face delays. Shehu *et al.* (2014) find that cost overruns are a fundamental and frequently observed problem for construction projects. Kwon and Kang (2018) in their review found that over 90 per-

cent of construction projects encounter the issue of cost overruns of between 50 and 100 percent. Flyvbjerg *et al.* (2002) conducted a fundamental study of cost overruns in public projects and found that cost overruns occur due to cost underestimation in 9 out of 10 projects. The projects under investigation included railway, bridge and road construction. Bhargava *et al.* (2010) collaborate that cost overruns are oftentimes encountered in infrastructure and road construction projects. Kaplan (1975) also emphasizes that variance investigation is demanding and resource consuming, implying that it is cost-intensive.

Hence, it is important to know whether the variance is insignificant and caused by random factors, or the root cause of the variance lies within the organizational procedures. In general, the cost-benefit analysis may serve as a guideline for the need to carry out variance investigation, as the investigation should be undertaken if and only if the benefits of the investigation outweigh the costs (Kaplan, 1975). Dean (1937) further confirms that it is important for the firm to identify the controllable portion of the cost variances in order to make use of the costing system and *"maximize managerial usefulness"*. Variations, random or controllable, may be a cause for project failure (Goh and Hall, 2011), hence it is of the utmost importance to identify the root causes of and decrease controllable variances, as well as prepare for the uncontrollable ones.

2.7 Cost Estimation Methods and Techniques

Estimating an accurate project budget is challenging for project managers, because of the unpredictable risks concerning how big the impacts on construction project results are and when they will occur. Furthermore, budget estimation is conducted during the planning phase (Caron *et al.*, 2013; Sato & Hirao, 2013), which is

an early stage of the project life cycle, when there is a lack of data and information. Project managers need a budget estimation method to respond to risks as accurately and precisely as possible in order to prevent cost overruns. Previous researchers have presented several methods to estimate cost reserves but those are not sufficient to cover all types of risks. One method is the traditional percentage model (Moselhi, 1997), which is arbitrary and difficult to justify or defend (Thomson & Perry, 1992); the other method is Monte Carlo simulations (Eldosouky, Ibrahim, & Mohammed, 2014); and a third method is the regression model (Adoko *et al.,* 2016). These models are used for estimating total project costs and are powerful statistical tools used for analytical and predictive purposes in forecasting the total final cost of the project. Other models using the fuzzy expert system (Idrus, Nuruddin, & Rohman, 2011) and artificial neural networks (Chenyun, 2012) have been used for the development of a project cost contingency estimation model. These models are suitable for the nonlinear modeling of data, which contrasts with linear approaches using regression (Baccarini, 2006), and may be used effectively in the risk assessment for identified risks, but they are less effective for estimating cost contingency. The results of previous research do not clearly estimate reserves for unidentified risks, because unknown-unknown risks were excluded from the research due to assumption by the author (Baccarini, 2006) or unmanageable (Chapman, 2000).

Furthermore, contingency resources estimated to handle unknown risk events cannot be justified because these could not be identified and estimated (Kitchenham & Linkman, 1997). In addition, these are events not known to the project team before they occurred or viewed as impossible in a specific project situation. By definition, unknown-unknowns are not foreseeable and thus cannot be dealt with proactively (Smith & Merritt, 2002; Thamhain, 2013). Although risk cost estimation methods for

identified risks have been presented by previous researchers, the reserves for unidentified risks have not been sufficiently examined. The rare studies on estimating reserves against unidentified risks cause large cost variances and difficulty for sponsors or project managers in making decisions properly in order to provide benefits from the project results. The oftentimes discussed cost estimation techniques are listed in Table 2.4.

Table 2. 4: Cost estimation techniques, literature review.

Technique	***Source***
Analogous estimating / project comparison estimating / historical-bid estimating	NASA, 2015; Queensland; Government, 2017; Dagostino and Peterson, 2011
Parametric modeling/functional estimate - R-squared - statistical significance - the F and t statistics - elemental parametric estimating	NASA, 2015; Chang, 2013; Dagostino and Peterson, 2011
Detailed cost estimating / Bottom-up /engineering build-up	Chang, 2013; Queensland Government, 2017; NASA, 2015; Dagostino and Peterson, 2011
Computerized tools	PMI PMBOK, 2001; Queensland Government, 2017
Expert opinion/guesstimates	GAO, 2009; Queensland Government, 2017; PMI PMBOK, 2017
Learning curves and progress functions	GAO, 2009
Top-down/ Design to cost (DTC) / target costing (TC)	Rush and Roy, 2000
Deterministic / factor-based /risk-based	Queensland Government, 2017;

estimating - Monte Carlo simulation - Three-point estimating	PMI PMBOK, 2017
Assembly estimating	Dagostino and Peterson, 2011

Source: Smith & Merritt, 2002

2.7.1 Specific Analogy technique:

This technique depends on known cost of an item used in previous but recent construction as a basis for determining the cost of similar item in a new construction (NASA, 2015). An estimate of costs based on historical data of a similar (analog) item. It is a conceptual estimate giving rough idea of cost (DoD, 2010). Adjustments are usually made to the known costs to make up for differences in relative complexities of uses, design and functional features. The analogy method compares a new or proposed system with one analogous (i.e., similar) system, that was typically acquired in the recent past, for which there is accurate cost and technical data. There must be a reasonable correlation between the proposed and "historical" system. The estimator makes a subjective evaluation of the differences between the new system of interest and the historical system. The analogy method is typically performed early in the cost estimating process, such as the pre-Milestone A and Milestone A stages of a program. This is early in the life of a potential acquisition program when there may be a limited number of historical data points and the cost estimator may be dealing with technology experiencing rapid technical change. The analogy method is also a very common technique used for cross checking more detailed estimates (i.e. sanity check) (Oyedele, 2015).

2.7.2 Parametric technique:

Parametric modeling is a technique of predicting project costs with functions or mathematical models. The estimation is carried out based on parameter inputs, which are project-depended and reflect the scope of the project, for example, building heights in the construction industry (Dagostino and Peterson, 2011). The accuracy of the parametric estimate is dependent on the availability and relevance of the available historical cost data used for parametric input, scalability of the model and whether the parameters are quantifiable (PMI PMBOK, 2001). Data is derived from the historical information or is developed from building a model scenario. Statistical analysis is performed on the data to find correlations between cost drivers and other system parameters, such as design or performance parameters. The analysis produces cost equations or cost estimating relationships that can be used individually or grouped into more complex models. This technique is useful when the information available is not very detailed. Example is unit cost method (length for trenches, square meters for tiling or cubic meters for space) (Oyedele, 2015).

2.7.3 Detailed Cost Estimate/ Bottom-Up Technique

Detailed cost estimating is a technique of estimating the costs of individual work elements or work packages at the most detailed level of a work breakdown structure. This technique typically is the most demanding and costly and requires quite a complete level of scope and schedule specification for the estimate to be accurate (Queensland Government, 2017). Bottom-up method just like the detailed method is generally done with work statement and set of drawings known as working drawings or specifications to “take off” the quantities of materials needed to do the project. It is an algorithm of costs which is done based on work breakdown structure (WBS). From the

quantities surveyed, direct labour, equipment and overhead costs are derived and added to the material cost. *C*onstruction project can be pre-determined and predicted. The estimate is prepared by breaking down the items of work in an orderly and logical basis. The foundation for a successful estimate relies upon reliable identification (takeoff) of the quantities of the various materials involved in the project (Oyedele, 2015).

2.7.4 Computer Aided Cost Estimation Methods

The practice of cost estimating precedes the use of computers. Because of this legacy, many of its original methods persisted even after computers were introduced. Computers are today an integral part of the business, used not only in actual calculations, but also in the storage, organization, retrieval and reporting of data, as well as a collaboration tool between different disciplines. As a result, estimates are now much more accurate and detailed, and the industry's requirements have also increased accordingly. There are thousands of software packages in the market, ranging from simple "excel-like" spreadsheet programs to complete corporate solutions. Pricing also varies widely with the complexity of the software. One of the greatest challenges is to migrate 'field knowledge' to the computer. Experienced field professionals often rely on others to operate estimating software (Oyedele, 2015). The most effective computerized software in cost estimation was concluded to be a database type software, which is capable of storing and retrieving physical and functional properties of offerings and the associated costs (Galluzzo, 1991). Galluzzo (1991) concludes that a well-maintained cost database can effectively assist in analogous, parametric and detailed cost estimation, making the process less costly and yielding more accurate outputs.

2.7.5 Expert Opinion Technique

Expert opinion is a subjective estimate of low accuracy, which is useful in the absence of data and for some preliminary estimate purposes (Queensland Government, 2017). Different numerous specialists like engineers, tillers, roof specialists, plumbers etc. are contacted repeatedly until a consensus cost estimate is determined. Opinions of experts are sought on a project to get a reasonable estimate. Expert opinion as a technique of estimation is frequent in litigation and arbitration concerning construction works (Oyedele, 2015).

2.7.6 The Learning Curve Estimation Technique

The learning curve concept originated from aircraft construction industry in the 1930s and is based on the assumption that organizations and individuals learn to carry out activities more efficiently as a result of repetition (GAO, 2009).

2.7.7 Design to Cost Technique

DTC is a product development technique, which is sometimes discussed in the cost estimation context, as in its essence, the idea of DTC is to guide the product design and planning towards the set target cost. The target cost may be determined through market and competitor analysis, which lets the firm set a competitive cost objective relative to the market. The target cost serves as a final estimate, from which the cost of activities and work packages is determined, which is a characteristic of a top-down estimating approach (Rush and Roy, 2000).

2.7.8 Assembly Estimation Technique

Assembly estimation is used in construction projects and is a technique where the cost estimate is computed based on the bid for a work module or an assembly that consists of the material and labor costs (Dagostino and Peterson, 2011).

2.7.9 Deterministic or Risk-Based Estimation Technique

The deterministic or risk-based approach focuses on setting an appropriate contingency reserve to cover the project risks by taking into account the likelihood and severity of the materialized risk event. The inaccuracy of this method amplifies with the size of the project, making the method more applicable to small projects (Queensland Government, 2017). One of the examples of risk-based cost estimation is Monte Carlo simulation, which is widely utilized in cost estimation and risk management (Zhu *et al.,* 2016). Monte Carlo simulation is a relatively complex mathematical method of calculating the expected value as an integral against a probability density function (Joshi, 2003). The method requires an abundance of processed historical data to be fitted to a distribution model (Peleskei *et al.,* 2015). Fitting is commonly done using specialized computer soft-ware and afterward, the correlation of the elements is evaluated.

2.7.10 Three-Point Estimation Technique

A three-point estimate is another technique belonging to the cost estimation through risk factors. The technique that takes into account the most likely, optimistic and pessimistic values and calculates the estimate based on the assumed distribution of the values. A visual example of a three-point estimate is presented in Figure 2.5

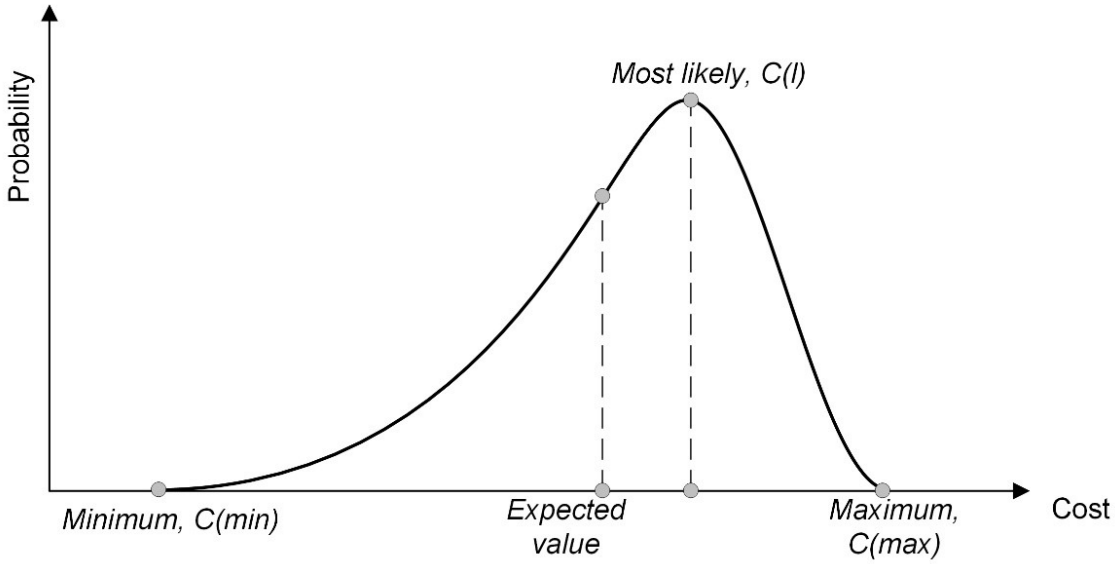

Figure 2. 5: Three-point estimation. (Source: PMBOK, 2017)

The figure illustrates the distribution of possible values and is a visualization of a program evaluation and review technique (PERT), which calculates a weighted average using the formula for beta distribution, shown as Formula 1. In the formula, *C(min)* stands for the minimum value, *C(l)* stands for the most likely value and *C(max)* is the maximum value. If the estimate is calculated based on a different probability distribution, the formula will also differ, and so will the assumed accuracy of the estimate, according to the confidence level of the distribution.

$$Estimate = \frac{C(min) + 4 \cdot C(l) + C(max)}{6} \quad (1)$$

2.7.11 Cost Review and Update Estimation Technique:

An estimate is constructed by examining previous estimates of the same internal arrangements, scope completeness, assumptions and estimating methodology used and updating them with changes due to difference in time. Interest rate, inflation rate,

exchange rate and other economic factors that may affect costs over time are considered (Oyedele, 2015).

2.7.12 Trend Analysis Estimation Technique

This method adopts the use of Contractor Efficiency Index (CEI). A Contractor Efficiency Index is obtained by comparing originally projected contract costs against actual cost on work performed to date. The index is used to adjust the cost estimate of work not yet completed. It is a forecast of cost based on the trend in the construction sector. In construction trend analysis is a mathematical technique that uses historical results to predict future outcome. This is achieved by tracking variances in cost and schedule performance. Trend analysis can be done graphically or through regression (Oyedele, 2015).

The cost estimation techniques can be subdivided into two categories: quantitative and qualitative. Quantitative estimation techniques are comprised of parametric and analytical types of estimates and qualitative types include intuitive and analogical (Budiono et al., 2014). The examples of parametric techniques were provided in Table 6, and they include statistical and functional estimates. Analytical quantitative estimates are represented by top-down and bottom-up cost estimation methods as well as deterministic approaches. These techniques include some level of analysis on top of the mathematical calculation. Expert opinion and guesstimates are classified as intuitive qualitative estimation techniques, where the estimation is rough and quick to produce. Analogous and project comparison estimating are variations of analogical qualitative estimation techniques.

Most organizations use multiple cost estimation methods at varying stages of the project lifecycle since the purpose of the cost estimate varies throughout the project

preparation phase and more information becomes available when the scope of the project is specified in more detail. The purpose of the cost estimate is at first strategic, gradually transforming into operational. The rough cost estimates help the organization to position itself in the mind of the customer among the competitors and roughly assess whether the offering is competitively attractive and profitable enough (Rajkumar and Kerr, 2013). After the go/no-go or bid/no-bid decision, cost estimation becomes central to setting cost objectives in the form of project budget and a cost management plan, which lay out a groundwork for final project profitability. As was discussed in Chapter 4.1, a significant share of total project costs (about 70 to 80%) is committed already at the conceptual stage of the project's lifecycle, thus it is crucial to set an appropriate cost objective as well as establish a realistic cost management plan to complete the project successfully within the established budget.

2.8 Risk Factors Affecting Cost Estimation of Construction Works

These are those elements of risks that may give rise to consequential costs. Ajator (2013) grouped the general risk factors earlier exposed in the introduction into five basic domains technological, social, physical, economic and political. They impact organizations' (agency or private) projects leading to consequential costs depending on actions or inactions of the project managers. They may present as internal and external risk factors. Internal risk factors are within the control of organization e.g., its human, physical, financial, technological and managerial value and ethics. While external risks are outside the organizations control. Labour, material, plant/equipment quality, availability, reliability and management efficiency are internal risks. Also opting for a contract without adequate human financial technical and technological resources or pricing competitive project at breakeven margin, or implementing too many projects

concurrently without adequate carrying capacity or lack of professional skill for a listed project are internal organization's risk while external risks are macro-economic, political, competition, environmental, multiple clients/joint venture project risks (Ajator, 2013).

There is therefore the need for application of strength weakness and opportunity threat (SWOT) strategies in project planning, execution and management to reduce consequential costs. Both internal, external and operational environment of construction organization have significant impacts on management/cost performance of project. Act of God risk factors include: heavy floods, landslide, fire, earthquakes, hurricanes. They have low probability of occurrence, yet with huge negative impact on project when they occur (Ajator, 2000). In a similar vein, Dey (2002) in measuring the likelihood of risks in a project, compartmentalized risk factors into five categories; Technical risk (0.479), Financial and Economic risk (0.228), organizational risk (0.146), Acts of God (0.064) and clearance risk (0.083). And stated the likelihood of occurrence of the risk sub factors in each category (see table I). He recorded the most likely occurring risk factor as the technical risk, with risk subfactors as; scope change, technology selection, implementation methodology, equipment risk, materials risk, engineering and design change. Mac-Barango, Imimabo and Ajator (2016) exposed the high-cost impacts of Spatial disparity (or difficult terrain) on the price of sandcrete blocks, which reduces project cost performance.

Table 2. 5: Likelihood of Risk in a Project

Factors	likelihood	Sub-factors
Technical Risk	0.479	Scope change Technology selection Implementation methodology Equipment risk Materials risk Engineering and design change
Financial & Economical Risk	0.228	Inflation risk Fund risk Changes in local law Changes in Govt. Policy Improper estimate
Organizational Risk	0.146	Capability of owner's project group Contractor's capability Vendor's Capability Consultant's Capability
Acts of God	0.064	Calamity Normal Calamity abnormal
Clearance risk	0.083	Environmental clearance Land acquisition Explosive clearance Other clearances

Source: Dey (2002)

Akinci and fisher (1998) report showed that contractors ascribed high importance index to construction related risk factors. Geological conditions, site accessibility and weather conditions have importance index of 62 whereas site location, non/delay payments and subcontractor with its supervision and management problems have importance index of 70, 74, 74 and 70 respectively. In tropical regions weather effect is significant because it is characterized by heavy rain, wind, fire, extreme heat/humidity which affect workers' and equipment output negatively. Delay payment and nonpayment create great difficulties for contractor. In most public projects contractors manage it in order to keep good relationship for future projects.

2.8.1 Further risk Categorization

Many other researchers have further categorized risk factors. Miller & Lessard grouped risk into Market risk; demand, financial, supply; competition risk; technical, construction, operational and instructional risks; regulatory, social acceptability and sovereign risks. Abrahamson (1998) arranged risk factors under subheads: Physical Works; ground conditions, artificial obstruction, defective material/workmanship, faulty samples and tests, weather, site preparation, inadequate staff, labour, plant, material, time and financial risks, Delay and disputes; possession of site, late/inadequate information, layout disputes, Direction and supervision; greed, incompetence, unreasonableness, partiality, poor communication, design/documentation errors, unclear requirements and breaches, inappropriate consultants, contractors and change orders, Damage and injury to persons/properties; negligence, accidents, loses, insurances/gaps, External factors; government tax policies, labour, safety laws, planning approvals, tight finances, payment restraints, war/civil commotion, vandalism, intimidation, industrial disputes, Payments; delay payments, delay claims agreement/payments, unpaid interest, insolvency, inaccurate valuations, high exchange rates, inflation, Law and Arbitration; Ambiguity of contract, delay in resolving disputes, cost of award and its enforcement, miscarriage of justice and law reforms.

Finerty (1996) categorized risk under: - Supply, technological competition, economic, financial, currency, political, environmental and force majeure. Chapman and Ward (2002) considered risk associated with: estimate variability, uncertainty of basis of estimate, uncertainty of design/logistics, uncertainty of objectives and priorities, uncertainty of mutual relationship of project parties. Other authorities (undated), grouped risks under; technical, construction, legal, natural, logistics, social,

economic, financial, commercial and political. Cohen & Palmer (2004) reviewed construction project risk sources to include project scope crip, design errors/ omissions, undefined roles/ responsibilities, unskilled staff/multi subcontractors and use of inexperienced contractor. The above categorizations especially construction risks of adversarial relationships of participants, use of new technologies, extensive subcontracting, unfamiliarity with local conditions, restiveness, language difficulties and force majeure, present risks as something negative and which threaten project success and heighten consequential costs.

Chapman (2001) further asserted that risk factors are factors that could bring a change in the objectives or plan of a contractor or client and grouped risk factors under physical factors; construction factors; and financial factors.

2.8.1.1 Physical Factors

Physical factors are factors that can bring about damage or change to the project. Some physical factors may include damage to structure; theft at the site; an accident to operative; damage to equipment; loss due to fire outbreaks; floods; weather conditions; change in design; and insufficient detailing (Chapman, 2001).

2.8.1.2 Construction Factors

Construction factors are the factors that affect the equipment and labour of a project. Some construction factors may consist of equipment/plant availability; suitability of plant; maintenance facilities of plant; equipment failure (breakdown); plant operation's skill level; level of productivity of Labour; strike by the Labour force causing disruption; availability of experienced & Skilled Labour; level of skill of management; level of supervision; materials availability; unforeseen adverse ground conditions; security and safety of Labour on site; latent defects occurring in the

structure through poor workmanship; familiarities with such work; and security equipment of the project area (Chapman, 2001).

2.8.1.3 Financial Factors

Finance plays an important role in construction. It can increase or decrease the pace at which the work is done. Some financial factors that affect a project include inflation; fluctuation; and cash flow administration (Chapman, 2001).

2.9 Internal Organizational Processes and Method for Reducing Project Cost Variances

Peter Drucker in his work "The Effective Executive" (1967), describes the difference between effectiveness and efficiency in a memorable manner – "effectiveness is getting the right things done, while efficiency is getting the things done right". The definition of effectiveness and efficiency resonate with the definitions of lean and six sigma philosophies. Lean was developed as a quality control technique in Japan at the time of economic recession, which concentrated on eliminating production 'waste' or the 3Ms (Nicoletti, 2012). The 3Ms are *muda, muri, mura,* which from Japanese mean waste, unreasonable and illogical, and variation and poor management. Lean by itself is not a holistic process quality control method. The most evolved quality control method is lean six sigma, which integrates the essential ideas from both philosophies. Six Sigma philosophy concentrates on identifying the activities that lead to defects and variation and the root causes for these variations, subsequently adjusting and improving the process (Bradley, 2015).

The synthesized lean six sigma philosophy is a method for continuous process improvement in an organization by correcting flawed processes as well as making sure that the processes are carried out with the optimal lead times. One of the mechanisms to

ensure that the "right things and being done right" within a project organization are to implement a systematic and standardized set of procedures. The systematic approach entails that the actions are carried out methodologically, i.e., based on predefined logic and logical correlations, which makes the attained knowledge organized and contributes to the overall increase in knowledge (Saunders *et al.,* 2009). Knowledge and information management are the starting point of managing uncertainty, as uncertainty is associated with the lack of information (Munier, 2014). Nonaka (1991) emphasizes the importance of knowledge in the modern economy, where "the only certainty is uncertainty" and knowledge is a source enabling organizations to sustain competitive advantage. Nonaka (1991) discusses the concept of knowledge spiral, which is based on the idea of organizational learning resulting from intersection and conversion of tacit knowledge to explicit knowledge and vice-versa. Ulonska and Welo (2014) emphasize that systematically converting tacit knowledge into explicit knowledge is beneficial for the efficiency of the organization, namely accessing the information and reducing uncertainty.

Grant (1996) discusses the foundation of knowledge management (KM) and some of the core principles are – transferability, the capacity of aggregation and knowledge acquisition. Transferability refers to the ability to codify tacit knowledge to the form of explicit knowledge, so that other individuals will be able to apply that knowledge.

Knowledge aggregation potential refers to the compatibility of different forms of knowledge through expressing that knowledge in a similar form. Although, there is a type of knowledge, called idiosyncratic, which cannot be easily aggregated, due to its circumstantial and highly specific nature (Grant, 1996). Knowledge acquisition is based on the idea that human has a limit to storing and processing knowledge, hence,

requiring various experts to take care of the necessary areas of competencies within the organization. It follows, that on the organizational scale, it is important to ensure that there is a systematic approach of data gathering, reporting and archiving. This, added to the research of Nonaka (1991) and Ulonska and Welo (2014), emphasizes a need for an information system architecture within an organization. Systematic knowledge sharing via reporting and archiving leads to knowledge accessibility, which is a mechanism of uncertainty reduction. Uncertainty is one of the characteristic challenges in cost estimation. The uncertainty can be managed with systematic knowledge management and procedures, defining a set of requirements and procedures for the cost estimation process can potentially alleviate the effect of uncertainty on the quality of the cost estimate. An inadequate and inaccurate cost estimate leads to cost overruns in projects (Shane *et al.,* 2009; Venkataraman and Pinto, 2008; Jørgensen *et al.,* 2012).

Although cost variance can be controlled during project preparation and implementation phases, if the cost baseline is unrealistic, then the project manager will be unable to meet the targets throughout the implementation phase (Hicks, 1992). The cost baseline is a component of the aggregated project estimate and contingency. Typically, contingency and management reserves are used to soften the effect of variances that are bound to occur throughout the project (Venkataraman and Pinto, 2008, p.97). Venkataraman and Pinto (2008) note that the customers tend to be skeptical towards the contingency reserves, as it may come across that the seller company is not capable of designing and pricing their own offering. Additionally, customer satisfaction may be impacted, if the cost estimate keeps increasing throughout the project planning phase. Thus, it is of importance to set the contingency levels appropriately, not to present higher than competitors' prices to the customer, while at the same time not risking your own profit. In order to provide a realistic estimate at the

required time, the organization and the cost estimator should be aware of the degree of uncertainty associated with the estimation technique used.

Skitmore and Lowe (1992) state that the high-quality estimate depends on the correctly chosen estimating technique, availability of design and cost information, size of the project and utilization of feedback from past cases. Taylor (2007) advises using the most accurate technique available and a combination of methods, if possible. The most accurate method, however, may be unfeasible and too expensive, besides being unattainable due to the degree of project specification and information deficiencies. Information availability is guided by project definition, at the same time allowing for a more accurate cost estimation technique to be used. Choosing the correct method of cost estimation is only a part of managing uncertainty involved in the process. Cost overruns are the manifestation of risk, which in turn, is a successor of uncertainties. The scope of this work is to evaluate the controllable factors internal to an organization involved in the process of cost estimation, excluding uncontrollable and external influences. For this purpose, a separate category of risks was defined as internal foreseen risks. Inadequate resource planning and unrealistic schedule are both precursors of inadequate project baselines, leading to cost overruns. Lack of information is a characteristic problem to cost estimation. Project prioritization and conflict of resources are the risks to be mitigated at the organizational level by coordinating the projects and departments and ensuring adequate resource planning and availability. Lack of systematic procedures is an element facilitating business operations through knowledge management, which ideally should be homogenous on the organizational level, and without a doubt, homogenous on the department level.

It was earlier suggested that contingency constitutes of risk-related costs and estimate uncertainty. To avoid the interference of the two types of contingencies, the

cost estimates should be based on the available information and not padded (Taylor, 2007). Such interference can cause double-counting the risks, which is a commonly occurring malpractice in risk management. Risk double-counting is a result of poor understanding of complexity and interactions between the elements in the risk analysis (Rodger and Petch, 1999). Separate risk evaluation and documentation for risk-related costs and cost uncertainties is a useful tool to consider. When thinking about aggregating a cost data-base, it would be beneficial to know the historic trends of cost overruns and whether they were caused by insufficient contingency reserves to account for the risk factors or cost uncertainties. Having a historical database for the cost uncertainty ranges is instrumental in setting the estimation accuracy boundaries. The internal foreseen risks, unlike the external, pure, technical and other typically identified risks (see Table 3) should not be mitigated via assigning contingency reserves in order to prevent the danger of double-counting. The internal foreseen risks identified in this work can be managed by implementing a systematic estimating procedure, which decreases, if not eliminates, this type of risk from the organization's operations. It is possible to avoid the internal foreseen risks because they originate from within the organization and are controllable in nature. GAO (2009) collaborates that a systematic standardized procedure for cost estimation leads to higher quality estimates and a higher rate of success throughout the projects. A synthesis of the reviewed procedures that accounts for the characteristics of high-quality estimates is presented in Figure 2

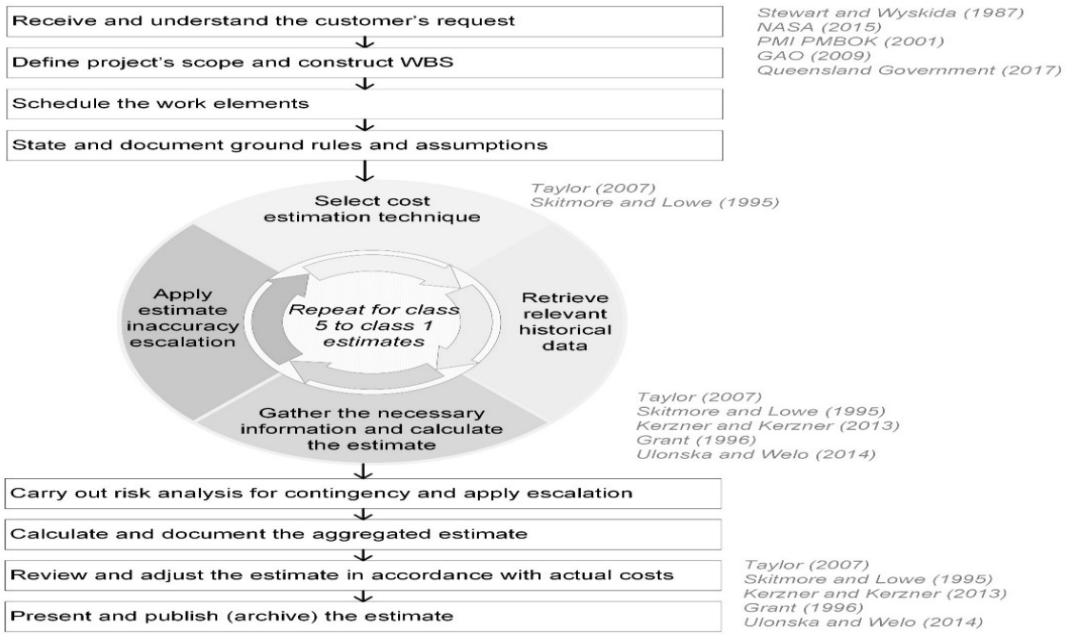

Figure 2. 6: Systematic cost estimation promoting estimation quality and KM.

The figure shows the twelve steps of systematic cost estimation that incorporate prerequisites for a high-quality estimate as well as promote knowledge management within an organization. The process is initiated with receiving and understanding the customer's request, defining technical specifications and constructing WBS. These steps form the information prerequisite that is needed for an accurate cost estimate, as poor design, misunderstanding the customer and inadequately constructed WBS lead to cost over-runs (Havranek, 2017; Venkataraman and Pinto, 2008; Shane et al., 2009). If the first three steps are carried out properly, some of the internal foreseen risks are avoided. Understanding the customer, defining the technical specifications, constructing 66 WBS and scheduling activities, if done adequately, ensure appropriate resource planning and realistic schedule, as well as information availability.

The lack of information can be furthermore tackled with creating and maintaining an ap-propriate archive of historical data. In the case of cost estimation, the data may be related to the unit cost of activity, supplier costs, transportation costs, sizes and weight of equipment delivered and their cost, and others. A database is also a form

of transforming tacit knowledge to explicit, as it entails documenting project specifics by the stakeholders in-volved in the project. A cost estimate report, containing the actual costs and the reflection on the accuracy of the estimate is an invaluable element of determining the estimation inaccuracy for future projects undertaken by the organization. A template for a cost estimating report is shown in Table 4. The complete schematic representation of the recommended cost estimation process for the project organization is schematically shown in Figure 2.7.

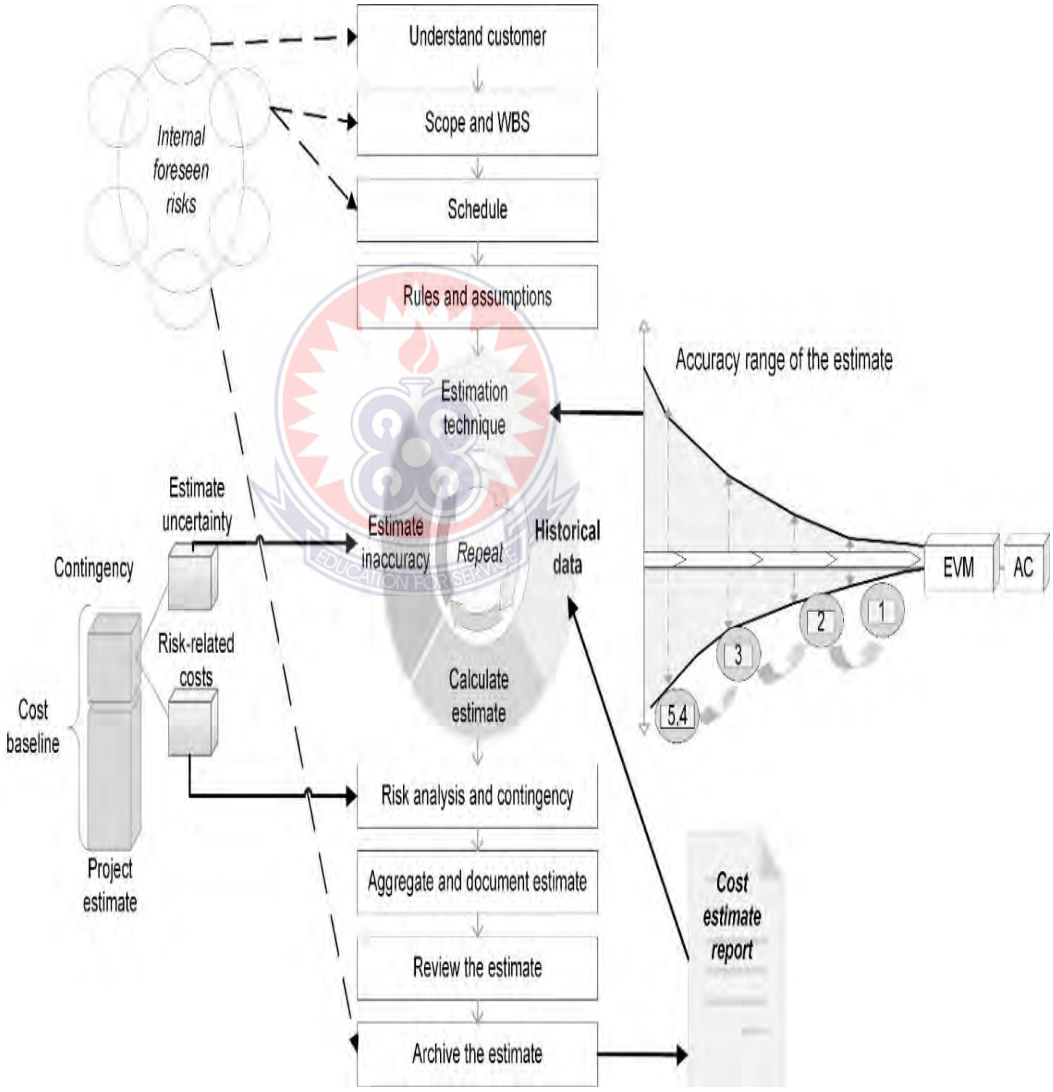

Figure 2. 7: Method for cost estimation in a project-based firm (Source: Havranet, 2017)

The figure demonstrates a systematic cost estimation process with a guide for selecting a cost estimating technique appropriate for the stage of the project preparation process. In addition, the method suggests how the internal foreseen controllable risks can be mitigated and contingency reserves assigned without double-counting the risks. A crucial part to the accuracy of cost estimation is the follow through the whole process and create a cost estimating report, which is then archived. The report should contain the initial cost estimate and all the adjusted estimates, including the final actual cost, which serves as a performance indicator of the initial cost estimate.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter deals with the methods and procedures employed to collect data for the study. The chapter covers the research design, population, sample and sampling techniques, data collection instruments, validity and reliability, data collection procedures and data analysis techniques employed.

3.1 Research Design

The researcher employed the survey research design in the study. A survey is a tool used to provide a quantitative or numeric description of trends, behaviours, concerns, actions and responses of a population through a sample (Creswell, 2014). It helps gather necessary information in line with specific research questions using either a survey or structured interviews (De Vaus, 2013). Due to its ability to provide specific results in relation to a particular question and address a wide sample for generalizations, it has been widely used in many research studies concerning variables and modelling (Fowler, 2013). Surveys can also be applied to a large sample, particularly for gathering demographic data (Heeringa, West & Berglund 2010).

3.2 Population

The target population for this research include: construction management, quantity surveyors and consultants like Casdide Construction Ltd. (Kwadaso), Jeomaxx Co. Ltd. (Sofoline), George Newyear Construction (Kwadaso), Frederick Williams Construction Ltd. (Bohyen-Kumasi), AFDB Consult Ltd. (Asokwa), Measurematics

Consult Ltd. (Kentinkrono), Obeng Engineering complex (Suame Magazine), A. J. Fanj Construction Ltd. (Asokwa) and others since these are the areas within the researcher's reach. In this study, the accessible population comprised of ten (10) construction companies, and five (5) consultancy firms operating in the Kumasi Metropolis.

3.3 Sampling Techniques and Sample Size

The researcher employed the used of convenience sampling technique in selecting the sample size The respondents were chosen by the researcher during his visit to the construction firm in the Kumasi Metropolitan and the selected respondents were the one who had the chance to respond to the questioners and the interview.

The advantage to the purposive sample technique was that, it helped researcher to choose samples that are knowledgeable and informative about the phenomena under study (Saunders *et al.,* 2007). In view of this, the researcher sent email to the respondents from the construction companies and consultancy firms to answer some few questions to determine their knowledge of the topic under study. From the results obtained the researcher purposively selected ten (10) construction managers, twenty-eight (28) contractors, thirty (30) quantity surveyors and twenty-two (22) building consultants making a total of ninety (90) respondents who had the highest score to represent the sample for the study.

3.4 Data Collection Instruments.

Mbwesa (2006) defines data collection instruments as the techniques and tools that are used for the purpose of data collection. Research instrumentation is also about how the research tools are deployed (Oso & Onen, 2011). For this study, data was collected using structured questionnaires that were issued to the respondents. Questionnaires

were preferred because they were simple to administer, comprehensive and were simpler to analyze since they provide direct observations.

3.4.1 Questionnaire

The questionnaires were the main instruments used in collecting data from the respondents as all the respondents were literates. There were questionnaires for construction managers, contractors, quantity surveyors and building consultants. The content of the questionnaire instrument was based on the findings of the literature reviewed in chapter two (2) and the questions covered the background information of respondents, sought information about project cost estimation practices, methods and processes that can be utilised by emerging construction firms to reduce project cost variance, significant risk factors affecting cost estimation of construction works and internal organizational processes and method for reducing project cost variances. The questionnaire used closed-ended questions and was also structured in the *Likert* fashion, on a five (5) point scale, ranging from "strongly agree" (SA), through "agree" (A), "not sure" (NS), "disagree" (DA) to "strongly disagree" (SD).

3.5 Validity of Questionnaire

Validity, in the context of this study refers to how accurately the questionnaire was able to collect the responses from the respondents as intended by the researcher in order to answer the research questions. Furthermore, it is the degree to which the study accurately answers the questions it was intended to answer (Gravetter & Forzano, 2010). Both face and content validity of the instrument were ensured. The face validity of the study was granted by the researcher's peers, colleague workers and other members of construction firms. The content validity on the other hand was determined

by the expert judgment of the supervisor and other professionals in field of construction.

Furthermore, to enhance the validity of the research instrument, the questionnaire was made available to the supervisor, to review and comment on with the view of establishing content validity. The study modified and deleted materials considered inaccurate or which the study felt infringed on the confidentiality of the respondents. The supervisor further scrutinized unclear, biased and deficient items, and evaluated whether items were members of the subsets they have been assigned. A few modifications were affected to improve the final instrument for the main survey which was then administered. Items that were not clearly stated were corrected. Some of the items were moved to the appropriate section of the instrument. Some of the items were also reformulated to suite the objectives of the study.

3.6 Data Collection Procedure

Meetings were held during with the executives of the construction companies and the consultancy firms so as to gain acceptance of their participation in the research. More specifically, the researcher came in touch with all the respondents and asked them to participate in the research after explaining the nature and the scope of the study. In general terms the respondents were willing to participate in the research. A total of one hundred and twenty-eight (128) questionnaires were administered directly to the chosen respondents. In all, one hundred and twenty (120) questionnaires were completed and successfully returned representing a retrieval rate of 93.6%. The possibility of retrieval rate of the questionnaires was as a result of the researchers' colleagues who offered a helping hand. The opposite could have been the case if the

researcher had taken the lonely task of going round the construction companies and consultancy firms to collect the questionnaires.

3.7 Data Analysis Techniques

The researcher adopted the used of non-probability sampling techniques (purposive sampling techniques) to select the respondent for the study. The data were collected from the field were screened, summarized and analyzed. The Statistical Product and Service Solutions (SPSS) version 20 software was used for the analysis. The results were presented in frequency tables, charts and percentages.

CHAPTER FOUR

PRESENTATION OF RESULTS AND ANALYSIS

4.0 Introduction

This chapter deals with the presentation, analysis and interpretation of data generated by the researcher through the questionnaires administered to construction managers, building contractors, consultants, and quantity surveyors living at Kumasi metropolitan assembly. The results of the questionnaire are presented in tables and their responses also have the percentage and mean ratings.A total of 100 questionnaires were administered. Out of it, twenty (20) copies were not returned, so eighty (80) was used.

4.1 Responses from building contractors, consultants and construction managers

Table 4.1 presents the results on general information of respondents selected.

Table 4. 1: General Information of Respondents

General Information variables	Frequency	Percentage (%)
Category of personnel that best describes the respondents		
Site Contractors	25	50%
Site Consultants	20	40%
Construction managers	5	10%
Total	50	100%
Years of experience of the respondents in the construction industry		
6-10 years	25	50%
0-5 years	14	28%
More than 10 years	11	22%
Total	50	100%
Number of construction projects the respondents have been involved in		

6-10	26	52.0%
1 - 5	12	24.0%
More than 10	12	24.0%
Total	50	100%
The type of projects respondent's organization has been engaged in		
Domestic buildings	19	38%
Office and administration buildings	11	22%
Hospital	11	22%
Hotel and business center building	5	10%
School buildings	4	8%
Total	50	100%
Types of contracts the respondents engage in		
Design-Build-Operate	27	54%
Traditional contracts	23	46%
Total	50	100%
The average project duration of the respondents		
12 months to 18 months	16	32%
18 months to 24 months	10	20%
30 months to 36 months	10	20%
24 months to 30 months	7	14%
Less than 12 months	7	14%
Total	50	100%
Regular assessment of risk in the execution of projects is done		
Yes	34	68%
No	16	32%
Total	50	100%
Specific risk assessment that is carried out by the respondents		
Assessment of organizational risk	18	36%
Assessment of clearance risk	17	34%
Assessment of technical risk	15	30%
Total	50	100%

Source: Field Data 2021

As shown in table 4.1, 25 out of 50 respondents representing 50.0% were contractors, 20 respondents representing 40.0% are building consultants and the remaining 5 respondents representing 10.0% are construction managers.

From table.4.1, the study revealed that 50.0% of the respondents have worked in the construction industry between 6-10 years, 28.0% has experience between 0-5 years while the remaining 22.0% has more than 10 years of experience. This indicates that majority of the respondents has more experience in the construction industry. Regarding the number of projects respondents have been involved in, 26 out of 50 respondents representing 52.0% had worked on 6-10 projects in the construction industry, followed by 12 respondents representing 24.0% had also worked on 1-5 projects and the rest 12 also representing 24% had involved in more than 10 construction projects.

The table above shows that, 19 respondents says that they engage in domestic building projects which represents 38.0%, 11 responses representing 22.0% works on office and administration building, other 11 also representing 22.0% ascertain that they work on hospital building projects, 5 or 10% engages in hotel and business center building projects and the remaining 4 respondents representing 8.0% also works on school buildings.

The result in table 4.1 indicates that the majority of the respondents which is 27 representing 54% engaged in design-build-operate contracts whereas the remaining 23 or 46% dealt with traditional contracts.

Regarding their average project duration, 32.0% of them use 12 months to 18 months to finish a project, followed by 20.0% who use 18 months to 24 months to complete a project. Another 20% completes a project within 30 months to 36 months and 14% use 24 months to 30 months while as the remaining 14% use less than 12

months to finish a project. It is evident from the table above that the majority of the respondents being 34 representing 68% confirmed that regular assessment of risk is conducted during execution of project while as the rest 16 representing 32% do not embark on such assessment.

Based on table 4.1, out of 50 respondents, a majority of 36.0% ascertain that they carry technical risk assessment on their project, 34.0% said they assess clearance risk while the remaining 30.0% assesses organizational risks factors during the execution of the project. This implies that, majority of the respondents contacted for the study carry risk assessment on projects during their duties and have acquired some skills in terms of risk factors that can be shared to enhance this study.

4.2: Risk Factors Affecting Cost Estimation of Construction Works

Table 4.1 presents the results on risk factors affecting cost estimation.

Table 4. 2: Risk Factors Affecting Cost Estimation of Construction Works

Risk factors	Not Significant 1 (%)	Moderate-tely Significant 2 (%)	Not Sure 3 (%)	Signifi-cant 4 (%)	Highly Signific-ant 5 (%)	Mean	Rank
Changes to the scope of the building	_	_	11 (22%)	19 (38%)	20 (40%)	4.18	1
Equipment failure (breakdown)	_	_	12 (24%)	21 (42%)	17 (34%)	4.10	2
Changes in government policies	_	16 (32%)	_	13 (26%)	21 (42%)	3.78	3
Loss due to fire outbreak	_	13 (26%)	11 (22%)	14 (28%)	12 (24%)	3.50	4
Availability of experienced and skilled labour	_	10 (20%)	17 (34%)	14 (28%)	9 (18%9	3.44	5
Technology selection implementation risk	_	14 (28%)	10 (20%)	26 (52%)	_	3.24	6
Plants operations skill level	_	13 (26%)	16 (32%)	21 (42%)	_	3.16	7

Accidents to operatives	_	15 (30%)	16 (32%)	19 (38%)	_	3.08	8
Land acquisition issues	10 (20%)	12 (24%)	13 (26%)	15 (30%)	_	2.66	9
Cash flow administration	14 (28%)	17 (34%)	_	19 (38%)	_	2.48	10
Level of leader's supervision	17 (34%)	16 (32%)	17 (34%)	_	_	2.00	11
Material and plant inflation risk	17 (34%)	18 (36%)	15 (30%)	_	_	1.96	12
Insufficient detailing of drawing	18 (36%)	18 (36%)	14 (28%)	_	_	1.92	13
Damage to the structure	18 (36%)	20 (40%)	12 (24%)	_	_	1.88	14
Theft at the site	20 (40%)	19 (38%)	11 (32%)	_	_	1.82	15

Source: Field Data 2021

From Table 4.2, changes to the scope of building had the highest mean value of (4.18) with only 11 representing 22% who were not sure to the statement and as many as 20 representing 40% sees it as highly significant whereas equipment failure (breakdown) recorded the next highest mean value of (4.10). This signifies that, the major risk factors that affects cost estimation of emerging construction firms at Kumasi metropolis are changes to the scope of the building and equipment failure. This may happen because of the fact that, management of construction sites mostly fails to critically analyze equipment that are used on site. This is in agreement with Dey (2002) as their study stated that the most likely occurring risk factor as the technical risk, with risk sub factors as; scope change, technology selection, implementation methodology, equipment risk, materials risk, engineering and design change.

According to Table 4.2, changes in government policies (3.78), loss due to fire outbreak (3.50), availability of experienced and skilled labour (3.44), and technology selection implementation risk (3.24), plants operations skill level (3.16) and accidents to operatives (3.08) also formed part of the major factors that affects cost estimation of construction works in Kumasi metropolis. This may occur as a result of frequent

changes in government policies concerning building regulations.Chapman (2001) in support identified damage to structure, accident to operatives, damage to equipment and loss due to fire outbreaks as some physical risk factors affecting cost estimation in the construction industry.

Theft at the site recorded the least mean value of (1.82) according Table 4.2. This can be due to the fact that, theft do not go on that much at site due to proper security put in place but can still have some significant impact on cost estimation.

The study concludes that, management of emerging construction firms at Kumasi Metropolis mostly fails to critically assess or analyze the equipment being used at their various sites in order to reduce the cost of estimation of construction works. The study therefore recommends that, building contractors, consultants and construction managers should pay more attention to equipment that will be used at sites when estimating so as to avoid under or over cost estimation of construction works.

4.3 Internal Organizational Processes, Methods and Techniques to Reduce Cost Variances

Table 4.1 presents the results on the internal organizational processes, methods and techniques to reduce cost variances.

Table 4. 3: Internal Organizational Processes, methods and techniques to Reduce Cost Variances

Processes, methods and techniques	Strongly Disagrees 1 (%)	Disagree 2 (%)	Not sure 3 (%)	Agree 4 (%)	Strongly agrees 5 (%)	Mean	Rank
Receive and understand the client's request	–	–	11 (22%)	24 (48%)	15 (30%)	4.08	1
Gather even the least necessary information before calculating the estimate	–	–	15 (30%)	19 (38%)	16 (32%)	4.02	2
Gather relevant historical information for each project	–	–	16 (32%)	24 (48%)	10 (20%)	3.88	3
Computer aided cost estimation methods	–	8 (16%)	9 (18%)	18 (36%)	15 (30%)	3.80	4
State and document ground rules and assumptions for the estimate	–	17 (34%)	9 (18%)	13 (26%)	11 (22%)	3.36	5
Specific analogy estimation technique	–	14 (28%)	14 (28%)	22 (44%)	–	3.16	6
Conducting risk analysis for contingencies	–	16 (32%)	14 (28%)	20 (40%)	–	3.08	7
Parametric estimation method	–	16 (32%)	17 (34%)	17 (34%)	–	3.02	8
Scheduling of project's elements	–	15 (30%)	20 (40%)	15 (30%)	–	3.00	9
Assembly estimation technique	–	18 (36%)	14 (28%)	18 (36%)	–	3.00	10
The learning curve estimation method	13 (26%)	–	12 (24%)	25 (50%)	–	2.98	11
Assessment of project to select suitable cost estimate technique	20 (40%)	–	9 (18%)	21 (42%)	–	2.62	12
Deterministic or risk-based estimation technique	18 (36%)	–	16 (32%)	16 (32%)	–	2.60	13
Defining project's scope and construct work breakdown structure	10 (20%)	14 (28%)	15 (30%)	11 (22%)	–	2.54	14

Source: Field Data 2021

The results according to Table 4.3 indicates that receive and understand clients request recorded the highest mean value of (4.08) as the major method which helps to reduce cost variance in the construction industry with 11 representing 22.0% not sure of the statement and 24 representing 48.0% agreeing to the statement. This implies that, when client's speck is understood and carried accordingly, it helps to reduce cost variance by emerging construction firms at Kumasi Metropolis. This agrees with (Havranek, 2017; Venkataraman and Pinto, 2008; Shane et al., 2009), they stated that, receiving and understanding the customer's request, defining technical specifications and constructing work breakdown structure (WBS) is very essential as these steps form the information prerequisite that is needed for an accurate cost estimate, as poor design, misunderstanding the customer and inadequately constructed WBS lead to cost over-runs.

From Table 4.3 the results show that the items gather even the least necessary information before calculating the estimate (4.02), Gather relevant historical information for each project (3.88), Computer aided cost estimation methods (3.80 and State and document ground rules and assumptions for the estimate (3.36) are also major methods and techniques that help to reduce cost variance in emerging construction firms at Kumasi Metropolis. This may be as a result of the fact that the need for organized and retrievable historical information for obtaining a more precise cost estimate is necessary but however, sometimes the information is not available. The lack of information may be based on the novelty of the product or incomplete cost estimating procedures. Stewart and Wyskida, (1987) in support opined that without historical data, most of the estimation techniques would not be possible.

According to Table 4.3, defining project's scope and construct work breakdown structureranked last with a mean value of (2.54) having 14 representing 28.0% disagreeing with the statement, 11 representing 22.0% agreeing with the statement. The result indicates that, defining projects scope and work breakdown structure in construction firms at Kumasi Metropolis has little or no impact on cost variance. This may be due to the fact that, workers in emerging construction firms at the Kumasi Metropolis always defines project well with its work breakdown structure.

The study concluded that when clients design is received and understood very well by building contractors, consultants and construction managers of emerging construction firms, it helps them to reduce cost variance. The study recommends that stakeholders in construction industry should endeavor to understand clients request and also should rely on relevant historical information in order to help reduce cost variance in their firms.

4.4 Responses from Quantity Surveyors

Table 4.1presents the results on the general information of respondents selected.

Table 4. 4: General Information of Respondents

General Information variables	Frequency	Percentage %
Years of experience respondents have in the construction industry		
0 – 5 years	15	50.0%
6 – 10 years	10	33.3%
More than 10 years	5	16.7%
Total	30	100%
Construction projects respondents have been involved in its estimation		
6 – 10	16	53.3%
1 - 5	8	26.7%
More than 10	6	20%
Total	30	100%
Type of projects respondents mostly perform cost estimates for		
Domestic buildings	17	56.7%
Office and administration building	8	26.7%
School buildings	5	16.7%
Total	30	100%
Types of contracts respondents engages in		
Traditional contracts	16	53.3%
Design-Build-Operate	14	46.7%
Total	30	100%
The average project duration		
18 months to 24 months	11	36.7%
24 months to 30 months	11	36.7%
12 months to 18 months	8	26.7%
Total	30	100%
Regular assessments of risk in the execution of projects		
Yes	20	66.7%
No	10	33.3%
Total	30	100%
Specific risk assessments that are carried out		
Assessment of technical risk	12	40%
Assessment of organizational risk	9	30%
Assessment of clearance risk	9	30%
Total	30	100%

Source: Field Data 2021

From table 4.4, regarding the respondent's experiences, 50% had from 0-5 years working experience in the construction industry; followed by 33% with 6-10 years working experience and 16% had more than 10 years working experience. It is clear from the findings that majority of the respondents representing 83.3% of the sampled population have worked in the construction industry for 1-10 years which implies that the respondents are familiar with the topic under study.

Based on Table 4.4, out of 30 respondents, a majority of 16 representing 53.0% have estimated between 6-10 projects, 8 representing 26.7% said they have worked on 1-5 construction projects while the remaining 6 also representing 20.0% have been involved in more than 10 construction projects.

Table 4.4 depicts the type of the projects the quantity surveyors perform estimate for. 17 representing 56.7% does estimation on domestic buildings and 8 or 26.7% makes estimation for office and administration building while the remaining 5 representing 16.7% usually estimate on school buildings. It can be said from the table above that, 16 respondents representing 53.3% engages in traditional contracts while as the remaining 14 or 46.7% also works on design-build-operate contracts.

Regarding their average project duration, 36.7% of them use 18 months to 24 months to finish a project, followed by another 36.7% who use 24 months to 30 months to complete a project. Another 26.7% completes a project within 12 months to 18 months.

Based on table 4.4, out of 30 respondents, a majority of 40.0% ascertain that they carry technical risks assessment on their project, 30.0% said they assess clearance risks while the remaining 30.0% assesses organizational risks factors during the execution of the project.

4.5 Project Cost Estimation Methods and Techniques That Can Be Utilized by Emerging Construction Firms to Reduce Project Cost Variance

Table 4. 5: Project Cost Estimation Methods and Techniques

Project Cost Estimation Methods and Techniques	Not Effective 1 (%)	Less Effective 2 (%)	Quite Effective 3 (%)	More Effective 4 (%)	Highly Effective 5 (%)	Mean	Rank
Cost review and update estimation method	_	_	10 (33.3%)	7 (23.3%)	13 (43.3%)	4.10	1
Computer aided cost estimation methods	_	6 (20.0%)	6 (20.0%)	8 (26.7%)	10 (33.3%)	3.73	2
Assembly estimation technique	_	8 (26.7%)	10 (33.3%)	_	12 (40.0%)	3.53	3
The learning curve estimation method	_	9 (30.0%)	12 (40.0%)	9 (30.0%)	_	3.00	4
Deterministic or risk-based estimation technique	_	8 (26.7%)	14 (46.7%)	8 (26.7%)	_	3.00	5
Detailed cost estimate/bottom-up technique	7 (23.3%)	_	10 (33.3%)	13 (43.3%)	_	2.97	6
Specific analogy estimation technique	_	12 (40.0%)	11 (36.7%)	7 (23.3%)	_	2.83	7
Parametric estimation method	8 (26.7%)	_	11 (36.7%)	11 (36.7%)	_	2.83	8
Expert opinion technique	11 (36.7%)	_	8 (26.7%)	11 (36.7%)	_	2.63	9
Design to cost method	10 (33.3%)	9 (30.0%)	11 (36.7%)	_	_	2.03	10
Trend analysis estimation method	_	9 (30.0%)	8 (26.7%)	13 (43.3%)	_	1.97	11
Three-point estimation method	11 (36.7%)	9 (30.0%)	10 (33.3%)	_	_	1.97	12

Source: Field Data 2021

According to Table 4.5, cost review and update estimation methodrecorded the highest mean value of (4.10) having 13 representing 43.3% agreeing to the statement with computer aided cost estimation methodsrecording the next highest mean value of (3.73). This implies that, the use of update estimation method to effectively review cost and the use of computer software to determine variance are among the major strategies that can help reduce project cost variance in emerging construction firms at Kumasi Metropolis. This agrees with Galluzzo (1991) as he concludes that a well-maintained cost database can effectively assist in analogous, parametric and detailed cost estimation, making the process less costly and yielding more accurate outputs.

Again, Oyedele, (2015) opined that an estimate is constructed by examining previous estimates of the same internal arrangements, scope completeness, assumptions and estimating methodology used and updating them with changes due to difference in time. Interest rate, inflation rate, exchange rate and other economic factors that may affect costs over time are considered.

From Table 4.5, assembly estimation technique (3.53), the learning curve estimation method (3.00) and deterministic or risk-based estimation technique (3.00) were also found to be among the major estimation methods and techniques to help reduce project cost variance by emerging construction firms at Kumasi Metropolis. This indicates that, it is highly possible for emerging construction firms to reduce project cost variance if these techniques are implemented judiciously. This is in agreement with Dagostino and Peterson (2011) as they suggested the use of assembly estimation in construction projects and is a technique where the cost estimate is computed based on the bid for a work module. In addition, GAO (2009) supports this by saying that the learning curve concept which was originated from aircraft

construction industry in the 1930s is used by organizations and individuals who learn to carry out activities more efficiently as a result of repetition.

With reference to Table 4.5 the Trend analysis estimation method (1.97) and Three-point estimation method (1.97) recorded the least mean values even though they formed part of the estimation methods and techniques to reduce project cost variance in emerging construction firms at Kumasi Metropolis. This indicates that, other methods and techniques are used to help reduce cost variance which seems rather more effective to the stakeholders of the emerging construction firms than trend analysis and three-point estimation methods.

The study concludes that, the use of cost review and update estimation method and computer aided cost estimation methodsfor estimating construction works are very important strategies in reducing project cost variance. It is recommended that, construction firms should employ quantity surveyors that are abreast with these techniques and methods, especially the computer software systems in order to reduce cost variance when it comes to estimation of construction works.

4.6 Risk Factors Affecting Cost Estimation of Construction Works

Table 4. 6: Risk Factors Affecting Cost Estimation of Construction Works

Risk Factors	Not Signifi-cant	Modera-tely Signifi-cant	Not sure	Signifi-cant	Highly Signifi-cant	Mean	Rank
	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)		
Equipment failure (breakdown)	–	6 (20.0%)	5 (16.7%)	9 (30.0%)	10 (33.3%)	3.77	1
Accidents to operatives	–	6 (20.0%)	8 (26.7%)	7 (23.3%)	9 (30.0%)	3.63	2

Loss due to fire outbreak	4 (13.3%)	–	9 (30.0%)	7 (23.3%)	10 (33.3%)	3.63	3
Damage to the structure	–	9 (30.0%)	10 (33.3%)	–	11 (36.7%)	3.43	4
Technology selection implementation risk	–	9 (30.0%)	8 (26.7%)	13 (43.3%)	–	3.13	5
Changes in government policies	8 (26.7%)	–	7 (23.3%)	15 (50.0%)	–	2.97	6
Level of leader's supervision	8 (26.7%)	–	7 (23.3%)	15 (50.0%)	–	2.97	7
Material and plant inflation risk	9 (30.0%)	–	10 (33.3%)	11 (36.7%)	–	2.77	8
Plants operations skill level	7 (23.3%)	9 (30.0%)	14 (46.7%)	–	–	2.23	9
Land acquisition issues	7 (23.3%)	9 (30.0%)	14 (46.7%)	–	–	2.23	10
Cash flow administration	8 (26.7%)	10 (33.3%)	12 (40.0%)	–	–	2.13	11
Changes to the scope of the building	8 (26.7%)	11 (36.7%)	11 (36.7%)	–	–	2.10	12
Theft at the site	10 (33.3%)	8 (26.7%)	12 (40.0%)	–	–	2.07	13
Insufficient detailing of drawing	7 (23.3%)	15 (50.0%)	8 (26.7%)	–	–	2.03	14
Availability of experienced and skilled labour	7 (23.3%)	16 (53.3%)	7 (23.3%)	–	–	2.00	15

Source: Field Data 2021

From Table 4.6, equipment failure (breakdown) had the highest mean value of (3.77) with only 5 representing 16.7% who were not sure to the statement and as many as 10 representing 33.3% sees it as highly significant whereas accidents to operatives and loss due to fire outbreak recorded the next highest mean value of (3.63) each. This signifies that, the major risk factors that affects cost estimation of emerging

construction firms at Kumasi metropolis are equipment failure, accidents to operatives and loss due to fire outbreak. This may happen because of the fact that, quantity surveyors of construction sites mostly fail to critically assess equipment that are used on site. This is in agreement with Chapman (2001)as he listed damage to equipment and loss due to fire outbreaks as physical risk factors that affects cost estimation of construction works.

According to Table 4.6, damage to the structure (3.43) and technology selection implementation risk (3.13), also formed part of the major factors that affects cost estimation of construction works in Kumasi metropolis. This may occur as a result any acts of God such as flood, earth quake or a strong storm which can go a long way to damage the building; and as such can equally affect the cost estimation of the construction works. Again, the results may be due to the fact that, the wrong technology is being implemented by the stakeholders. Chapman (2001)in support identified damage to equipment, floods; weather conditions and change in building design as other imperative risk factors affecting cost estimation of construction works.

Availability of experienced and skilled labourrecorded the least mean value of (2.00) according Table 4.6. This can be due to the fact that, quantity surveyors do not necessary need skilled labours before estimating for construction works. Ajator (2013) in agreement opined that opting for a contract without adequate human financial technical and technological resources or pricing competitive project at breakeven margin, or implementing too many projects concurrently without adequate carrying capacity or lack of professional skill for a listed project are internal organization's risk.

The study concludes that, quantity surveyors of emerging construction firms at Kumasi Metropolis mostly fails to critically analyze equipment that are used on site and also do not really envisage that there could be a force majeure. The study therefore recommends that, quantity surveyors should pay more attention to every nitty-gritty when estimating for construction works so as to reduce project cost estimation as Chapman (2001) asserted that risk factors could bring a change in the objectives or plan of a contractor or client.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the summary of findings, conclusion and recommendations, of the study that sought to investigate project cost estimation practices in emerging construction firms to reduce project cost variance in Kumasi metropolis.

5.1 Summary of Findings

The following are the summary of findings;

- Parametric estimation method, detailed cost estimate/bottom-up technique, computer aided cost estimation methods and others are the major project cost estimation methods and techniques utilized by emerging construction firms to reduce project cost variance in the Kumasi metropolis.
- Changes to the scope of the building, changes in government policies, equipment failure (breakdown), availability of experienced and skilled labour among others are the major risk factors that affect construction cost estimationin the Kumasi metropolis.
- Scheduling of project's elements, state and document ground rules and assumptions for the estimate, gathering of relevant historical information for each project among others are the major internal organizational processes, methods and techniques to reduce cost variancesin the Kumasi metropolis.

5.2 Conclusion of the Study

Based on the findings identified from the study, the following specific conclusions were made;

1. Emerging construction firm managers at Kumasi metropolis must critically examine and utilized the most appropriate project cost estimation method and technique applicable to each construction project to help reduce cost variance.
2. Clients or management of emerging construction firms at Kumasi metropolis mostly incur exorbitant cost/loses during or at the completion of construction projects due to the disregard of project cost estimation risk factors.
3. Receipt and understanding of client's requests are a very important internal organizational process and method which is highly utilized by emerging construction firms at Kumasi metropolis to help reduce project cost variances.

5.3 Recommendations

Based on the findings identified from the study, the following recommendations were made;

1. Building professionals (contractors, consultants, construction managers and quantity surveyors) are to ensure that all the effective cost estimation methods and techniques are fully adhered to in the construction of domestic buildings, public and industrial buildings as well.

2. Building professionals should ensure that they are well informed of the significant risk factors affecting cost estimation of construction works in order to make the right estimation required.
3. Contractors, consultants and construction managers should make it a point to put into good use the internal organizational processes available to them in order to help reduce cost variances.

5.4 Suggestions for Future Research Work

More research needs to be done in order to have a complete set of detailed implementable strategies for improving risk factors affecting cost estimation in building construction.

REFERENCES

Abrahamson, M.W. (1998) RISK Management; - International Construction Law, USA.

Adoko, M. T., Mazzuchi, T. A., & Sarkani, S. (2016). Developing a cost overrun predictive model for complex systems development projects. Project Management Journal, 46(6), 111–125.

Ajator, U.O (2000) Mitigating the Effects of Natural and Man-made Hazards in Settled Areas, in: Man, and Environment Obasikene, Adinna and Uzoechi (Eds), Computer Age Publisher, Pp. 363- 382, Enugu.

Ajator, U.O. (2013) Financial Engineering and Project Risk Management: Imperatives (for Professional Quantity Surveyors, Presented Paper at the NIQS Enugu State Chapter Conference on Financial Engineering/Project Risk Management, Held at Sunshine Guest House Enugu on the 8-9 th of August, 2013.

Akinci, B. and Fisher, M. (1998) Factors Affecting Contractor's Risk of Cost Overburden, in: Journal of management in Engineering. Vol. 14, pp. 67-75.

Al-Momani, A., (1996). Construction Cost Prediction for Public School Buildings in Jordan. Construction.

Artto K., Martinsuo M., Kujala J. (2011). Project business – the project manage-ment textbook, Helsinki, Finland, available: http://pbgroup.tkk.fi/en/, (last accessed: 24.10.19).

Baccarini, D. (2006). The maturing concept of estimating project cost contingency—A review. In G. Runeson & R. Best (Eds.), Proceedings of the Australasian University building educator's association annual conference 2006: 31st Annual Conference, 11–14 July 2006. Sydney, New South Wales, Australia: University of Technology.

Becker, T. V., Jaselskis, E. J., & El-gafy, M. (2014). Improving predictability of construction project outcomes through intentional management of indirect construction costs. Journal of Construction Engineering and Management, 140(6), 401–414. doi: http://dx.doi.org:10.1061/(ASCE)

Bhargava, A., Anastasopoulos, P.C., Labi, S., Sinha, K.C., Mannering, F.L. (2010). Three-Stage Least-Squares Analysis of Time and Cost Overruns in Construction Contracts, Journal of Construction Engineering and Management, Vol. 136(11), pp. 1207-1218.

Biemer, P.P., Groves, R.M., Lyberg, L.E., Mathiowetz, N.A. & Sudman, S. (2011), Measurement errors in surveys, vol. 173, John Wiley & Sons.

Blaikie, N. 2009, Designing social research, Polity.

Bradley, J.R. (2015). Improving Business Performance with Lean, Business Expert Press, LLC, 2nd edition, Ney York, 255 p.

Broyles, R.W., Lay, C.M. (1982). Budgeting and Controllable Cost Variances, The case of Multiple Diagnoses, Multiple Services and Multiple Resources, Journal of Medical Systems, Vol. 6(6), pp. 599-611.

Budiono, H.D.S., Kiswanto, G., Soemardi, T.P. (2014). Method and Model Development for Manufacturing Cost Estimation During the Early Design Phase Related to the Complexity of the Machining Processes, International Journal of Technology, Vol.2, pp. 183-192.

Burns, N. and Grove, S.K. (2003) Understanding nursing research. 3rd Ed. Philadelphia, W.B. Saunders Company.

Caron, F., Ruggen, F., & Merli, A. (2013). A Bayesian approach to improve estimate at completion in earned value management. Project Management Journal, 44(1), 3–16.

Chapman, C. & Ward, S. (2002) Managing Project Risk and Uncertainty, Chichester: John Wiley and Sons ltd.

Chapman, C. (2000). Project risk management—The required transformations to become project uncertainty management. PMI Research Conference, Paris, France.

Chapman, R. (2001). The Controlling Influences on Effective Risk Identification and Assessment for Construction Design Management. International Journal Of Project Management,vol. 19, pp 147-160.

Chenyun, Z. Y. (2012). The BP artificial neural network model on expressway construction phase risk. Systems Engineering Procedia, 4, 409–415.

Cohen, M.W & Palmer, G.R. (2004) Project Risk Identification and Management, ACCE International Transactions.

Cooke, B. and Williams, P., (2009). Construction Planning, Programming and Control (3rded.), Wiley-Blackwell: publishing, Oxford.

Creedy, G. D., Skitmore, M., & Wong, J. (2010). Evaluation of risk factors leading to cost overrun in delivery of highway construction projects. Journal of Construction Engineering and Management, 136(5), 528–537.

Creswell, J.W. (2009), 'The selection of a research design', Research design: qualitative, quantitative and mixed methods approaches. Thousand Oaks, CA: Sage Publications.

Creswell, J.W. (2012), Qualitative inquiry and research design: Choosing among five approaches, Sage.

Creswell, J.W. (2014), A concise introduction to mixed methods research, Sage Publications.

Dagostino, F.R., Peterson, S.J. (2011). Estimating in Building Construction, Pearson Education Inc. publishing as Prentice Hall, 7th edition, New Jersey, 273 p.

Danso H.and Antwi J. K., (2012). Evaluation of the Factors Influencing Time and Cost Overruns in Telecom Tower Construction in Ghana International, Journal of the Institute for Science, Technology and Education (IISTE),Vol 2, No.6, pp. 15-24.

De Vaus, D. (2013), Surveys in social research, Routledge.

Dean, J. (1937). Correlation analysis of cost variation, The Accounting Review, Vol. 12 (1), pp. 55-60.

Dey, P.K. (2002) Project Risk Management: A combined Analytic Hierarchy Process and Decision Tree Approach, In: Cost Engineering, Vol. 44, No. 3 March 2002.

Doloi, H.K. (2013). Cost Overruns and Failure in Project Management: Understanding the Roles of Key Stakeholders in Construction Projects, Journal of Construction Engineering and Management, Vol. 139(3), pp. 267-279.

Dubai Architecture, (2014). 'Burj Dubai'.www.dubai-architecture.info/DUB-004.htm[Accessed: 22 June 2014].

Eldosouky, A. A., Ibrahim, A. H., & Mohammed, H. E. (2014). Management of construction cost contingency covering upside and downside risks. Alexandria Engineering Journal, 53(4), 863–881.

Ferris, K.R. (1976). The Apparent Effects of Profit Forecast Disclosure on Managerial Behavior: An Empirical Examination, Journal of Business Finance & Accounting, Vol. 3(3), pp. 53-66.

Finnerty, J. (1996). Project Financing –Asset Based Financing Engineering, New York, John Wiley and Sons.

Flyvbjerg, B., Holm, M.S., Buhl, S. (2002). Underestimating Costs in Public Works Projects – Error or Lie? Journal of American Planning Association, Vol. 68(3), pp. 279-295. Fowler Jr, F.J. (2013), Survey research methods, Sage publications.

Frimpongs Y., Oluwoye J., and Crawford L., (2003). Causes of Delay and Cost Overrunsin Construction of Groundwater Projects in a DevelopingCountries; Ghana as a Case Study. International Journal of Project Management, Vol. 21, No.5, pp. 321-326. Fugar, F. D. K ., and Agyakwah-Baah, A. B., (2010). Delays in Building Construction Projects in Ghana, Australasian Journal of Construction Economics and Building, 10 (1/2) 103-116

Galluzzo. (1991). Database Development and computerized Cost Estimation, Cost Engineering, Vol. 33(12),pp. 9-13.

GAO. (2009). Cost Estimating and Assessment Guide – Best Practices for Developing and Managing Capital Program Costs, United States Government Accountability Office, GAO-09-3SP, 420 p.

GAO. (2009). Cost Estimating and Assessment Guide – Best Practices for Developing and Managing Capital Program Costs, United States Government Accountability Office, GAO-09-3SP, 420 p.

Gill, J. & Johnson, P. (2010), Research methods for managers, Sage.

Goh, J., Hall, N.G. (2013). Total Cost Control in Project Management via Satisficing, Management Science, Vol. 59(6), pp. 1354-1372.

Grant, R.M. (1996). Toward a Knowledge-Based Theory of the Firm, Strategic Management Journal, Vol. 17 (Winter Special Issue), pp. 109-122.

Gravetter, F. J., & Forzano, L. B. (2010). Research methods for the behavioural sciences (3rd ed.). Belmont: Thomson Wadsworth.

Haseeb, M., Xinhai-Lu, Aneesa Bibi, A., Maloof-ud-Dyian, and Rabbani, W. (2011). Causes and Effects of Delays in Large Construction Projects of Pakistan. Kuwait Chapter of Arabian Journal of Business and Management Review, Vol. 1, No.4; December 2011.

Havranek, T. (2017). Modern project management techniques for the environmental remediation industry, CRC Press, 456 p.

Heeringa, S.G., West, B.T. & Berglund, P.A. (2010), Applied survey data analysis, CRC Press.

Hicks, J.C. (1992). Heavy Construction Estimates, With and Without Computers, Journal of Construction Engineering and Management, Vol. 118(3), pp. 545-560.

Holm, L., Schaufelberger, J. E., Griffin, D., & Cole, T. (2005). Construction cost estimation – process and practice. Pearson Prentice Hall.

Idrus, A., Nuruddin, M. F., & Rohman, M. A. (2011). Development of project cost contingency estimation model using risk analysis and fuzzy expert system. Expert Systems with Applications, 38(3), 1501–1508. Jørgensen, M., Halkjelsvik, T., Kitchenham, B. (2012). How does project size affect cost estimation error? Statistical artifacts and methodological challenges, International Journal of Project Management, Vol.30, pp. 839-849.

Kaplan, R.S. (1975). The Significance and Investigation of Cost Variances: Survey and Extensions, Journal of Accounting Research, Vol. 3(2), pp. 311-337.

Keisala, J. (2009). Cost Accounting methods for construction projects in North-West Russia: Case study Pöyry CM Oy. Accounting and Finance Master's thesis, University of Kuopio.

Kerzner, H., Kerzner, H.R. (2013). Project Management: A Systems Approach to Planning, Scheduling and Controlling, 11th edition, John Wiley & Sons Inc., USA, 1296 p.

Kesavan, R., Elanchezhian, C., Vijaya Ramnath, B. (2009). Process Planning and Cost Estimation, New Age International, 2nd edition, New Delhi, 229 p.

Kitchenham, B., & Linkman, S. (1997). Estimates, uncertainty and risks. IEEE Software, 14(3), 69–73.

Kujala, S., Artto, K., Aaltonen, P., Turkulainen, V. (2010). Business models in project-based firms – Towards a typology of solution-specific business models, International Journal of Project Management, Vol. 28(2), pp. 96-106.

Kwon, H., Kang, C.W. (2018). Improving Project Budget Estimation Accuracy and Precision by Analysing Reserves for both Identified and Unidentified Risks, Project Management Journal, Vol. 50(1), pp. 1-15.

Lorenz, A., Raven, M., Blind, K. (2019). The role of standardization at the interface of product and process development in biotechnology, Journal of Technology Transfer, Vol. 44, pp. 1097–1133.

Love, P.E.D., Wang, X., Sing, C., Tiong, R.L.K. (2013). Determining the Probability of Project Cost Overruns, Journal of Construction Engineering and Management, Vol. 139(3), pp. 321-330.

Lowe, D., Skitmore, M.R. (1994). Experiential Learning in Cost Estimating, Construction Management and Economics, Vol. 12(5), pp. 423-431.

Mac-Barango, D.O., Iminabo, L.& Ajator, U.O. (2016) Analysis of the Influence of Spatial Disparity on the Price of Sandcrete Blocks in Nigeria, In: Journal of Oil and Gas Technology, Vol. 1, No. 2, October 2016, pp. 131-143

Moselhi, O. (1997). Risk assessment and contingency estimating. AACE transactions, Dallas, TX.

Munier, N. (2014). Risk Management for Engineering Projects: Procedures, Methods and Tools, Springer, 220 p.

NASA. (2015). Cost Estimating Handbook, NASA CEH, February 2015, Version 4.0, Washington DC, 52 p.

NASA. (2018). NASA Work Breakdown Structure (WBS) Handbook, National Aeronautics and Space Administration (NASA), January 2018, Revision B, Washington D.C., 58 p.

Nicoletti, B. (2012). Lean and Digitize: An Integrated Approach to Process Improvement, Routledge and Taylor & Francis Group, London and New York, 216 p.

Nonaka, I. (1991). The Knowledge-creating Company, Harvard Business Review, November-December 1991, pp. 96-104.

Norman, E.S., Brotherton, S.A., Fried, R.T. (2008). Work Breakdown Structures: The Foundation for Project Management Excellence, John Wiley & Sons Inc. and Project Management Institute (PMI), 286 p.

OECD/OAS (2002), Public Sector Transparency and Accountability: Making it Happen, OECD Publishing, Paris, 210 p.

Oyedele, O. (2015). Evaluation of Construction Cost Estimation Methods in Nigeria, Femi Oyedele & Co. (Estate Surveyors and Valuers) conference papers.

Peleskei, G.A., Dorca, V., Munteanu, R.A., Munteanu, R. (2015). Risk Considera-tion and Cost Estimation in Construction Projects Using Monte Carlo Simulation, Management, Vol. 10(2), pp. 163-176.

Pinto, J.K. (2016). Project Management: Achieving Competitive Advantage, Pear-son Education Inc., 4th edition, 542 p.

Project Management Institute (PMI). (2001) A guide to the project management body of knowledge (PMBOK®), 2000 edition, Project Management Institute Inc., USA, 211 p.

Project Management Institute (PMI). (2006). Practice Standard for Work Break-down Structures, Project Management Institute Inc., 2nd edition, 111p.

Project Management Institute (PMI). (2017). A guide to the Project Management Body of Knowledge (PMBOK® Guide), 6th edition, Project Management Institute Inc., USA, 592 p.

Queensland Government. (2017). Project Cost Estimating Manual (PCEM), Department of Transport and Main Roads, State of Queensland, July 2017, 7th edition, 135 p.

Rajkumar, R., Kerr, C. (2013). Cost Engineering: Why, What and How? Decision Engineering Report Series, Cranfield University, UK, 39 p.

Rodger, C., Petch, J. (1999). Uncertainty and Risk Analysis: A practical guide from Business Dynamics, Business Dynamics, PricewaterhouseCoopers, MCS, 46p.

Rush, C., Roy, R. (2000). Analysis of cost estimating processes used within a concurrent engineering environment throughout a product life cycle, 7th ISPE International Conference on Concurrent Engineering: Research and Applications, Lyon, France, July 17th - 20th, Technomic Inc., Pennsylvania USA, pp. 58-67.

Sato, T., & Hirao, M. (2013). Optimum budget allocation method for projects with critical risks. International Journal of Project Management, 31(1), 126–135.

Saunders, M., Lewis, P. and Thornhill, A. (2007) Research Methods for Business Students. 4th Edition, Financial Times Prentice Hall, Edinburgh Gate, Harlow.

Saunders, M., Lewis, P., Thornhill, A. (2009). Research Methods for Business Students, Prentice Hall, 5th edition, 614 p.

Seeletse, S. & Ladzani, W. (2012). Project cost estimation techniques used by most emerging building contractors of South Africa: Journal for the Physical and Development Sciences.

Sekaran, U. (2010) Research Methods for Business: A Skill-Building Approach. 4th Edition, John Wiley & Sons, UK.

Shane, J.S., Molenaar, K.R., Anderson, S., Schexnayder, C. (2009). Construction Project Cost Escalation Factors, Journal of Management in Engineering, Vol. 25(4), pp. 221-229.

Shane, J.S., Molenaar, K.R., Anderson, S., Schexnayder, C. (2009). Construction Project Cost Escalation Factors, Journal of Management in Engineering, Vol. 25(4), pp. 221-229.

Shehu, Z., Endut, I.R., Akintoye, A-. Holt, G.D. (2014). Cost Overrun in The Malaysian Construction Industry Projects: A Deeper Insight, International Journal of Project Management, Vol. 32, pp. 1471-1480.

Skitmore, R.M., Lowe, D.J. (1992). Human Factors in Estimating, in Estimating Capital Costs of Projects, ed. Smith, N.J., Institute of Civil Engineers / Thomas Telford, London, pp. 91-100.

Smith, P. G., & Merrit, G. M. (2002). Proactive risk management. New York, NY:Productivity Press.

Stenberg, K., Rajan, D. (2016). Strategizing National Health in the 21st Century: a Handbook, Chapter 7, Estimating Cost Implications of a National Health Policy, Strategy or Plan, World Health Organization (WHO), 53 p.

Stewart, R., Wyskida, R.M. (1987). Cost Estimator's Reference Manual, John Wiley & Sons Inc, Canada, 620 p. Sung-Hoon An, Hunhee Cho and Ung-Kyun Lee, (2010). Reliabilty assessment of conceptual cost estimates for building construction projects. International Journal of Civil Engineering, vol 9, pp 9-16.

Sunjka, B.P. and Jacob, U. (2013). Significant causes and effects of project delays in the Niger delta region, Nigeria. SAIIE25 Proceedings: Stellenbosch, South Africa © 2013 SAIIE.

Tanaka, M., Yoshikawa, T., Innes, J., Mitchell, F. (1993). Contemporary Cost Management, Chapman & Hall, UK, 185 p.

Taylor, J. (2007). Project Scheduling and Cost Control: Planning, Monitoring and Controlling the Baseline, J. Ross Publishing, 313 p.

Thamhain, H. (2013). Managing risks in complex projects. Project Management Journal, 44(2), 20–35.

Thomson, P. A., & Perry, J. G. (1992). Engineering construction risks. London, England: Thomas Telford.

U.S. Department of Energy (DOE). (2011). Cost Estimating Guide, DOE G 413.3-21, Washington DC, 170 p.

US Department of Defence (DoD). (2010). United Facilities Criteria (UFC), Hand-book: Construction Cost Estimating, UFC 3-740-05, 8 November 2010, 103p.

Valtanen, A. (2020). Project Cost Estimation: Promoting quality of cost estimation to reduce project cost variance. Master of Science Thesis, Tampere University.

Venkataraman, R.R., Pinto, J.K. (2008). Cost and Value Management in Projects, John Wiley & Sons Inc., 289 p.

Williams, T. (2016). Identifying success factors in construction projects: A case study. Project Management Journal, 47(1), 97–112.

World Bank Report, (2012). Status of On-Going World Bank Financed Projects in Ghana as at December 2012-www.worldbank.org/ghana[Accessed: 22 June 2014].

Zhu, B., Yu, L., Geng, Z. (2016). Cost estimation method based on parallel Monte Carlo simulation and market investigation for engineering construction project, Cluster Computing, Vol.19, pp. 1293-1308.

APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA-KUMASI CAMPUS

QUESTIONAIRE FOR CONSTRUCTION MANAGERS, CONTRACTORS AND BUILDING CONSTRUCTION PERSONNEL AT KUMASI METROPOLITAN ASSEMBLY

Introduction

Hello, I am graduate student of the above-mentioned institution and conducting a research on the **"Project cost estimation practices in emerging construction firms to reduce project cost variance in Ghana"** in partial fulfillment for a Master's degree in Construction Technology. I will be very grateful if you would complete the attached questionnaire. The information provided will be treated with strict confidence and respondents will not in any way be identified.

Instruction for completing the questionnaires: Please kindly tick (√) inside the box provided to indicate your choice of a response and also write where necessary the appropriate response in the space provided.

SECTION A

General Information of Respondents

1. Which of the following category of personnel best describes you?

a. Construction Manager b. Contractor c. Consultant

2. How many years of experience do you have in the construction industry?

a. 0-5 years b. 6-10 years c. More than 10 years

3. How many construction projects have you been involved in?

a. 1-5 b. 6-10 c. More than 10

4. What type of projects has your organization been engaged in?

a. Building School b. Office and Administration Building c. Hospital

d. Hotel and Business Center Building e. Domestic buildings

Others, please specify

……..

5. What main types of contracts are you engaged in?

a. Traditional contracts b. Design – Build – Operate

Others please

specify:……..

6. What is the average project duration?

a. Less than 12 month b. 12 month to 18 month c. 18 month to

24 month

d. 24 month to 30 month e. 30 month to 36 month

Others please

specify……..

7. Are there regular assessment of risk in the execution of projects?

a. Yes b. No

8.If yes specify briefly how it is carried out

……

……

……

……

……

SECTION B

Risk Factors Affecting Cost Estimation of Construction Works

Which of the following risk factors to the best of your ability affects cost estimation of construction works of emerging construction companies?

Please use the following scales to answer the questions below. Please tick where appropriate

1. Not Significant, 2. Moderately Significant, 3. Not Sure, 4. Significant, 5. Highly Significant

S/N	Risk factors that affect construction cost estimation	1	2	3	4	5
1	Changes to the scope of the building					
2	Technology selection implementation risk					
3	Material and plant inflation risk					
4	Changes in government policies					
5	Land acquisition issues					
6	Cash flow administration					
7	Equipment failure (breakdown)					
8	Plants operations skill level					
9	Level of leader's supervision					
10	Availability of experienced and skilled labour					
11	Damage to the structure					
12	Theft at the site					
13	Accidents to operatives					
14	Loss due to fire outbreak					
15	Insufficient detailing of drawing					

Other please specify

……

……

SECTION C

Internal Organizational Processes to Reduce Cost Variances

Which of the following internal organizational processes to the best of your ability can help to reduce cost variances of emerging construction companies? Please use the following scales to answer the questions below. Please tick where appropriate

1. Strongly Disagree, 2. Disagree, 3. Not Sure, 4. Agree, 5. Strongly Agree

S/N	Internal organizational processes to reduce cost variances	1	2	3	4	5
1	Defining project's scope and construct work breakdown structure					
2	Scheduling of project's elements					
3	State and document ground rules and assumptions for the estimate					
4	Assessment of project to select suitable cost estimate technique					
5	Gather relevant historical information for each project					
6	Gather even the least necessary information before calculating the estimate					
7	Conducting risk analysis for contingencies					

8	Publish and archive informations from previous estimate					
9	Separation of risk evaluation and documentation for risk-related costs and cost uncertainties					
10	Have historical database for cost uncertainty ranges					
11	Implementation of systematic estimating procedure to manage internal foreseen risk					
12	Review and adjustment of estimates in accordance with actual cost					
13	Application of estimate inaccuracy escalation					
14	Receive and understand the client's request					
15	Specific analogy estimation technique					
16	Parametric estimation method					
17	Detailed cost estimate/bottom-up technique					
18	Computer aided cost estimation methods					
19	Assembly estimation technique					
20	Expert opinion technique					
21	The learning curve estimation method					
22	Design to cost method					

Other please specify.

……

……

……

UNIVERSITY OF EDUCATION, WINNEBA-KUMASI CAMPUS

QUESTIONAIRE FOR QUANTITY SURVEYORS AT KUMASI METROPOLITAN ASSEMBLY

Introduction

Hello, I am a graduate student of the above-mentioned institution and conducting a research on the **"Project cost estimation practices in emerging construction firms to reduce project cost variance in Ghana"** in partial fulfillment for a Master's degree in Construction Technology. I will be very grateful if you would complete the attached questionnaire. The information provided will be treated with strict confidence and respondents will not in any way be identified.

Instruction for completing the questionnaires: Please kindly tick (√) inside the box provided to indicate your choice of a response and also write where necessary the appropriate response in the space provided.

SECTION A

General Information of Respondents

1. How many years of experience do you have in the construction industry?

a. 0-5 years b. 6-10 years c. More than 10 years

3. How many construction projects have you been involved in its estimation?

a. 1-5 b. 6-10 c. More than 10

4. What type of projects do you mostly perform cost estimates for?

a. Building School b. Office and Administration Building c. Hospital

d. Hotel and Business Center Building e. Domestic buildings

Others, please specify

……

5. What main types of contracts are you engaged in?

a. Traditional contracts b. Design – Build – Operate

Others please

specify:……

6. What is the average project duration?

a. Less than 12 month b. 12 month to 18 month c. 18 month to 24 month

d. 24 month to 30 month e. 30 month to 36 month

Others please

specify……

7. Are there regular assessment of risk in the execution of projects?

a. Yes b. No

8. If yes specify briefly how it is carried out

……

……

……

……

SECTION B

Project Cost Estimation Methods and Techniques that can be Utilized by Emerging Construction Firms to Reduce Project Cost Variance

Which of the following cost estimation methods and techniques to the best of your ability can be utilized by emerging construction firms to reduce project cost variance?

Please use the following scales to answer the questions below. Please tick where appropriate

1. Not Effective 2. Less Effective 3. Quite Effective 4. More Effective 5. Highly Effective

S/N	Cost estimation techniques/methods	1	2	3	4	5
1	Specific analogy estimation technique					
2	Parametric estimation method					
3	Detailed cost estimate/bottom-up technique					
4	Computer aided cost estimation methods					
5	Expert opinion technique					
6	The learning curve estimation method					
7	Design to cost method					
8	Assembly estimation technique					
9	Deterministic or risk-based estimation technique					
10	Three-point estimation method					
11	Cost review and update estimation method					
12	Trend analysis estimation method					

Other please specify.

……

……

……

SECTION C

Risk Factors Affecting Cost Estimation of Construction Works

Which of the following risk factors to the best of your ability affects cost estimation of construction works of emerging construction companies?

Please use the following scales to answer the questions below. Please tick where appropriate

1. Not Significant, 2. Moderately Significant, 3. Not Sure, 4. Significant, 5. Highly Significant

S/N	Risk factors that affect construction cost estimation	1	2	3	4	5
1	Changes to the scope of the building					
2	Technology selection implementation risk					
3	Material and plant inflation risk					
4	Changes in government policies					
5	Land acquisition issues					
6	Cash flow administration					
7	Equipment failure (breakdown)					
8	Plants operations skill level					
9	Level of leader's supervision					
10	Availability of experienced and skilled labour					

11	Damage to the structure					
12	Theft at the site					
13	Accidents to operatives					
14	Loss due to fire outbreak					
15	Insufficient detailing of drawing					

Other please specify

……

……

……