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COLLEGE OF TECHNOLOGY AND BUILT ENVIRONMENT

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

USE OF HISTORICAL BID DATA TO ESTIMATE FUTURE UNIT RATE FOR SELECTED BUILDING WORK ITEMS

MSC. THESIS IN CONSTRUCTION TECHNOLOGY & MANAGEMENT

BY ETSEGENET KENENISSA

ADVISOR: ABRAHAM ASSEFA (PHD)

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A THESIS SUBMITTED TO SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN CONSTRUCTION TECHNOLOGY AND MANAGEMENT

Use of Historical Bid Data to Estimate Future Unit Rate for Selected Building Work Items

M.Sc. Thesis By

Etsegenet Kenenissa

APPROVED BY BOARD OF EXAMINERS

Dr. Abraham Assefa Advisor	…………………… Signature	June 03, 2026 date
Prof. Dereje Hailu Internal Examiner	…………………… Signature	June 03, 2026 date
Dr. Girmay Kahsay External Examiner	…………………… Signature	June 03 2026 date
Dr. Yenesew Mengiste Chairman	…………………… Signature	03 JUN 2026 date
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I hereby certify that the research work entitled "Use of Historical Bid Data to Estimate Future Unit Rate for Selected Building Work Items" is my own work and has not been presented elsewhere for assessment. Any material or information obtained from other sources has been duly acknowledged and properly referenced.

Etsegenet Kenenissa

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Abstract

This research work used historical bid unit rates of selected items found in most construction projects and have less specification deviation from one another on building projects to create a model that enables estimation of future unit rates. The scope was limited to projects in Ethiopia. Data for a total of 37 projects with 80 building blocks were collected and analyzed. Analysis using multiple linear regression technique was performed between the dependent variables (unit rates) and independent variables which are quantity of the work item; the distance of the project from the capital city of the country; building plot area,; total floor area; number of stories/floors; contract signing date; USD to ETB exchange rate on contract signing date; client type; function of the building and contract type. From the analysis, the regression models predicted the unit rate of C-15 sub structure concrete work with coefficient of determination as high as 0.906. Where, high value of coefficient of determination reveals that the link among outcome and predictor variable is respectable. Whereas, the least accurate model was developed for superstructure C20 concrete unit rate with coefficients of determination of 0.403.The key cost drivers or independent variables that appear in most of the regression models are contract signing date, distance of the project from Addis Ababa, Contract type, number of stories and USD to ETB exchange rate. This thesis has proposed a single formula to estimate unit rate for the selected work items. However, it is highly recommended to include more data for improved accuracy and predictive capability of the models. Therefore, the models developed in this research should serve as a stepping stone for further research on the topic rather than generalizing tool beyond the sample projects.

Key Words: Cost estimation, Historical bid data, Multiple regression analysis

Chapter One

1. Introduction

The construction sector is very fragmented and fiercely competitive, requiring contractors to submit bids competitively for majority of their work and at the same time manage the risks and uncertainties connected with the bidding process (Akintoye and Skitmore, 1992). Considering contractors technically qualified for a bid, the preceding requirement is financial statement. Which is a summary of cost estimate for the given project work items.

Consequently, cost estimation is a crucial element of project management, as it serves as a foundation for bid preparation and later cost control. When an estimate for a project is too low, the company risks financial loss during the execution of the work whereas if the estimate is too high, the company may forfeit the contract due to overpricing (Lester, 2007).

Accordingly, this thesis emphasizes on the assessment of past project data in Ethiopian building projects to develop a model which is based on the country's specific project variables.

1.1 Problem Statement

Cost is a key factor in the decision making process within the construction sector. In today's competitive world, shrinking profit margins and reducing market shares makes cost control essential for staying competitive while upholding high quality standards (Murat and Zeynep, 2004).

Consequently, cost estimation is a crucial aspect of the construction sector. It is an essential skill for business. The success or failure of a project hinges on precision of estimates conducted from conceptual and feasibility estimates to the detailed or bid estimates (Ahuja et al. 1994).

The function of cost estimation is different at various stages for the parties involved. However, the financial gain or loss of each participant in the construction business rests on how accurately the anticipated cost targets align with the estimates and execution plan that correspond with the expected events forming the estimate (Ahuja et al. 1994).

The estimating process is crucial since it allows construction companies to identify their direct costs, and establishes a minimum cost that makes it uneconomical to perform the work (Smith, 1999). Exaggerated costs lead to an increased bid price and denial by the client. Similarly, an underestimated cost may result in a situation where a contractor experiences losses. If the contractor is chosen, the estimate ought to serve as the foundation for budgeting and controlling the project (Potts, 2008).

Generally, the requirements of an estimate are to predict the most probable cost and programme of the work, to identify and quantify potential problems and risks, to state all assumptions and note all exclusions, and to base a forecast of expenditure, i.e. the cash flow based on the project programme. (Smith, 2002)

As indicated by Asteway (2008) citing Ofori (1993), construction projects in developing nations frequently face significant delays and higher expenses. The primary element leading to this scenario include; challenges in securing tenders, inefficiencies in the planning, designing, and construction phases; struggles in acquiring essential resources (materials, equipment and skilled personnel – along with their high and unstable costs); inadequate estimating and financial forecasting; unsuitable tendering and contractual procedures; and unproductive construction on-site.

“The most important estimates for a project are probably those prepared at the sanction, and for a contract, those prepared at the tender. It is at these points that the promoter and the contractor become committed” (Smith, 2002). Therefore, accurate cost estimating at these stages reduces claims and delays which intern reduces different costs resulting from delay, claim, cost and time overrun. It also helps the contractor to avoid over and underestimating unit rates during bidding. And one way to increasing the accuracy is, by using historical bid data and predicting future unit rates.

1.2 Research Objectives

The general objectives of this research are to use past bid unit rates of selected items on building projects and create a model that enables to estimate future bid unit rates.

The specific objectives of this research are:

- To investigate historical bid data and review trends of unit rates of selected items.
- To develop a model that can predict and estimate bid unit rate of selected items without using input data.

1.3 Research Questions

- What are trends of the construction company unit rates of the selected work items over the past years?
- How can we use historical bid unit rates to predict and estimate unit rate of similar activities for the future?
- How accurate is the model created using the historical bid unit rates?

1.4 Conceptual Frame Work

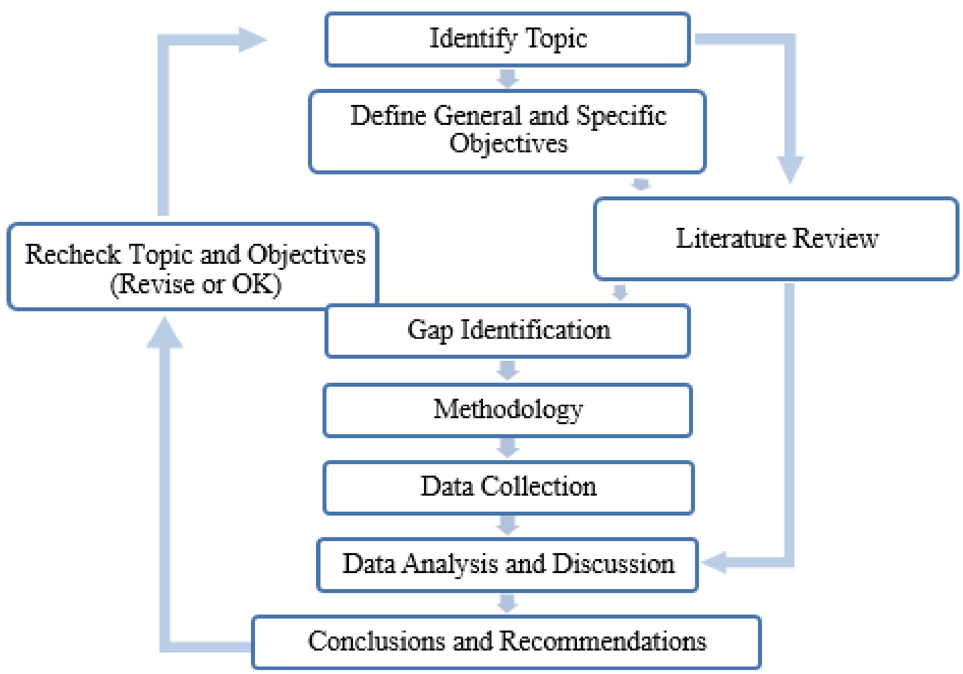

Figure 1. Conceptual framework of the research

1.5 Scope and Limitation of the Research

Considering the difficulty in obtaining well organized and recorded data and; the availability of similar work activities with different specification, the scope of this research is limited to, selected work items from sample building projects based on the data collected from:

- Grade one construction companies participated in the study.
- Clients and consultants currently working with grade one general or building contractors on building projects.

1.6 Relevance or Significance of the Research

This research is relevant to the construction industry in general and specifically to construction companies and clients by predicting unit rates of selected items. Therefore, the expected beneficiaries from this research are mainly contractors, clients, and consultants.

It is expected that this research assists contractors to serve as a guideline for unit cost estimation by analyzing the past trend and avoid fixing impractical unit rate during bidding; to budget according to the estimated cost by considering the predicted cost of the selected work items.

Clients and consultants are also expected to benefit from this research by using the model and the predicted unit rates to increase the accuracy of cost estimates prepared at various stages of project life cycle and to plan the allocated budget appropriately.

Chapter Two

2. Literature Review

2.1 Project and Project Management in Construction

As highlighted by Ahuja et al. (1994), a project, whether it is construction related or not, is a singular endeavor aimed at achieving a specific goal that is defined by scope, quality, time, and cost objectives. Whether the objective involves infrastructure construction, organizational restructuring or academic research, the specified quality and cost targets relies heavily on the strategic management of the limited resources available.

Lester (2007) also refers to the definition of project given in BS 6079-1 Guide to Project Management as 'A unique set of coordinated activities, with definite starting and finishing points, undertaken by an individual or organization to meet specific objectives within defined schedule, cost and performance parameters.'

According to Lock (2004) project is a way to undertake something innovative, which may be risky or adventurous. In the corporate world, this typically involves developing a product or service that someone else desires and is willing to purchase. Most projects have goals, meaning they must be constructed right, within a financial limit, and be completed by a specific deadline.

Projects are frequently executed to realize an organization's strategic objectives which are carried out by individuals and constrained by scarce resources. Projects are also scheduled, performed and managed. Project is most accurately described by the project management body of knowledge, PMI (2000) based on its unique characteristics as a "*temporary*" endeavor initiated to produce a "*unique* product or service".

Temporary signifies that each project has a clear start and a clear end. The end is reached when the project's goals have been accomplished or when it becomes evident that those goals will not be met, or the project is ended when the necessity for the project no longer exists. Unique signifies that the product or service is distinct in characters that sets it apart from other products or services. To meet the requirements of a project, knowledge, skills, tools and techniques need to be applied on each activities and this process is referred as project management (PMI, 2008).

The discipline of project management is an art of leading and managing human and material resources throughout a project lifecycle by means of modern management methods to accomplish established goals concerning the scope, cost, time, quality, and stakeholder satisfaction (Hendrickson and Au, 1989).

Project management is planning, monitoring and control of all aspects of a project and the motivation of all those involved in it, in order to achieve the project objectives within agreed criteria of time, cost and performance (Lester, 2007).

Project management combines the art and science of guiding human and material resources to accomplish stated goals while adhering to the limitations of time, budget, and quality ensuring the satisfaction of all parties involved (Ahuja et al., 1994).

Numerous construction projects include the design and construction of a building customized to satisfy the particular needs of the client. Every construction project is unique; there is no average building project. The cost of the building project will rest on its specific features which are mainly influenced by the architect. The design options are nearly endless and predicting the associated costs can often be challenging to do accurately. Conversely, certain types of buildings possess well established cost record and are often subject to a cost limit (Cunningham, 2013).

Construction project management involves planning, coordinating and overseeing a project from its beginning to its end (including commissioning) on behalf of a client. It involves understanding the client's objectives concerning utility, function, quality, time and cost, as well as connecting resources, integrating, monitoring and regulating the project participants and their outcomes, while evaluating and choosing alternatives to achieve the client's satisfaction with the project result (Walker A, 2002).

The PMBOK identifies nine project management knowledge areas: integration, scope, time, cost, quality, human resources, communications, risk and procurement management. These knowledge areas outline the project management knowledge and methodologies regarding their constituent processes. One of the knowledge areas in project management included here is project cost management

Project cost management mainly focusses on the expenses associated with the resources required to carry out project activities. Project cost management need to take into account the stakeholder desires for capturing costs. Various stakeholders will evaluate project costs and at various intervals using diverse manners. It must also take into account the impact of project decisions on the subsequent recurring costs related to using, maintaining and supporting the outcomes, products or service of the project.

The steps involved in project cost management include estimating costs, setting the budget and controlling costs. These processes engage with one other and with processes from other knowledge areas, enabling the project be finished within the allocated budget. In smaller projects, cost estimating and cost budgeting are so closely associated that they are considered as a unified processes that can be executed by a single individual in a brief time frame (PMI, 2008).

2.2 Cost Estimating in Construction

The idea of cost is described in multiple ways. Cost generally refers to monetary or financial value of all the goods and services utilized to carry out an operation (Yaman, 2007). Cost likewise described as worth of an activity or asset. Generally, this value is established by the cost of the resources that are consumed to execute the task or create the asset (AACE, 2004).

Cost estimation is a key process included in project cost management that is necessary to safeguard the project completion within the authorized budget. Taking the characteristics of construction projects into account, it is an important process with in the construction sector. It entails estimating the financial resources required to complete the project activities. Cost estimates are forecasts that rely on information available at a specific point in time. It involves recognizing and evaluating different costing options to start and complete the project (PMI, 2008).

Cost estimating involves compiling and forecasting costs of a project throughout its life cycle (Paul, 1993). It entails creating an approximation (estimate) of the expenses associated with the resources necessary to carry out the project activities. The PMI (2000), clearly emphasizes the importance of distinguishing cost estimating from pricing, when a project is executed under contract. Cost estimating entails creating an assessment of the probable numerical outcome regarding expenses incurred by the performing organization to deliver the product or service. While pricing is a business choice regarding how much the performing organization will charge for its product or service. During this process, the estimator assesses the factors contributing to variation of the final estimate to enhance the project management (PMI, 2000).

Cost estimation is essential and valuable in all businesses. It is particularly significant for businesses that handle large and complex projects. Without an established to precisely calculate the costs of a project, it becomes unfeasible to budget for a project or manage throughout its progression. Therefore, cost estimation is a crucial element in the construction industry. The quality and success of a project rest on the precision of the estimation. The estimate serves as the most reliable information for deciding a project price and it helps in effectively planning and organizing the construction process properly (Nikhil and Alester, 2016).

Cost engineering as outlined by the American Association of Cost Engineers is the field of engineering practice where engineering expertise and experience are applied using scientific principles and methods to address the problem of cost estimation, cost control and profitability issues. At every stage of a project; a cost engineer uses information existing on hand to create guideline of project cost which is referred as cost estimate. This shows the significance of cost estimate in project management (Hendrickson and Au, 1989).

The stages of development of the project life cycle provided by Hendrickson and Au (1989) are not strictly sequential as some stages require iteration, and others may be carried out in parallel or with overlapping time frames, depending on the nature, size, and urgency of the project. Estimates of cost is prepared and revised at many stages throughout the development of a project. From the perspective of an owner, the project life cycle for a constructed facility may be illustrated schematically in Figure 2.

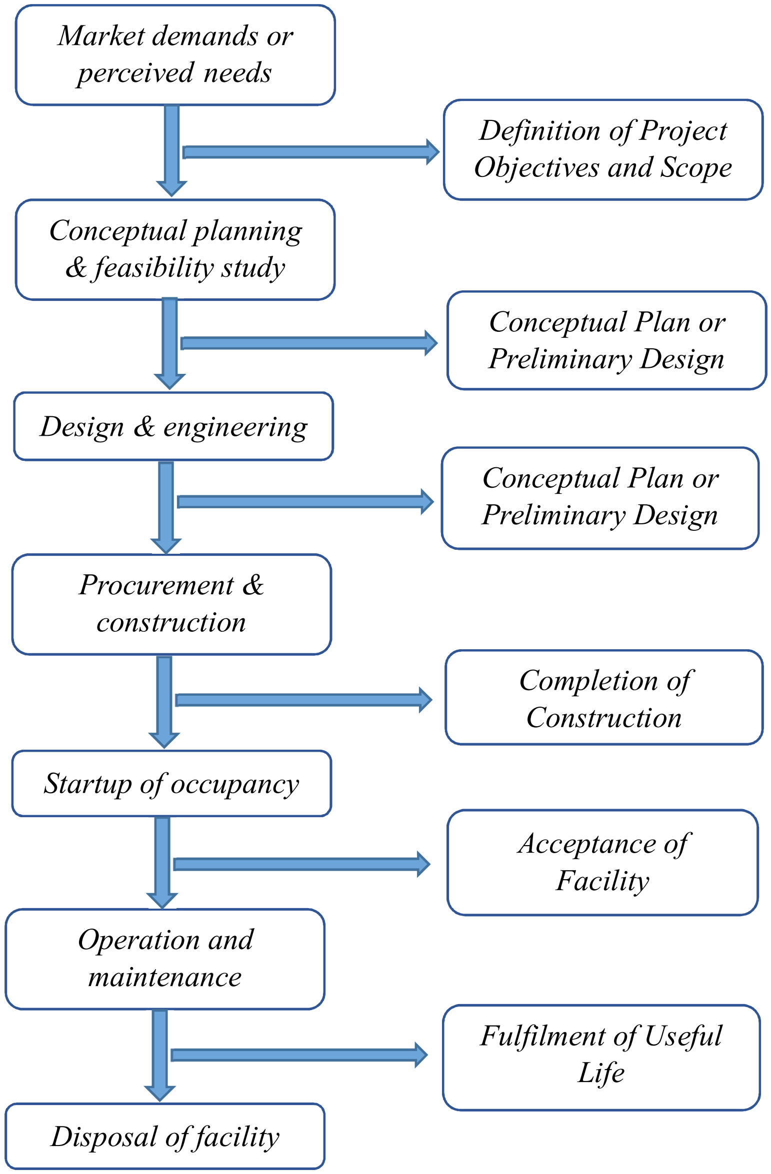

Figure 2. The Project Life Cycle of a Constructed Facility (Adapted from Hendrickson and Au 1989)

Cost estimation can be done either manually or using a software such as Management Computer Controls ICE System, Timberline Software Corporation Medallion System or Estimating Lite, Bid Master, and many more. The manual cost estimation method depends upon expertise. This includes an expert who is familiar with this project type. Analysis of structure and the quantity of materials, labors, plant requirements and overhead costs will be done by the person. Then start with the estimation depending upon the knowledge. The second method is by using software. This method looks into similar projects and compares the current project and then gives its estimated cost. This method is useful for the estimation of large projects (Nikhil and Alester, 2016).

2.3 Types of Construction Cost Estimates

Estimates vary based on several factors influencing them, and different scholars give numerous types by considering factors like degree of project definition, its purpose, methodology followed, function, the amount of information available about the project, and the time and effort required to prepare the estimate.

Popescu et al. (2003), state that there are numerous methods to categorize building cost estimates. The key factors include the degree of project definition, the final application of the estimate, and the methodology used to generate the estimate.

The initial classification, the level of project specification, relies on the proportion of finalized architectural and engineering designs. It specifies the input data accessible to the estimator. The second classification, the purpose of the estimate, relies on the progress of available data and includes conceptual estimates for investment feasibility, studies for funding approval, budgets, and detailed contractor estimates for lump-sum bidding. The third category, the estimate gathering methodology, relies on methods used to predict building costs that are stochastic and deterministic.

In the stochastic method that incorporates randomness, uncertainty and probability for outcome predictions, the foundation for cost estimation relies on amount of work units being installed (square meters of tiles, quantity and type of windows, etc.). The cost estimation method applied in this strategy are affected by numerous factors taken into account by a skilled estimator, which are often not clearly defined. In the deterministic approach, the project is clearly outlined and estimators take into account two factors; the quantity of a particular type of work and the predicted unit cost to finish one unit. The unit price is a variable factor influenced by location, time, and the experience and management abilities of contractor (Popescu et al., 2003).

According to Barzandeh (2011) referencing Ashworth (2004), cost estimation is categorized as Preliminary: an initial estimate for establishing a project’s benchmark; feasibility: assessing whether to move forward with the project; viability: similar to feasibility, an exploration of the project; authorization: a conclusive cost plan incorporating construction detailing: final budget:

a method for verifying the original budget intended for the project; and control: throughout the construction phase and during work execution to monitor progress.

Another classification of cost estimation is given by Hendrickson and Au (1989). Regardless of the numerous kinds of cost estimates utilized at various phases of a project; cost estimates can best be characterized into design estimate, bid estimate, and control estimate as per their function.

Design estimate is used by the client or its selected design professionals. At the beginning of the project, "*Screening or order of magnitude estimate" is done which* relies upon the cost information of comparable projects executed in the past. This is followed by "*preliminary estimate or conceptual estimate"*, which is decided when the tools for the design process are chosen. This estimate depends on the "conceptual design" of the project. Next to this "*detailed estimate or definitive estimate"* is prepared relying on characterized extent of the work and the ongoing full design. Finally when plans and specifications are settled and ready for offer from contractors, "*engineers estimate"* is set.

Bid estimate normally comprises of direct development cost including field oversight, with allowance for general overhead and benefits. This offer from contractors; either for "competitive bidding or negotiation" is given to the owner. The eagerness and assessing instruments available to the contractor are observed on the amount of this estimate. Since lowest bidder is usually the winner of the bid, this estimate depends on the belief of the contractor on its chance of winning the bid. The bid estimate is considered for this research.

Control estimate is used to monitor the project during construction. This estimate must be adopted by both the owner and the contractor. The owner is required to have budget estimate initially for arranging long term financing, which should be updated regularly with reference to the actual work. The update may occur either as a consequence of change orders initiated by the owner or due to unexpected cost overruns or savings. On the contractor's side, budget estimate used for cash flow analysis and regulating is assumed to be equivalent to bid estimate. Similar to the client's case, updating this estimate in accordance to the actual case is necessary (Hendrickson and Au, 1989).

Keeping the above classification in mind, the types of estimates used at different stages of a project excluding Operation and maintenance and Disposal of facility stages described in Figure 2 can be further elaborated as shown below on Figure 3.

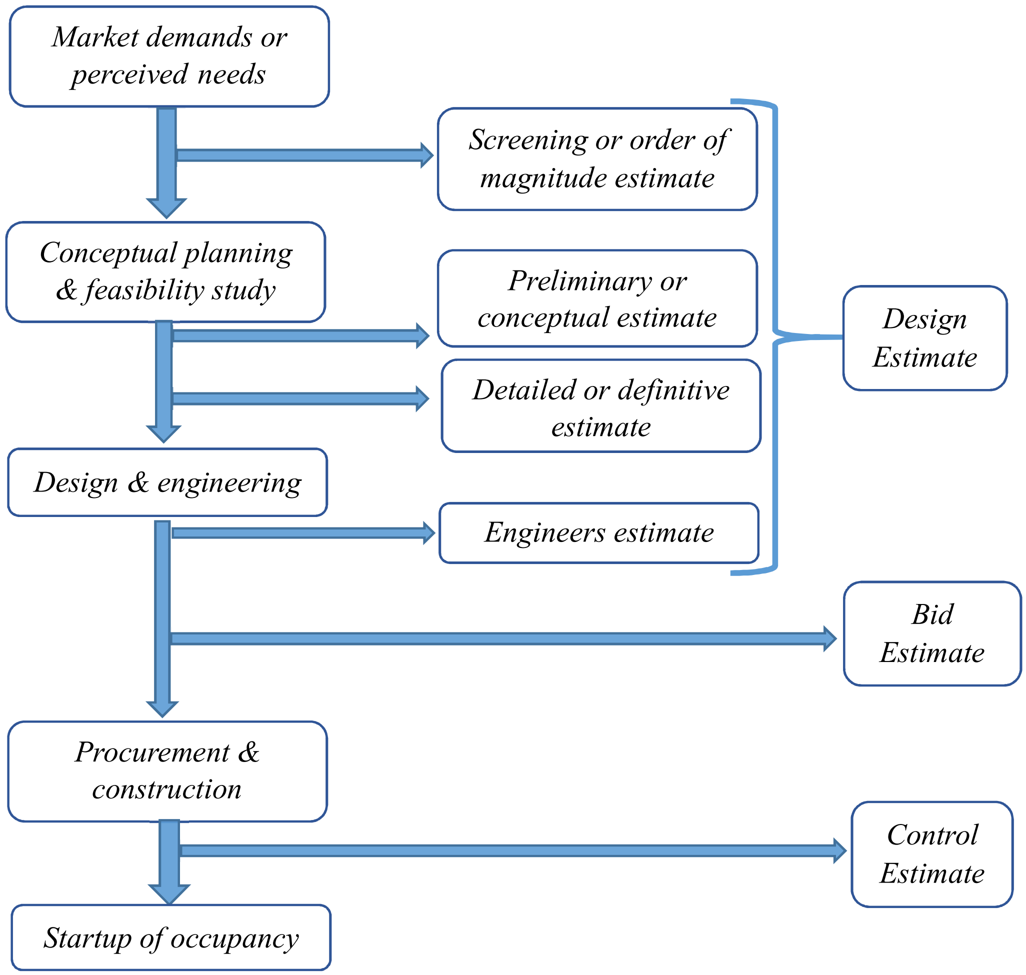

Figure 3. Types of construction cost estimates at various project life cycles

Another classification of construction cost estimates is project lifecycle estimate provided by Popescu et al. (2003), which best describes the construction estimates and their relationship with a building lifecycle by considering owner/project manager, project phases and project estimates as shown on Figure 4 below.

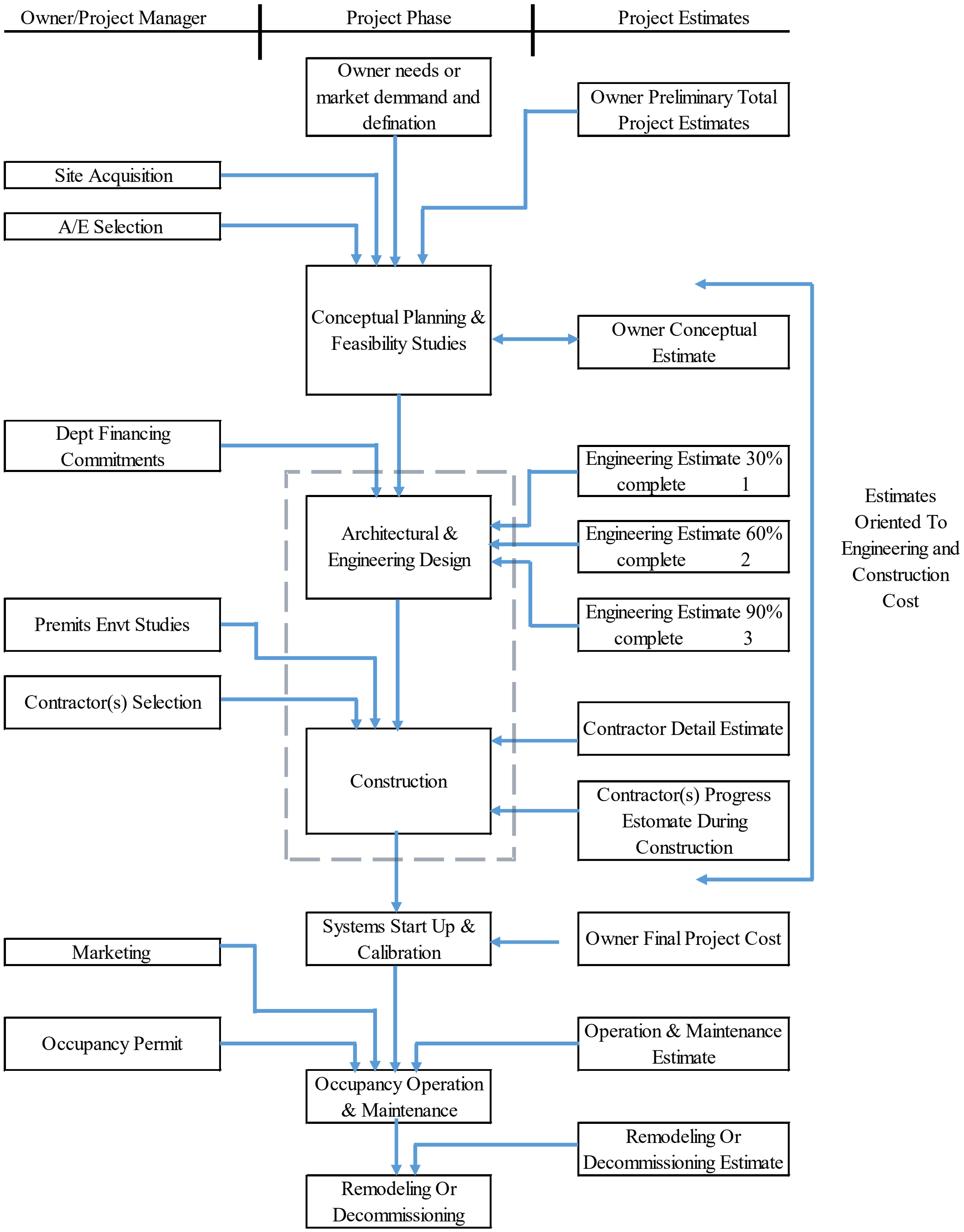

Figure 4. Project lifecycle estimates (Adapted from Popescu et al. 2003)

As noted by Popescu et al. (2003), design review submissions or status drawings must be provided at set intervals throughout the design stage. At the start of the project, the manager must to identify the frequency of the submissions to be created and their objectives. Standard frequencies for these submissions occur at the 30, 60, and 90% stages of design (often called design development). Some managers prefer receiving two submissions at 50 and 90%. The greater the complexity of the project, the more often the manager might need to asses the design. In most instances, the 90% design submission should represent a finalized set of design documents. The final 10% includes all last review remarks or regulations from permitting authority in the bid set documents.

In the design phase, the designer or the project manager must create cost estimates using available information at the data date to assess the project's cost status. For a complex building, a comparison estimate is also advised. When there are discrepancies exceeding 10% between two estimates produced by different estimators, it benefits the project for the two estimators to identify and address the differences.

Popescu et al. (2003) further elaborates the estimates by grouping the estimates into Conceptual Estimates (Engineer's Estimate), Firm Price Contracting Estimate and Non-Firm Price Estimating. These estimate types are briefly discussed in the referenced book as listed in the proceeding paragraphs.

Conceptual Estimates (Engineer's Estimate) typically utilizes published standard average costs per unit area, unit volume of a building, or occupancy unit (cars in a parking garage, beds in a hospital, students in a high school, etc.). This process can offer a fast and fairly simple way to acquire a preliminary project estimate.

However, various challenges can arise when applying this method of assessing a building's cost using existing data summaries like published cost standards, location factors and the time factor pertinent in predicting future construction costs. Moreover, a key limitation of this approach, is that the existing standard costs often do not align with the distinct characteristics of the specific project. Even when the kind of building or structure generally aligns with the standard, it is improbable that every feature or proportion will be identical.

Firm Price Contracting Estimate on the other hand is done when the design is completed (including contracting documents). During this stage a client may advertise or request for competitive bids, or acquire negotiated contract through proposals for a negotiation. Both methods involve the interested contractor to estimate the likely cost involved in fulfilling project demands within the given time frame. In the competitive biding situation, various choices concerning future project cost are obtainable to determine a price contract.

The firm price contracting estimate is of two types namely unit price estimating and lump-sum estimate. The unit price estimating is further classified in to unit crew-hour estimate, unit direct cost and unit bid estimate.

Unit crew-hour estimate is appropriate when the contractor or subcontractor is asked to provide the labor fee only for installation while the client is supplied the materials and equipment required for the execution of the work. The primary benefits of this estimate is that it highlights how the weighted crew average hourly rates affect the overall estimated labor cost. *Unit direct cost* is a method used by building subcontractors when the overall amount of work is not clearly established (± 20%) during the bidding stage. In this case the contractor must supply a complete direct cost for each unit of work installed on top of labor expenses, then calculate the cost of materials and equipment required for installation. In this scenario, a cost line item for jobsite overhead and profit needed to be included as a separate general cost line item. With the exception of the projected job site overhead and profit in the cost of installing one unit of bid work, the *Unit bid price estimate* is comparable to unit direct cost. The engineering estimated total quantity of work, with an accepted variation of ± 10% is the basis for the estimated unit cost of work.

As the design contract documents reach 90 to 100% a lump-sum estimate can be applicable. During this estimate the general contractor and subcontractors partaking in the bid proposal are solely responsible for determining the overall amount of work and associated unit pricing.

Non-Firm-Price contracting are usually used for building projects that are either not fully specified by advance plans and specifications or may only be envisioned as a rough idea of what the owner/client needs. It is done when an owner awards the wok without competitive bids due to incomplete tender documents or, sometimes to avoid public attention for their project. These owners choose to discuss terms privately with familiar construction companies, occasionally on a variable-price basis. There are also circumstances where industrial organizations make a practice of negotiating their proposed construction with given contractors to obtain the superior technical advantages and talents of the contractor's organization. The need to save time is perhaps the most compelling motivation for not following the method of competitive bidding. Basically, non-firm-price contracts can be broadly classified into these general categories: Cost plus a percentage fee, Cost plus a fixed fee, Cost plus a fixed fee with guaranteed maximum price, Target price with incentive fee and penalty fees, and Turnkey projects (Popescu et al., 2003).

2.4 Accuracy of Cost Estimate

When evaluating potential projects, there are numerous decision points to determine whether a specific project should continue its development. Each successive decision-making stage in the project life cycle usually demands cost estimates of increasing accuracy. Estimating is therefore a repetitive process utilized in every phase of the project life cycle as the project scope is clarified, altered, and enhanced (AACE, 2004).

Project cost estimates are performed through various phases of the project life cycle, and these estimates at different stages or phases may either exceed or fall short of the actual cost. Since cost estimation is an approximation, the final estimate depends on the data available to the estimator. However, even if the data is more or less accurate and all the required information is obtained, the estimate cannot still guarantee an exact prediction, but it can provide a much better view of the required cost and time to complete the activity.

The goal of any estimate, regardless of the stage it is created, is to forecast the most probable cost of the project. It is crucial to recognize that there exists a spectrum of potential costs where the most probable cost is situated. The level of realism and reliability of the estimate depends on the level of detail of the work and the degree of the uncertainty (Smith, 2002).

Smith, (2002) plotted the limits of possible range of project cost over its timescale as shown on Figure 5. This figure best illustrates the range of possible distributions. Typically, these indicate a reducing scope and a growing assurance as the project advances. However assurance is attained only after the finial accounts and audits of all project-related costs. The potential cost variation is significantly larger during the early stages. This occurs due to the limited information accessible to the estimator regarding scope, organization, time and cost data. Therefore many risks are latent in a project at its earliest stages and decrease over the life of a project. However, this may not be continuous; from time to time there may be increasing risks or new risks which arise during the project's development.

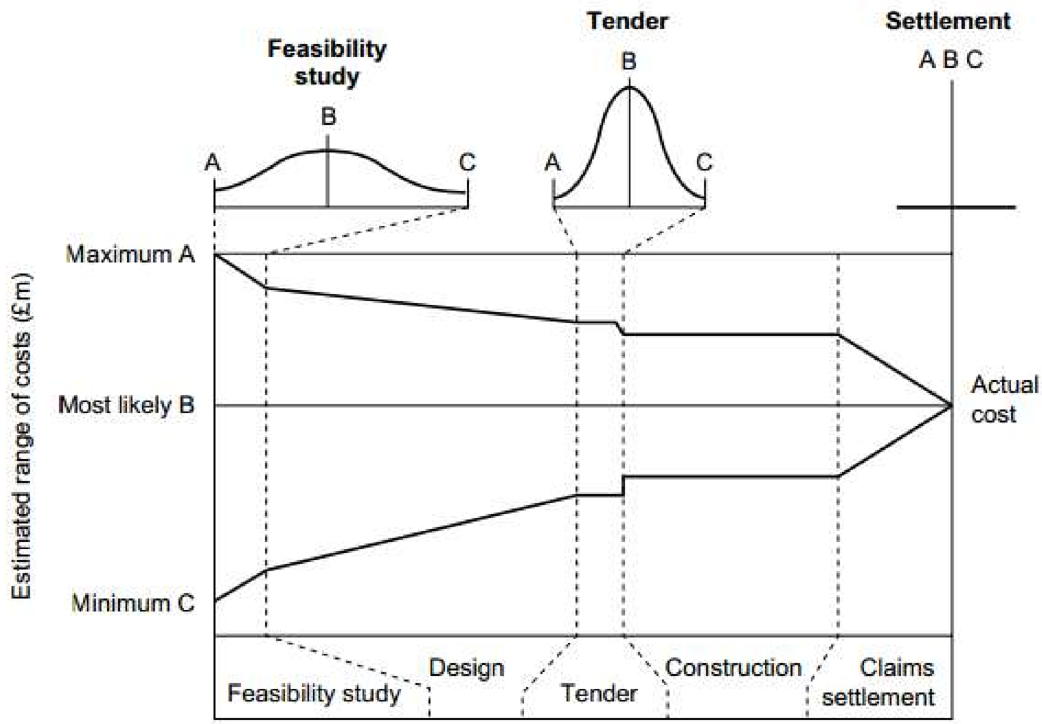

Figure 5. Range of Estimates over the project cycle (Smith, 2002).

Lock (2004) also pointed out the estimating accuracy by considering the time the estimate is made. An estimate created toward the competition of a project will be more precise than one produced at the start since the later estimate will include a significant portion of actual documented costs. The book classified estimates according to their accuracy as Ballpark estimates, Comparative estimates, Feasibility estimates and Definitive estimates. The level of expected accuracy on this classification increases from Ballpark estimates to Definitive estimates.

Benator and Thumann (2003) assert that the precision of estimates varies significantly and is heavily influenced by the quality of the estimating software and estimator's experience.

Ralph and Irwin (1998) highlight various elements that affect the precision of the cost estimate as follows. Creating an accurate cost estimate relies on the quality of information accessible for estimation, an effective work breakdown structure (WBS), degree of project definition, time estimates, work estimate and assumptions (Ralph and Irwin, 1998).

Lester (2007) relates level of accuracy and cost estimating methods depending on the status of the project and the information available and classify the cost estimating methods into four which are: Subjective, Parametric, Comparative and Analytical.

Subjective or approximate parametric estimate (degree of accuracy +/- 20% to 40%) is used during proposal phase. With this method, the estimator depend on his knowledge of comparable projects to provide a cost estimate that is primarily based on ‘hunch’. In addition to the more evident labor and material elements, geographic and political factors content must considered. Therefore, the level of accuracy is largely impacted by the estimator’s experience.

The parametric method (degree of accuracy +/- 10% to 20%) would be employed at the budget preparation stage although it depends on solid historical data derived from previous jobs or experience. By utilizing well-established empirical formulae or ratios in which costs can be related to specific characteristics of known sections or areas of the project, it is feasible to generate a reliable estimate that can serve as a foundation for firm judgments. For example office buildings are often estimated in currency/square meter of floor space. The requirements would be the location, ground conditions and costs of the land etc.

Comparative method (degree of accuracy of +/- 10%) can be used as an alternative to the parametric method when a new project is very similar (based on project type, size, complexity construction method, location, material or function) to another project which is recently completed. While using this method, due allowance must clearly be made for the inevitable minor differences, inflation and other possible cost escalations.

Analytical method (degree of accuracy +/- 5%) or bill of quantities method is used when project has been approved and a working budget estimate is required to project cost. This type of estimate may also be required where a contractor is obligated submit a fixed price tender. This is the most accurate estimating method, but it requires the project to be divided into sections, subsections and finally individual components before each component can be assigned a cost value (Lester, 2007). Therefore, this research focuses on bid estimate by using analytical method.

2.5 Cost Estimating Inputs

“The cost of a constructed facility to the owner include both initial capital costs and the subsequent operation and maintenance costs. Each of these major cost categories consists of a number of cost components. The capital cost for a construction project includes the expenses related to the initial establishment of the facility" (Hendrickson and Au, 1989).

According to AACE (2004), cost is the amount measured in money, cash expended or liability incurred in consideration of goods and/or services received. Resources utilized are categorized as material, labor, and "other"

Cost estimating includes different inputs, tools and techniques, and outputs. The inputs used for cost estimating are Work breakdown structure, resource requirements, resource rates, activity time estimations, estimating publications, historical data, chart of accounts and risk. Analogous estimating, parametric modeling, bottom-up estimation, computerized tools and other cost estimating methodologies can all be employed. The results of this process include cost estimates, supporting detail and cost management plan (PMI, 2000).

Different inputs are considered to determine the unit rate for a given work item. The estimator must know how much each unit will cost to produce, deliver to the site, accept and store at the site, install in the correct position, and maintain until the project is turned over to the owner. Production and delivery to the site are included in the material unit price. The cost of installing the product is part of the labor unit price. The equipment necessary to move the unit into place and install it is included in the equipment unit price. Project overheads covers the cost of accepting the material, storing it on the job site and protecting it until the project is accepted. Company overhead includes the cost of preparing the estimate and marketing the company and providing broad based technical and administrative support for the project. (Fredric and Nancy, 2009).

Overhead costs are those costs which cannot be attributed exclusively to a single product or service, or the summary of expenses that benefit more than one cost objective. Another definition is that overhead costs are those costs which are not a component of the actual construction work but are incurred by the contractor to support the work (Swait, 2014).

Swait (2014) classified overhead costs similarly to Fredric and Nancy, (2009). These are Construction Company overhead and project overhead costs. Company overhead cost, also known as general and administrative overhead, comprises all expenses incurred by the construction company that are unrelated to the particular project but are necessary to keep the business operating and support the manufacturing process. Project overhead cost is also called job site overhead. It is a project specific cost, rather than a trade or work item specific cost.

Project overhead costs are the contractor's expenditure for overseeing the project at the construction site.

AACE, (2004) further structures the cost elements within the material, labor, and other resource categories in order to understand how they influence the total cost of the activity or asset and to get a better understanding of how they can be controlled. The cost components are divided into direct costs, indirect costs, fixed costs and variable costs using this structure. In reality, some expenses might fit into more than one of these categories.

Direct costs are resources that are expended exclusively to finish the activity or asset. Indirect costs are resources that must be expended to sustain any activity or asset but that are also related to other activities and assets. Other name for indirect costs include "overhead costs" or "burden costs." Indirect costs include expenditures for utilities, taxes, legal services and general administrative tasks related to running a firm, as well as costs for supplying and maintaining field equipment or a manufacturing facility (AACE, 2004).

Fixed costs are cost components that must be supplied regardless of the volume of work activity or asset production that they support. These expenses can be either direct or indirect. The cost components that must be supplied and are reliant on the volume of job or asset production that they support are known as variable costs (AACE, 2004).

According to Ralph and Irwin, (1998) components of a project cost money. The most common ones are; equipment (purchase, lease, rental, and usage), facilities (office space, warehouses), labor (employee, contract), supplies (paper, pencils, toner, and miscellanies), training (seminars, conferences, symposiums), and transportation (land, sea, air). Other methods of categorizing expenses mentioned in this literature include Direct vs. Indirect Costs, Recurring vs. Nonrecurring Costs and Fixed vs. Variable Costs. Materials and specialized labor are examples of direct costs that are directly related to the building project or product. Indirect costs are not necessarily related to the building of a product like rent and taxes. Long term facility payments are an example of a recurring cost whereas equipment purchases are an example of nonrecurring costs. Fixed costs such as facility usage fees are costs which are not alterable owing to changes in work volume. On the other hand, variable costs such as material costs change based on activity and consumption.

According to Tadesse (2006), as sited in Asteway (2008), the components of cost in construction cost estimating include direct construction costs, indirect construction costs and risk allowance. Direct construction costs are all costs that can be specifically assigned to project activities and mainly include material, labor, equipment and subcontract costs. These costs account for the major share of the overall project cost efficiently planned, tracked and managed.

Asteway (2008) further explained that indirect construction costs are costs that cannot be directly allocated to specific tasks that are necessary for the operation of the project. These costs, commonly referred to overhead costs, are categorized in to head office overhead costs and site overhead costs. Head office overhead costs encompass costs linked to company administration, management, office operations, insurance, transportation and bidding activities. whereas site overhead costs involve expenses tied to site management, mobilization, utilities, camp facilities, transportation and various site operational activities.

Furthermore, Asteway (2008) stated that risk allowance or contingency is an important component in construction project pricing because it compensates for uncertainties arising from contractual, technical, political and economic risks. The author also noted that contractors include profit margins after estimating project costs to maximize returns from construction contracts and the profit level mainly depends on project size, competition and uncertainty.

2.6 Factor Affecting Cost Estimating

There are many factors that have major influence on cost estimating and also the outputs. Potts, (2008) stated different factors by referring to various studies conducted to identify the main problem facing the estimators, factors influencing project-cost-estimating practice and factors resulting in inaccurate estimate.

The m*ain problem facing the estimators* identified include tough competition, short contract period, incomplete drawings and specification, incomplete project scope definition, unforeseeable changes in material prices, changes in owner's requirements, current workload, errors in judgment, inadequate production time data, lack of historical data for similar jobs and lack of experience of similar projects. The *factors influencing project-cost-estimating practice* are complexity of the project, scale, and scope of construction, market condition, methods of construction, site constraints, client's financial position, constructability and location of the project (Potts, 2008).

Factors that affect the accuracy of the estimate include, but not limited to insufficient time for tender preparation, poor tender documentation, insufficient analysis of the documentation by the estimating team, low level of involvement from the site team that will be responsible for construction, poor communication between the estimating and construction teams and lack of review of cost estimates by company management, tendering for work in an area which contractors have little knowledge, inappropriate assessment of risk, inappropriate contract strategies and human characteristics of the individual estimator (Potts, 2008).

2.7 Cost Estimating Techniques

Various methods of cost estimation can result in the ultimate pricing. The Project Management Body of Knowledge, 2000 edition (PMI, 2000) provides the following tools and techniques for cost estimating.

Analogous Estimating or top-down estimating uses the real cost of former, similar projects as the basis for estimating the cost of the current project. It is frequently used to estimate costs when there is a limited amount of detailed information about the project (e.g., in the early phases). Analogous cost estimating uses expert judgment. This technique is commonly less expensive, but mostly dependable when prior projects are similar in fact, not just in appearance, and when the individuals or groups creating the estimates possess the necessary experience.

Project characteristics or parameters in a mathematical model are used in Parametric modeling to forecast project costs. The model might be simple or complex depending on the parameter used. The cost and accuracy of this model varies widely. It is most likely reliable depending on the accuracy of the historical information used, use of easily quantifiable parameter, and whether the model works for very large as well as very small projects.

Bottom-up Estimating technique involves estimating the cost of individual tasks or work packages, then adding these estimates to determine the project overall cost. The cost and accuracy of this estimating method depends on the quantity and complexity of each individual task or work package.

In addition, computerized tools, such as Project management software spreadsheets and simulation/statistical tools are widely used to assist with cost estimating. These products can make certain cost estimate methodologies easier to use and enable quick evaluation of numerous costing options.

Another cost estimating technique stated on the PMI (2000), is analyzing vendor bids and evaluating what the project ought to cost. When projects are secured through competitive processes the project team may need to conduct further cost estimation efforts to analyze the expenses of specific deliverables, and determine a cost that aligns with the overall total project expense.

Keith (2008), provides three primary estimating methods employed by contractors when pricing major construction works which are; unit-rate estimating, operational estimating and man-hours estimating. Since the most commonly used technique in Ethiopia and the one considered for this research is the unit rate estimating.

The unit rate estimating technique involves pricing individual rates in the bill of quantities (BoQ). The unit rates are calculated using the inputs discussed previously. Since unit rate estimating is the most commonly used method in Ethiopia, it is considered for this research.

2.7.1 Detailed Cost Estimating Technique

Detailed Cost Estimate also called Quantity Unit/Cost Estimate, Analytical estimating, Definitive estimate, bid estimate and Bottom-up Estimating technique. It involves estimating the cost of individual activities or work packages, then summarizing these estimates to get the project total. It is the most accurate category because, the available information consists of working drawings, detailed specifications, and subcontractor and supplier price quotations. These estimates include direct and indirect cost estimates of materials, labor, equipment, engineering, support staff, insurance, bonds, taxes, allowances, contingencies, and profit (Ahuja et al. 1994). In addition to accuracy, this method is also found to be costly and time-consuming, as detailed takeoffs must be made of all labor and material units in the system (Benator and Thumann, 2003).

This method requires that engineering be sufficiently advanced so that accurate material quantity takeoffs can be produced. It also requires detailed historical data for applying unit man-hour rates and monetary costs to the estimated quantities. This estimate can be developed only when the process design has essentially been completed. It will also require a significant amount of detailed engineering to be completed so that bulk material takeoffs can be developed. A detailed estimate would be quantity based with separate unit costs for material, labor, and man-hours (Benator and Thumann, 2003).

As Hendrickson and Au (1989) clearly stated; in the event that the tools for design has been determined, the project can be divided into components at varying levels of detail for cost estimation purpose. Depending on the levels of detail for cost estimation purpose required by the contractor and the availability of cost information, unit cost for each bill of quantity item are estimate in order to determine the total construction costs. This idea is appropriate to both design estimates and bid estimates, as detailed estimates or quantity takeoffs.

Detailed estimate is again addressed by AACE (2004) as follows. A detailed estimate is one in which every element of a project scope definition is quantitatively surveyed and priced using the most reasonable unit prices available. To support the final budget authorization, contractor bid tenders, cost control during project execution, and change orders, detailed estimates are prepared. Pricing data should include vendor quotes, current pricing information from recent purchase orders, current labor rates, subcontract quotations, project schedule information (to determine escalation requirements), and the construction plan (to determine labor productivity and other adjustments) AACE (2004).

Although it may not be strictly sequential, the steps of activities undertaken while creating a thorough estimate provided by AACE, (2004) are listed and briefly discussed as follows:

1. Prepare project estimate basis and schedule: - The first activity is reviewing the organization's estimating policies and practices or steps with the estimating team. The estimating team should decide which data, techniques and resources, will be used to prepare the estimate. Any estimate exclusions that are known estimate preparation should be examined and recorded.
2. Prepare direct field cost (DFC) estimate: - This is the most intensive step in creating the detailed estimate. All technical deliverables should be put together and the project scope should be examined and comprehended. The estimating department and any unique project guidelines should be followed while doing the estimate takeoff. This involves measuring each of the estimate's numerous labor and material components. It is important to make sure that all quantities are recorded without double counting. The best available pricing information is used to apply material pricing to the material quantities. Wage rates are applied, labor productivity is taken into account, and the labor hours are allocated to the labor activities. Allowances for estimates are set. Any materials provided by the owner or additional owner expenses are recorded.

3. Prepare indirect field cost (IFC) estimate: - this estimate is started when the DFC estimate is completed, reviewed and labor workhours are acknowledged. These are naturally a foundation for factoring many of the of IFC costs. The indirect estimate factors should be determined and applied. Indirect labor wage rates and staff labor rates are established and applied, and any indirect estimate allowances are accounted for.
4. Prepare home office cost (HOC) estimate: - For a detailed estimate, detailed workhour estimates for project activities should be provided by various project administration and engineering disciplines. Then the suitable wage rates are applied to the workhour estimates. Home office overhead factors are determined and applied to develop the home office overhead costs and expenses.
5. Prepare sales tax/duty estimates: - If sales tax is applicable to all (or portions) of the facility, they will need to be estimated using the appropriate local sales tax rates. If materials are to be imported, duties may be charged and will need to be estimated.
6. Prepare escalation estimates: - Escalation costs should be estimated based on the project schedule.
7. Prepare project fee estimate: - Appropriate project fee estimates must be computed and included, depending on the contracting strategy and project delivery method.
8. Prepare cost risk analysis/contingency determination: - Finally, a cost risk analysis study should be performed and appropriate contingency is included in the estimate.
9. Review/validate estimate: - An estimate should go through a rigorous review process since it is crucial to the success of a project. In addition to assessing the estimate's quality and accuracy, it should also make sure that it includes all necessary information and is presented in a manner that all members of the project team and client staff can comprehend.

2.8 Cost Estimation Models

According to Business Dictionary (2020); cost model consists of mathematical equations that convert resource information into cost information. In a similar manner Wikipidia (2019) defines cost estimation models as mathematical formulas or parametric equations utilized to assess the cost of a product or project. SAVE International (2007), defines cost model as "
A financial demonstration such as a spreadsheet, graph, and/or diagram utilized to represent the overall cost of groups of systems, components, or parts within an entire complex product, system, structure or facility. Cost modeling is described as "A symbolic depiction of a system,

revealing the components of that system in relation to the elements that affect its cost" according to Ferry and Brandon (1991), as cited by Soutos and Lowe (2005).

Yaman (2007), summarizes the background of building cost estimation models staring from the earlier models developed on 1960's until 2006. These cost estimation models are summarized based on their historical development, the type of variables used and according to their characteristics. According to Holm (2005) as cited by Yaman (2007), initiatives have been undertaken since 1950's, to comprehend the cause effect relationship between the design parameters and the construction cost, as well as to create models for estimating these cost.

Samuel et al. (2015), also reviews different studies conducted between 2004 up to 2013 on several cost estimation techniques that intend to reduce volatility of cost in construction industry from inception to completion stage. By citing various literatures, the author articulates that the value of cost models can be seen in their ability to reduce project cost overruns and delays, depending on their level of reliability and method of derivation. However, poor estimation parameters have been reported to be the cause of project cost overruns and delays due to failures of cost models' predictive ability and reliability. The author also mentions that not including qualitative parameters in cost models as one factor for delay in progress and uncertainty of the model outcomes. Nonetheless the predominant cost drivers identified through this literatures were Area of Typical floor, Number of floors, Number of elevator's, volume of HVAC and Type of plastering (rendering); Time unit corresponding to the working time of an average worker, Estimated quantity of infrastructure component unit, Quantity of materials making up one infrastructure component unit and Unit price. There have also been other models which seek to explain project performance with alternative to value for money in terms of time and cost.

Lowe et al. (2006) used 286 sets of real data in the United Kingdom to develop linear regression models with the aim of predicting construction cost of buildings. The authors identified 41 independent (predictor) variables on which both forward and backward stepwise regression analyses were performed to produce a total of six models. The outstanding predictor variables that appeared in each of the six models and which are considered the key linear cost drivers include GIFA (gross internal floor area), function, duration, mechanical installations and piling.

According to Bala (2014), as stated by Subhi (2016), Practitioners and researchers have recognized the uncertainty of construction cost estimates and the need to improve the capability of cost prediction models. Substantial efforts have been made to address this issue, and considerable conceptual cost prediction models are currently available in practice based on such techniques as probabilistic cost estimation, regression analysis, neural network (NN), fuzzy logic (FL), genetic algorithm (GA), and case-based reasoning (CBR).

Ofori-Boadu (2015) conducted quantitative study to develop a cost estimating model to forecast early building cost estimates by exploring the cost estimating relationships that exist between high-rise building cost estimates and a set of cost drivers. In this study 100 high-rise buildings (buildings more than 14 stories) constructed in over 20 different countries were considered for model development. The 8 independent variables selected for this study were location, ease of doing business, monthly wages, completion date, height of building, height per story, floor area, and structural material. Using multiple regression analyses all cost drivers appear significant in all eight regression models except ease of doing business and height per story.

Subhi (2016), developed a multiple linear regression model for conceptual initial cost estimation of conventional and sustainable college buildings in North America using 320 data points. The predictor variables considered in this study were building area, number of floors, floor height and structure type.

Using 30 structures in the Philippines, Pantoja and Pantoja (2017) developed a mathematical model by means of parametric cost analysis to estimate future project costs. According to this study, the project duration, exterior wall area, volume of excavation, building perimeter, building volume, and total weight of steel bars were the independent variables found from the results of regression analysis.

Usman and Thomas (2020) conducted a study to identify the critical factors affecting the cost overrun and obtain statistical models using regression analysis. Major factors affecting the cost of construction projects were identified by conducting a questionnaire survey done on 30 firms. This was followed by considering 10 case studies and the estimation data is used to develop regression models to predict the cost of construction. During the questionnaire survey, cost is selected as dependent variable and quantity of cost items as the independent variable. The regression model obtained in this journal identified quantity of 13 cost items as the independent variable. These are Earthwork & Site Clearance, Foundation & Plinth, Steel Reinforcement, Laterite Masonry, Concrete Works, Internal Plastering, Internal Painting, Tiling, False Ceiling, External Plastering, Water Proofing, Landscaping and MEP Works.

Samuel et al (2015) argues that the search for an all-powerful and universal formula by the construction industry to estimate the cost of a proposed building project from inception to completion stage by simple substitution of prices is unrealistic due to the inherent differences in the operational output and difference in measuring unit of work items. Consequently, cost and quantity data of C25 concrete was extrapolated and broken down into cost of material, cost and output of labor, profit and overhead to develop a cost model for unit rate pricing of concrete item in construction project. It also proposes that all other building elements including but not limited to block work, rendering, excavation, roof members, painting to be modeled in their unit rate form, multiplying with their respective quantities and summing up the result to get the building cost.

2.8.1 Multiple Regression Analysis Models

Regression analysis is a statistical technique that is highly beneficial in Engineering and Science, for examining the relationship between two or more variables (Montgomery and Runger, 2003). It is a highly efficient instrument that allows the researcher to gain deeper insights into the data under examination (Al-Zwainy et al. 2013). It helps to comprehend how the typical value of the dependent variable (or 'criterion variable') shifts when any single independent variables is altered, while the other independent variables remain constant (Nivea and Anu, 2016).

A regression model that includes more than one Independent variable is known as a multiple regression model. Moreover, when the model is a linear function of the unknown parameters, it is referred to as a Multiple Linear Regression model (MLR) (Montgomery and Runger, 2003). Hence, it is the method of statistics in regression that is utilized to examine the connection between one response variable (dependent variable) and multiple controlled variables (independent variables) (Ghani and Ahmad, 2010).

The Multiple linear regression model provides a prediction of a dependent variable from the independent variables and it takes the form:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots \beta_k x_k + \varepsilon \dots\dots\dots\dots\dots\dots\dots. \quad (1)$$

Where y – Dependent, Response or Output variable

β_0 - regression constant or intercept

$\beta_1, \beta_2, \dots \beta_k$ - Regression estimates or parameters

$X_1, X_2 \dots X_k$ – Independent, Predictor, Input or Explanatory variables

ε – Random error (Nivea and Anu, 2016).

Thus, the Multiple Linear Regression model serves as a solid foundation for estimating and for casting the unit rates of the selected work items which is the dependent variable and quantity of the dependent variable, distance of the project from Addis Ababa, plot area of the building, total floor area, total number of stories or floors , date the contract was signed, USD to ETB exchange date on date of contract signing, client type, function of the building and contract type are the independent variables considered in this research.

In general regression estimation models are well established and generally utilized in cost estimation. They are considerable because of a very much characterized scientific equation, just as having the option to clarify the significance of every variable and correlation between explanatory variables. “Basically, linear regression models are intended to find the linear combination of independent variables which best correlates with independent variables” (Sodikov, 2005). Even though the true functional relationship between dependent and independent variables is not known, over a certain range of the independent variables, the multiple linear regression models often serve as a satisfactory approximating functions (Montgomery and Runger, 2003).

Regression models have been used for decades and found to be reliable (Lowe et al., 2005; Lowe et al., 2006; Sodikov, 2010 and Subhi, 2016). Regression models provide numerous advantages, including the ability to be expressed mathematically and clarifying the connection between dependent variable and independent variables (Sodikov, 2010).

Subhi (2016), best recapitulates studies done on regression analysis for building construction projects. This paper cites Lowe et al. (2005) for its proposal of step-wise linear regression models for office buildings in Hong Kong. A similar study was reported in the United Kingdom by Lowe et al. (2006) to forecast construction cost of buildings based on linear regression models from 286 sets of real data.

Samuel et al. (2015) proposed cost model for unit rate (m^3) of C25 concrete using cost of material, labor, profit and overhead as independent variables. This was done by using productivity study by time and motion to determine the various outputs for materials and labor.

However, there is a scarcity of published studies concerning the development of cost estimation and prediction models for selected building work items area. Meanwhile, numerous literatures conducted on building cost estimation using models mainly regression analysis technique focuses on total building cost rather than the unit rate of individual work items.

This thesis is mainly motivated by the need to address significant gap identified in existing studies regarding the use of historical bid data for estimating future unit rate. The study seeks to contribute to the improvement of construction cost estimation practices by developing a practical approach for predicting future unit rate using historical project information supported by regression models.

The goal of regression analysis was to determine coefficients of the regression equation. The regression analysis was conducted using IBM SPSS statistical tool, version 20 software. The regression results obtained from the data analysis in this thesis are presented on chapter four of this research.

2.9 Model Development

Initially the predictor variables to be entered in the estimate equation need to be known to create models successively by interchanging variables with the use of multiple regression analysis techniques. Then, linear combination of predictor variables which best associates with outcome variables is identified by the regression models. The goal of the model was to estimate regression coefficients of the regression equation.

As it is previously stated it is assumed that the selected unit rates or dependent variables are function of the independent variables. Therefore, the developed models help to identify the engineering relationship between the dependent and independent variables.

$$DV = \beta_0 + \beta_1 IV_1 + \beta_2 xIV_2 + \beta_3 xIV_3 + \cdots \beta_{10} xIV_{10} + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots. \quad (2)$$

Where DV	-	Dependent variables
β0	-	regression constant or intercept
β1, β2, …. β9	-	Regression estimates or parameters
IV1	-	Quantity of the dependent variable
IV2	-	Distance of the project from Addis Ababa
IV3	-	Plot area of the building
IV4	-	Total floor area
IV5	-	Total number of stories or floors
IV6	-	Date the contract was signed
IV7	-	USD to ETB exchange date on date of contract signing
IV8	-	Client type
IV9	-	Function of the building
IV10	-	Contract type
E	-	Random error

Chapter Three

3 Research Design and Methodology

As Defined by Kothari (2004) research is a scientific and systematic search for relevant information on a specific topic. In fact, research is an art of scientific investigation. Kothari (2004) citing The Advanced Learner's Dictionary of Current English lays down the meaning of research as "a careful investigation or inquiry especially through search for new facts in any branch of knowledge."

Kumar (1999) states that when a researcher undertakes research to find answers to a question, the process being applied is undertaken within a frame work of set of philosophies, uses procedures, methods and techniques that have been tested for their validity and reliability; and designed to be unbiased and objective.

Therefore, this chapter serves as the basis for the realization of the aforementioned definition of the study's applicability. Using the research definition mentioned above as a basis, the study commences with the formulation of the study type and approach, followed by the selected research design and method. Based on the selected design and methodology, the chapter precedes to elaborate on data sources and collection, followed by data management. Ultimately it covered some steps regarding writing of the research.

3.1 Research Type and Approach

According to Kumar, (1999), types of research can be classified based on three different perspectives; which are *applications* of the findings of the research study; *objectives* of the study and *mode of enquiry* used in conducting the study. This classification is best shown on the following figure.

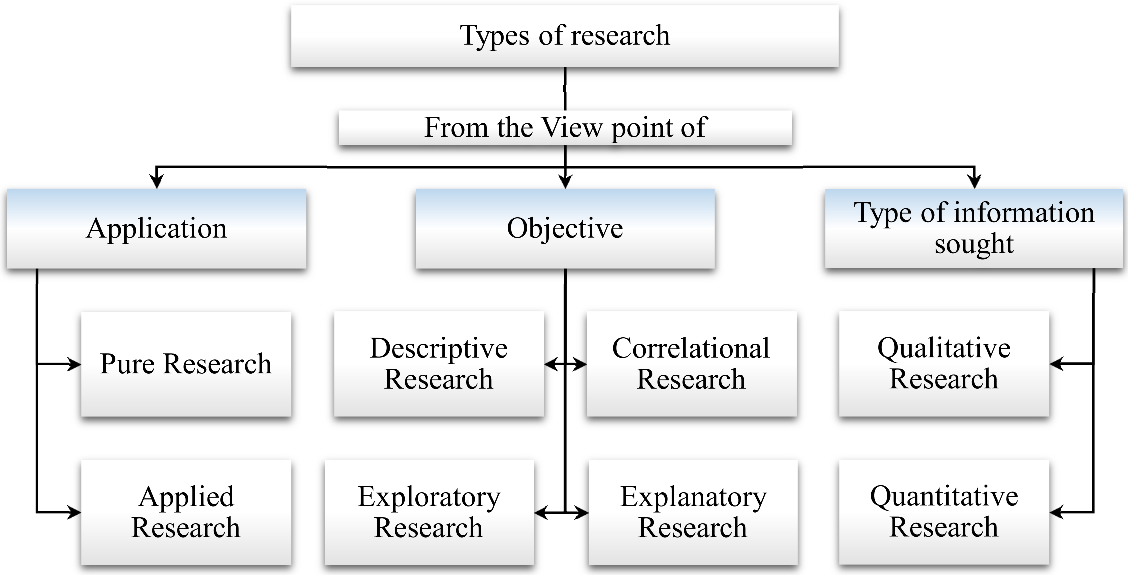

Figure 6. Types of Research, (Kumar, 1999)

From the perspective of its usage, this is *applied* research since the data collected can be utilized or applied in estimating and predicting unit rates by considering different variables and the improving the comprehension of the phenomenon.

From the perspective of its objective, this research is *descriptive* as it seeks to systematically outline the connection between various cost driving factors (independent variables) and unit rates of the selected work items systematically. It is also *correlational* as it seeks to identify or establish the presence of a relationship / association / interdependence between the variables.

Based on the type of information sought, this research is *quantitative* as it focuses on measurement of quantity or amount so it establishes a basic link between the empirical observation and mathematical representations. It is applicable to phenomena that can be represented in terms of quantity. It aims to measure the connection and establish parameters for future application.

Consequently, this thesis utilizes the aforementioned classification and, as such it is applied, descriptive, correlational and quantitative research. It aims to illustrate the actual connection of historical bid data for the development of cost models and recognize the existence of relationship between the examined variables. It aims to identify cost driving parameters for the selected work items in building projects and to develop realistic estimation models.

3.2 Research Design and Method

According to Kumar (1999), a plan, structure and strategy of investigation supposed to answer questions or problems of research is known as research design. Selltiz, (1962) as cited by Kumar (1999) describe research design as the organization of conditions for gathering and examining of data in a manner that strives to merge relevance to the research goal with efficiency in method.

Nick (2000) as cited by Abraham (2008) states that research design is primarily influenced by the aim and objective of the study. The Author outlined six principles for choosing the most suitable research, which are; maintain simplicity, borrow from existing work, gather only necessary information, be cautious the distortion that research creates, utilize existing expertise and recognize that some things cannot be quantified.

The research design answers basic questions while conducting a research like; what procedures will be adopted to obtain answers to research questions? How will the researcher carry out the tasks needed to complete the different components of the research process? What should the researcher do and not do in the process of undertaking the study?

Kothari (2004) stated that "there are three two basic approaches to research, viz., *quantitative approach* and the *qualitative approach*. *Quantitative approach* involves the generation of data in quantitative form which can be subjected to rigorous quantitative analysis in a formal and rigid fashion This approach can be further sub-classified into *inferential*, *experimental* and *simulation approaches* to research. The purpose of *inferential approach* to research is to form a data base from which to infer characteristics or relationships of population. This usually means *survey research* where a sample of population is studied (questioned or observed) to determine its characteristics, and it is then inferred that the population has the same characteristics" (Kothari, 2004).

Since this research is quantitative in nature, survey research has been chosen primarily due to its emphasis on data analysis and establishing a relationship among the various variables being examined.

3.3 Data Source and Collection

According to Kothari (2004), there are two types of data, primary and secondary. The primary data are those which are collected afresh and for the first time, and thus happen to be original in character. The secondary data, on the other hand, are those which have already been collected by someone else and which have already been passed through the statistical process.

Kumar (1999) provides a similar categorization, dividing data into primary and secondary types. Primary data is gathered from primary sources via observation, interviews and surveys. The secondary data is gathered from secondary sources or documents such as government publications, previous studies, census data, personal records client histories and service records.

The information collected and sources of data utilized in this thesis are contract documents of the projects like bill of quantities, agreements and drawings from contractors; USD to Ethiopian birr exchange rate at the time of bid from National Bank of Ethiopia and distance of projects from Addis Ababa obtained from federal transport authority. Since these data are collected from the primary sources for the first time, they are considered as *primary data*. In addition, *secondary data* like government publications books, journals and internet sources, have been used for this research. These secondary data offer an overall grasp of the topic by showcasing a diverse array of concepts in the field which assist in enhancing the specific details acquired from the primary data.

In this research, the sources of data are Grade one general and building contractors in Addis Ababa with building projects in Ethiopia (nine contractors). Therefore, choosing a suitable research population manages unnecessary variation and assists in establishing the boundaries for generalizing the study results.

Kumar (1999) categorized sampling in to three groups as

1. Random/probability sampling designs;
2. Non-random/non-probability sampling designs;
3. ‘Mixed’ sampling design.

Fink (1998) as cited by Abraham (2008) also stated that types of sampling can be divided as:

1. Simple Random Sampling

2. Systematic Sampling
3. Stratified Sampling – where the population is divided into groups or strata
4. Cluster Sampling – where the population is divided into batches.
5. Convenience Sampling – based on easy to get data.

Considering the lack of well-organized and compiled data of unit rates in the Ethiopian construction industry, an attempt was made to collect data from Grade one construction firms considerate enough to join the research.

According to Wubishet (2004) cited by Shihunegn (2014), collecting data is challenging, and in developing countries, it becomes even more demanding and exhausting. This study encountered similar challenges, such as inadequate documentation fragmented data access (contractors had low awareness of uses and benefits of proper documentation), insufficient modern information technology and management as well as concealed information. Another challenge was unwillingness to share data. Although contractors were assured that the data is completely for educational purpose and that they had clear understanding of the questions, they believed that the data is company secret so, they were not motivated and willing to share.

Therefore, the sampling method used in this thesis is non probability sampling method in which all possible data from nine grade one contractors has been taken to develop the model. This was done by obtaining list of Grade 1 building and general contractors from Construction Works Regulatory Authority. Contractors with more than ten years of experience were filtered from the list from which the nine contractors were selected based on accessibility and relevance of their work to the area of this thesis.

Data for a total of 37 projects with 80 building blocks in total were collected and analyzed. All data from contractors were from projects the contractor had won through bidding process. The projects can be completed or ongoing.

Therefore, unit rate for selected work items from 37 building projects were collected. The work items found in most construction projects in Ethiopia, that have less specification deviation from one another are selected. These wok items are believed to be less unique to specific site. In addition to the unit rates, other relevant data was also collected from the contract documents and drawings.

Hence, C-5 lean concrete, C-15, C-20, C-25, C-30, formwork and reinforcement bar works make random selection of work items from sub structure concrete work. Similarly C-25, C-30, formwork, reinforcement bar and class B HCB in (200mm) thickness works were selected from super structure. Even though C-25, C-30 concrete are similar types of work, they are evaluated as distinct work items for substructure and superstructure because their unit price varies as the superstructure works rate considers material transportation towards upper floors.

3.4 Proposed Model's Variables

Most of previous studies revolve around estimation of total construction project cost based on qualitative and quantitative factors rather than figuring out unit price. However, estimation of unit price gives more precise and accurate result than a generalized total project construction cost; as construction cost is normally the sum total of those unit prices. Moreover, starting from the specific items that buildup the total project cost is reasonable and justifiable way of explaining or briefing the total project cost.

Ofori-Boadu, (2015) best summarizes the variables or cost drivers obtained from eight literatures conducted starting from 1984 until 2011. As stated on the journal cost drivers of building costs include but not limited to location, time of realization, function, height, quality and technology, floor areas, floor height, gross floor area, number of stories, length of contract, liquidated damages, building height, parking, site area, steel and concrete frame, gross building area, city cost index, mechanical installations and piling.

Similarly, Nabil (2012) as cited by Samuel et al (2015) identified area of typical floor and number of floors to be part of the major cost drivers. As these variables define the project characteristics and the amount of materials consumed. Lowe et al. (2006) also identified gross internal floor area and function of the buildings as outstanding predictor variables. Likewise Subhi (2016) incorporated building area, number of floors and floor height as predictor variables. Pantoja and Pantoja (2017) identified quantity as part of the most significant predictor variables. Hassanean et al. (2025) additionally included location as relevant factor during cost forecasting model development.

As supported by those cited references, this thesis identified, the dependent & independent variables first to find the relationship between them; and develop the final regression model. The dependent variable here in this thesis is unit price of selected work items whereas quantity of the work item, distance of the project from the capital city of the country (Addis Ababa), building plot area, total floor area, number of stories/floors, contract signing date, USD to ETB exchange rate on the contract signing date, client type and function of the building were considered to be independent variables. Table 1, 2 and 3 bellow summarizes the dependent variables, quantitative independent variables and qualitative independent variables considered in this thesis respectively.

Table 1. Selected Work Items (Dependent Variables)

Sub Structure Selected Work Items (Dependent Variables)			Super Structure Selected Work Items (Dependent Variables)		
Dependent Variable	Work Item	Unit	Dependent Variable	Work Item	Unit
DV 1	C-5 lean concrete	Birr/m^3	DV 8	C-25 concrete	Birr/m^3
DV 2	C-15 concrete	Birr/m^3	DV 9	C-30 concrete	Birr/m^3
DV 3	C-20 concrete	Birr/m^3	DV 10	Formwork	Birr/m^2
DV 4	C-25 concrete	Birr/m^3	DV 11	Reinforcement Bar	Birr/Kg
DV 5	C-30 concrete	Birr/m^3	DV 12	Class B HCB (20cm thick)	Birr/m^2
DV 6	Formwork	Birr/m^2			
DV 7	Reinforcement Bar	Birr/Kg			

The selected cost drivers or independent variables are best classified in to objective (quantitative) and subjective (Qualitative) variables. The quantitative (objective) variables are the variables that can be measured, depending on the unit of measurement, such as total floor area is measured in m^2 and Distance from Addis Ababa is measured in Km.

The qualitative (subjective) variables are measured depending on coding system, for example, function of the building and type of client can be classified and each class can be assigned unique codes respectively.

Table 2. Quantitative Independent Variables

Quantitative Independent Variables			
No	Variable Name	Description	Units
IV 1	Qty.	Quantity of the dependent variable	m^2 or m^3 or Kg
IV 2	Distance from AA	Distance of the project from A. A	Km
IV 3	Plot A	Plot area of the building	m^2
IV 4	Total A	Total floor area	m^2
IV 5	No of Stories	Total number of stories or floors	No
IV 6	Contract signed date	Date the contract was signed	Date
IV 7	USD to ETB	USD to ETB exchange rate on date of contract signing	No

Table 3. Qualitative Independent Variables

Qualitative Independent Variables			
No	Variable Name	Units	Assigned code examples
IV 8	Client type	category	1 = Government
			2 = Private
			3 = Other
IV 9	Function of bldg.	category	1 = Auditorium/ Conference hall Building
			2 = Cafeteria
			3 = Class Room
			7 = Dormitory
			11 = Hospital building
			12 = Laboratory
			16 = Mixed Use Building
			17 = Office
IV 10	Contract type	category	1 = Admeasurement
			2 = Lump sum

3.5 Data Analysis

As means of data management information obtained from primary and secondary sources was entered into Microsoft Excel spreadsheet software. This helps to gather the information from different sources into one format, to detect outliers better and to organize the data for additional analysis. Finally, IBM SPSS (Statistical Package for Social Science) statistical tool Version 20 was employed to perform multiple regression analysis.

Chapter Four

4 Data Analysis and Discussion

In this chapter, the data obtained from different sources are analyzed and discussed. The results, findings and discussions are presented in the following sections within the framework of the primary research questions and goals of the study.

As described in previous chapter; work items with less variability in specification were selected to be the dependent variables. The selected work items from sub structure concrete work are C-5 lean concrete, C-15, C-20, C-25, C-30, formwork and reinforcement bar works. Whereas, the selected work items from super structure concrete work are C-25, C-30, formwork, reinforcement bar and class B HCB in (200mm) thickness.

Both scale and categorical independent variables were selected. These cost drivers are quantity of the dependent variable, distance of the project from Addis Ababa, building plot area, total floor area of the building, total number of floors, date the contract was signed, USD to ETB exchange date on date of contract signing, type of client, function of the building and type of contract.

4.1 Description of the projects

The projects considered for this thesis are 37 projects with different blocks making the total number of buildings 80. Each block is treated as an individual building. The dependent variables are carefully examined for outliers immediately, as this is one of the fundamental criteria for creating reliable model. Although some variables like unit rate of the selected work items or the dependent variable and its respective quantity are different for every dependent variable, the remaining variables can be described as follows.

The data for this thesis was gathered from Grade one general contractors centered in Addis Ababa with building projects in different cities of Ethiopia. Thus, location of the projects in terms of distance from Addis Ababa was used as one variable. Out of the 80 buildings, 25 were located in Arba Minch, 25 in Addis Ababa, 16 in Jimma, 4 in Gondar, 3 in Harar, 2 in Semera and the remaining projects are located in Adama, Bahir Dar, Bale Robe, Nekemt, and Debre tabor. The plot area of the building's ranges from 13.8m^2 to 125,977.12m^2 while the total floor area ranges from 13.8 m^2 to 125,977.12m^2. The number of stories range between 1 and 29. The oldest contract considered in this research was signed on 21-Jun-2007 and the most recent contract was signed on 21-Feb-2019. The clients for 59 of the buildings were government while 8 buildings were owned by private limited companies and the remaining 13 buildings were owned by non-governmental and non-private organizations. Another variable considered to be cost driver for this test is the function of the building. Considering this variable majority 24 of the buildings function as an office, 9 projects are mixed-use buildings, 8 hospital buildings function with 7 laboratory buildings, 5 cafeteria, 4 class room, 4 residence, 3 dormitory and 3 library buildings are considered. Another variable is contract type where 91% of the buildings are admeasurement contract where the remaining is lump sum.

The table below shows descriptive statistics of the dependent variables for the selected work items from the observed building projects. It presents minimum, maximum, standard deviation and the mean of each work item. Table 4 provides output based on all observations from all projects before detecting and omitting any outliers.

Table 4. Descriptive Statistics of Dependent Variables

Dep. Variable	Work Item	Unit	Min	Max	Mean	Std. Deviation
DV 1	C-5 lean concrete	Birr/m^3	810.00	3,510.80	1,497.76	645.84
DV 2	C-15 concrete	Birr/m^3	986.40	2,500.00	1,714.24	445.34
DV 3	C-20 concrete	Birr/m^3	1,000.00	2,180.30	1,856.18	301.69
DV 4	C-25 concrete	Birr/m^3	1,250.00	6,222.66	2,409.37	831.11
DV 5	C-30 concrete	Birr/m^3	1,400.00	4,293.11	2,822.16	602.83
DV 6	Formwork	Birr/m^2	64.00	390.00	153.40	79.86
DV 7	Reinforcement Bar	Birr/Kg	11.34	62.85	32.91	11.61
DV 8	C-25 concrete	Birr/m^3	1,018.77	4,975.95	2,486.48	819.88
DV 9	C-30 concrete	Birr/m^3	1,600.00	4,763.24	2,890.72	669.68
DV 10	Formwork	Birr/m^2	65.84	398.00	168.75	85.98
DV 11	Reinforcement Bar	Birr/Kg	10.00	61.00	33.33	11.90
DV 12	Class B HCB (20cm thick)	Birr/m^2	222.00	650.00	319.50	106.37

Before proceeding with the analysis, it is important to identify outliers because, these values are very different from the rest of the data and can bias the model we fit to the data. Therefore, boxplot was used as it is very useful for spotting outliers. After outliers were identified, the data was checked if it was entered correctly. If the data was entered correctly, that problem case was removed from the analysis.

Since it is not necessary to present all models in detail, model developed for Dependent variable 1 will be shown in detail in the following subsections. Followed by overall summary of the regression analyses and models.

4.2 Correlations

Prior to conducting the regression analysis, it is essential to inspect the variables for excessive correlation. The correlation matrix can be examined as an initial check for multicollinearity. Correlation between the dependent variables with independent variables used in the analysis is also illustrated.

The range of Karl Pearson's coefficient of correlation '*r*' is between ± 1. Positive values of *r* signify a positive correlation between the two variables, while negative values of '*r*' signify a negative correlation between the two variables. A value of '*r*' equal to zero signifies that there is no relationship between the two variables. When $r = (+)\ 1$, it signifies perfect positive correlation and when $r = (–)\ 1$, it represents perfect negative correlation, indicating that changes in independent variable (*X*) account for 100% of the changes in the dependent variable (*Y*). A value of '*r*' close to +1 or –1 signifies a strong correlation between the two variables (Kothari, 2004).

Correlations among independent variables and dependent variable 1 (DV 1) is displayed in table 5. It illustrates a rough interaction among the determinant variables and unit rate of C5 lean concrete under substructure work which is the considered dependent variable.

It is seen that substructure C5 Unit Rate (ETB) has a relatively strong positive correlation with the variables Contract type, Total no of floors, Clint type, USD to ETB Exchange Rate and Contract Signed Date. The correlation coefficient ranges from 0.401 to 0.835. Whereas plot area and Contract type are found to show relatively weaker correlation with the dependent variable. The independent variables USD to ETB Exchange Rate and Contract Signed Date have strong positive correlation with each other which causes multicollinearity. Therefore, only the contract signed date variable will be used in the model for DV1.

Table 5. Correlations of Variables Dependent Variable 1

Correlations [c]		(DV 1)	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 7)	(IV 8)	(IV 9)	(IV 10)
(DV 1)	*r*	1										
	ρ. (2-tailed)											
(IV 1)	*r*	.261*	1									
	Sig. (2-tailed)	.024										
(IV 2)	*r*	-.369**	-.201	1								
	Sig. (2-tailed)	.001	.084									
(IV 3)	*r*	.144	.950**	-.124	1							
	Sig. (2-tailed)	.219	.000	.290								
(IV 4)	*r*	.278*	.809**	-.273*	.762**	1						
	Sig. (2-tailed)	.016	.000	.018	.000							
(IV 5)	*r*	.401**	.089	-.580**	-.097	.417**	1					
	Sig. (2-tailed)	.000	.449	.000	.408	.000						
(IV 6)	*r*	.835**	.335**	-.313**	.218	.426**	.464**	1				
	Sig. (2-tailed)	.000	.003	.006	.061	.000	.000					
(IV 7)	*r*	.819**	.341**	-.311**	.232*	.436**	.440**	.985**	1			
	Sig. (2-tailed)	.000	.003	.007	.045	.000	.000	.000				
(IV 8)	*r*	.426**	.000	-.128	-.102	-.007	.201	.367**	.390**	1		
	Sig. (2-tailed)	.000	.999	.273	.383	.955	.083	.001	.001			
(IV 9)	*r*	.281*	.028	-.221	-.063	.000	.395**	.173	.169	.155	1	
	Sig. (2-tailed)	.015	.811	.057	.593	.999	.000	.138	.147	.183		
(IV 10)	*r*	.159	-.106	.234*	-.078	-.185	-.236*	-.001	.043	.656**	-.097	1
	Sig. (2-tailed)	.172	.363	.043	.506	.113	.041	.993	.715	.000	.406	

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=75

Source: SPSS output from collected data

Similar method is followed to inspect the variables for correlation through scanning the correlation matrix developed for every dependent variable and independent variables. Each correlation matrix is scanned to see the correlation of the independent variables with each dependent variable using Pearson's coefficient of correlation '*r*'. Again, each correlation matrix is scanned for multicollinearity by looking at the Pearson's coefficient of correlation '*r*' between the independent variables. Then only one of the independent variables will be used in the regression model. Correlation matrix for the independent variables selected in this research is attached in Appendix B of this research.

4.3 Regression Analysis

As stated in the previous chapter *multiple linear regression analysis* was adopted because the researcher has one dependent variable which is presumed to be a function of more than two independent variables. The objective of this analysis is to make a prediction about the dependent variable based on its covariance with all the concerned independent variables. Hence cause and effect relationship can be studied through multiple regression equations (Kothari, 2004).

The regression analysis determines that some independent variables have more effect than others, so their weights must be taken into account when they are the basis of a prediction. This is best applied by using step-wise regression techniques. Step-wise regression techniques help to have a better idea of the independent contribution of each explanatory variable. Under these techniques, each explanatory variable is entered into the prediction equation one by one computing betas and R^2 at each step (Kothari, 2004).

In other words, while applying stepwise method of analysis the predictor variable is entered, if it meets the criteria of making a significant contribution to the model. At that point in the process the model is analyzed and any predictor variables that do not meet the requirements for staying in the model are removed. This method continues until there are no longer any predictor variables that meet the criteria for entering in to or being removed from the model. Therefore, this research uses stepwise method.

4.3.1 Regression Analysis for DV 1

Since stepwise multiple linear regression method was selected for this model, the most important explanatory or independent variables of substructure C5 unit rate were found to be; contract signed date, contract type, distance of the project from Addis Ababa and Function of the building. The results of the multiple linear regression analysis revealed the remaining independent variables to be statistically insignificant predictors to the model ($p > 0.05$)

As one of the first things to look for in in SPSS output when performing regression analysis is the significance of the model in general. This is done by testing the model using Analysis of Variance (ANOVA). As shown in table 6 the significance value is less than 0.001, therefore, we can say the regression model as a whole is significant. Sig. ($p <0.001$) indicate for 99% confidence in the ability of the model to explain the dependent variable.
The linear regression's F-test has the null hypothesis that there is no linear relationship between the two variables (in other words $R^2 = 0$). Table 4 also shows, with F = 56.858 and 74 degrees of freedom the test is highly significant $F (4, 70) = 56.858$, $p < 0.001$, thus we can assume that there is a linear relationship between the variables in our model.

In this multiple linear regression analysis four models were tested using the stepwise method and only the fourth model is shown in the following table.

Table 6. ANOVA - Dependent Variable – 1

ANOVA [a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
4	Regression	13401870.697	4	3350467.674	56.858	.000[e]
	Residual	4124921.080	70	58927.444		
	Total	17526791.777	74			

a. Dependent Variable: Sub C5 Unit Rate (ETB)
e. Predictors: (Constant), Contract Signed Date, Contract Type, Distance from A.A (Km), Function of The Building
Source: SPSS output from collected data

As shown in table 7 the multiple regression shows significant correlation between the four independent variables and dependent variable-1 sub C5 unit rate (R = .874). This suggests that the model is relatively a good predictor of the outcome. The R-square value indicates 76.46 % of the variance in the data can be accounted for by the four predictor variables. The Durbin-Watson d = 1.175 is between the two critical values of 1.5 < d < 2.5, therefore we can assume that there is no first order linear autocorrelation or no consecutive errors are correlated in the data.

Table 7. Model Summary Dependent Variable - 1

Model Summary [e]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.835[a]	0.69655	0.69239	269.920	
2	.850[b]	0.72225	0.71454	260.022	
3	.864[c]	0.74734	0.73667	249.740	
4	.874[d]	0.76465	0.75121	242.750	1.175

a. Predictors: (Constant), Contract Signed Date
b. Predictors: (Constant), Contract Signed Date, Contract Type
c. Predictors: (Constant), Contract Signed Date, Contract Type, Distance From A.A (Km)
d. Predictors: (Constant), Contract Signed Date, Contract Type, Distance From A.A (Km), Function of The Building
e. Dependent Variable: Sub C5 Unit Rate (ETB)/m^3
Source: SPSS output from collected data

The Standardized Coefficients (Beta) values indicate the relative influence of the entered variables. As shown on table 8 Contract Signed Date has the greatest influence on Sub C5 Unit Rate (Beta =.765), followed by Contract Type (Beta = .208), Distance from A.A (Km) (Beta =

0.136) and Function of the Building (Beta = -0.136). The direction of influence for the three variables was positive except Function of the Building. This table also checks for multicollinearity in our multiple linear regression model. Since none of the independent variables have a variance inflation factor (VIF) not greater than ten (the obtained VIFs are 1.130, 1.068, 1.211 and 1.068), there are no apparent multicollinearity problems; in other words, there is no variable in the model that is measuring the same relationship/quantity as is measured by another variable or group of variables.

As it is defined in chapter three, the unstandardized coefficients (β 1 up to β 10) are the coefficients of the estimated regression model. Hence, the final predictive model for sub structure C5 concrete can be written as;

$$\text{Unit Rate (C5)} = -41858.647 + 3.160\text{E} - 06 * IV_6 + 346.22 * IV_{10} - .296 * IV_2 - 11.566 * IV_9$$

Where DV 1 - Dependent variables 1 (Sub C5 Unit Rate (ETB))

IV_6 - Contract signed date

IV_{10} - Contract type

IV_2 - Distance of the project from Addis Ababa

IV_9 - Function of the Building

Table 8. Regression Model Summary Dependent Variable - 1

Coefficients *								
DV	Model	IV	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	VIF
			B	Std. Error	Beta			
DV 1	4	(Constant)	-41858.647	3450.773		-12.130	.000	
		IV 6	3.160E-06	.000	.765	12.405	.000	.885
		IV 10	346.220	99.577	.208	3.477	.001	.936
		IV 2	-.296	.127	-.149	-2.334	.022	.826
		IV 9	11.566	5.097	.136	2.269	.026	.936

**. Dependent Variable: Sub C5 Unit Rate (ETB)*
IV 6. Independent Variable: Contract Signed Date
IV 10. Independent Variable: Contract Type
IV 2. Independent Variable: Distance From A.A (Km)
IV 9. Independent Variable: Function of The Building

a. Dependent Variable: Sub C5 Unit Rate (ETB)
Source: SPSS output from collected data

The statistical plots associated with the fit diagnostics for DV 1 Model were generated during statistical analysis of the data. In conformance to one of the major assumptions of multiple regression analysis, the histogram and normal curve shows that the residuals approximately follow normal distribution with mean close to zero in Figure 7. The P-P plot of regression standard residuals also show very slight deviation from normality. Thus, the observed residuals are close to normal distribution. Therefore, one can conclude from this analysis that most assumptions for a linear, multiple regression model have been met.

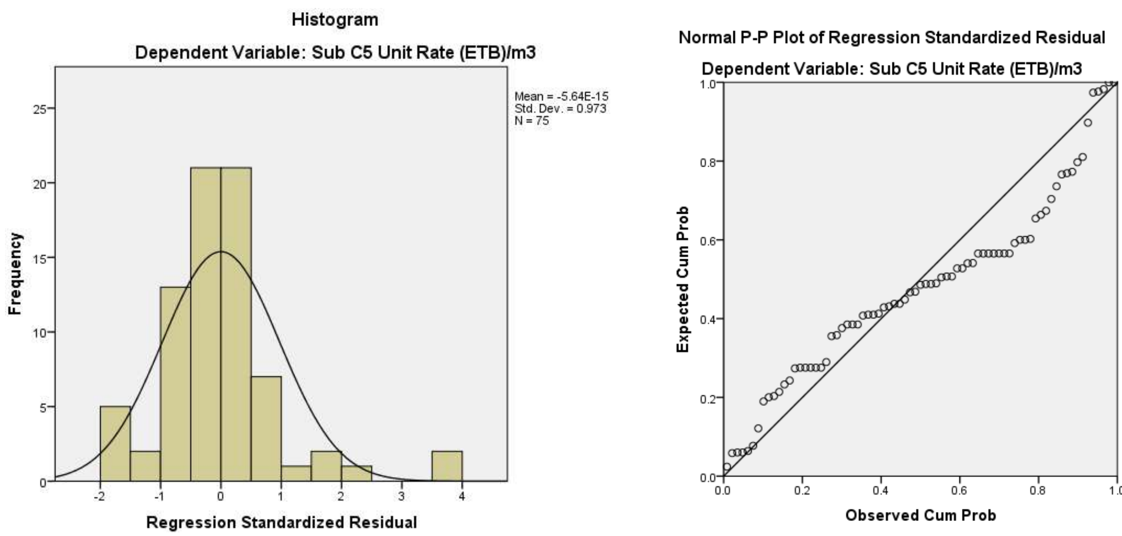

Figure 7. Histogram & Normal P-P plot of Regression Standardized Residual DV 1

4.3.2 Summary of Regression Analyses

Similar procedure was adopted to develop the mathematical models and estimate unit rates for the selected work items using the project characteristics or parameters. Outliers were identified using boxplot and were either corrected or removed from the investigation. Each dependent variable's correlation with the independent variable was examined individually, as detailed in Appendix B. Since these correlations are foundation of multiple regression analysis, they will provide a solid initial indication of the relationship between the dependent and independent variables. Values of Pearson coefficients of correlation were used to examine the association between the dependent variables and every independent variable. Additionally, it checked the occurrence of multicollinearity within individual independent variables. As Pearson coefficient of correlation value above 0.9 is an indication of multicollinearity, only one of the variables will be used in the model.

After independent variables were diagnosed for multicollinearity, stepwise multiple linear regression method was selected to identify the most important explanatory or independent variables for each dependent variable. This was followed by checking the significance of the model in general or the goodness of fit using ANOVA (Analysis of Variance).

The F-ratio evaluates "if the model overall demonstrates statistically significant predictive ability making it an additional valuable measure when examining the model's predictive strength. The null hypothesis, which checks that the model lacks predictive ability is rejected when the F ratio is large" (Dallal, 2000). As it can be seen in Table 7 and Table 8 all values of the F ratio is high and $p<0.001$, thus, allowing for rejection of the null hypothesis. Thus, it can be inferred that the models possess significant predictive abilities in forecasting unit rates for the associated dependent variables and we may assume that there is a linear relationship exists between the variables in that model. For each dependent variable, various multiple linear regression analyses were conducted using the stepwise approach and only the final models are presented in Table 9 and Table 10.

Table 9. ANOVA – Summary selected sub structure work items

ANOVA [a]							
DV	*Model*		Sum of Squares	df	Mean Square	F	Sig.
DV 1	*4*	Regression	13401870.697	4	3350467.674	56.858	.000[e]
		Residual	4124921.080	70	58927.444		
		Total	17526791.777	74			
	a. Dependent Variable: Sub C5 Unit Rate (ETB) e. Predictors: (Constant), Contract Signed Date, Contract Type, Distance from A.A (Km), Function of The Building						
DV 2	*2*	Regression	3055298.612	2	1527649.306	72.441	.000[c]
		Residual	316324.072	15	21088.271		
		Total	3371622.684	17			
	a. Dependent Variable: Sub C15 Unit Rate c. Predictors: (Constant), Contract Signed Date, Client Type						
DV 3	*2*	Regression	591581.545	2	295790.773	8.103	.009[c]
		Residual	876139.562	24	36505.815		
		Total	1467721.107	26			
	a. Dependent Variable: Sub C20 Unit Rate (ETB) c. Predictors: (Constant), Contract Signed Date, Total No of Stories or Floors						
DV 4	*3*	Regression	17874916.824	3	5958305.608	51.055	.000[d]
		Residual	7469015.449	64	116703.366		
		Total	25343932.273	67			
	a. Dependent Variable: Sub C25 Unit Rate (ETB) d. Predictors: (Constant), Contract Signed Date, Contract Type, Total No of Stories or Floors						
DV 5	*2*	Regression	5628385.781	2	2814192.890	15.474	.000[c]
		Residual	4910465.449	27	181869.091		
		Total	10538851.229	29			
	a. Dependent Variable: Sub C30 Unit Rate (ETB) c. Predictors: (Constant), Contract Signed Date, Distance From A.A (Km)						
DV 6	*3*	Regression	321692.604	3	107230.868	101.586	.000[d]
		Residual	77056.566	73	1055.569		
		Total	398749.171	76			
	a. Dependent Variable: Sub Formwork Unit Rate (ETB) d. Predictors: ((Constant), Contract Signed Date, Distance From A.A (Km), Total No of Stories or Floors						
DV 7	*3*	Regression	7413.180	3	2471.060	66.009	.000[d]
		Residual	2695.350	72	37.435		
		Total	10108.530	75			
	a. Dependent Variable: Sub Rebar Unit Rate (ETB) d. Predictors: (Constant), Contract Signed Date, Total Floor Area (m2), Contract Type						

Source: SPSS output from collected data

Table 10. ANOVA – Summary selected super structure work items

ANOVA [a]							
DV	*Model*		Sum of Squares	df	Mean Square	F	Sig.
DV 8	*5*	Regression	35985699.666	5	7197139.933	38.847	.000[f]
		Residual	12412919.027	67	185267.448		
		Total	48398618.693	72			
	a. Dependent Variable: Super C25 Unit Rate (ETB) f. Predictors: (Constant), Contract Signed Date, Contract Type, USD to ETB Exchange Rate, Total No of Stories or Floors, Distance From A.A (Km)						
DV 9	*2*	Regression	5779117.001	2	2889558.500	12.755	.000[c]
		Residual	4984127.561	22	226551.253		
		Total	10763244.561	24			
	a. Dependent Variable: Super C30 Unit Rate c. Predictors: (Constant), USD to ETB Exchange Rate, Distance From A.A (Km)						
DV 10	*2*	Regression	412969.434	3	137656.478	87.668	.000[c]
		Residual	117765.120	75	1570.202		
		Total	530734.554	78			
	a. Dependent Variable: Super Formwork Unit Rate (ETB) c. Predictors: (Constant), Contract Signed Date, Distance From A.A (Km), Plot Area (m2)						
DV 11	*3*	Regression	8177.337	3	2725.779	76.747	.000[d]
		Residual	2592.710	73	35.517		
		Total	10770.048	76			
	a. Dependent Variable: Super Rebar Unit Rate (ETB) d. Predictors: (Constant), Contract Signed Date, Total Floor Area (m2), Contract Type						
DV 12	*2*	Regression	461349.960	3	153783.320	47.326	.000[c]
		Residual	172221.589	53	3249.464		
		Total	633571.549	56			
	a. Dependent Variable: Super Class B 200mm thick HCB Unit Rate (ETB) c. Predictors: (Constant), Contract Signed Date, USD to ETB Exchange Rate, Quantity (m2)						

Source: SPSS output from collected data

In assessing whether the models that include significant variables are effective in predicting the unit rates of the independent variables, the model summary has been evaluated. The R^2 is a crucial measure that shows the extent to which the variance in the dependent variable is explained by the various predictors within the model. The adjusted R^2 reflects the extent to which the model can be applied to a large population (Fields, 2009).

The Model Summary output of the analysis describes the overall models. The values of multiple correlation coefficient (R), R^2, adjusted R^2 and Durbin Watson for every dependent variable with number of models tested are stated. The table also includes which predictors or independent variables were included in every model for each dependent variable.

As presented in table 11 and 12 the R squares in this research range from 0.403 up to 0.906 for unit rate of dependent variable 3 and 2 respectively. Which means that 40.3% of dependent variable 3 and 90.6% of dependent variable 2 is accounted for by the combination of the independent variables.

The value of Durbin-Watson test statistic tests whether the assumption of independent errors is tenable. It tests for serial correlations between errors in *regression models*. Specifically, whether adjacent residuals are correlated. The test statistic can vary between 0 and 4 with a value of 2 meaning that the residuals are uncorrelated (Fields, 2009). Accordingly, the values of Durbin-Watson obtained for this research range from 1.025 up to 2.551 for dependent variable 3 and 2 respectively. With values below 1 and above 3 raising some questions and value close to 2 being preferable, All Durbin Watson values obtained in this research are within the preferable range. Hence, the assumption that residuals in the regression are independent has been met.

Table 11. Model Summary - Selected Sub Structure Work Items

Model Summary *						
DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 1	1	.867[a]	.751	.747	183.003	
	2	.888[b]	.789	.781	170.257	
	3	.923[c]	.852	.844	143.654	
	4	.929[d]	.863	.853	139.647	1.396

a. Predictors: (Constant), Contract Signed Date
b. Predictors: (Constant), Contract Signed Date, Contract Type
c. Predictors: (Constant), Contract Signed Date, Contract Type, Distance From A.A (Km)
d. Predictors: (Constant), Contract Signed Date, Contract Type, Distance From A.A (Km), Total No of Stories or Floors
**. Dependent Variable: Sub C5 Unit Rate (ETB)*

DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 2	1	.932[a]	0.8687	0.8605	166.3629	
	2	.952[b]	0.9062	0.8937	145.2180	2.5509

a. Predictors: (Constant), Contract Signed Date
b. Predictors: (Constant), Contract Signed Date, Client Type
**. Dependent Variable: Sub C15 Unit Rate (ETB)*

DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 3	1	.510[a]	0.2603	0.2307	208.3893	
	2	.635[b]	0.4031	0.3533	191.0649	1.0246

a. Predictors: (Constant), Total No of Stories or Floors
b. Predictors: (Constant), Total No of Stories or Floors, Contract Signed Date
**. Dependent Variable: Sub C20 Unit Rate (ETB)*

DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 4	1	.751[a]	0.5641	0.5575	409.1298	
	2	.817[b]	0.6679	0.6577	359.8208	
	3	.840[c]	0.7053	0.6915	341.6187	1.3267

a. Predictors: (Constant), Contract Signed Date
b. Predictors: (Constant), Contract Signed Date, Contract Type
c. Predictors: (Constant), Contract Signed Date, Contract Type, Total No of Stories or Floors
**. Dependent Variable: Sub C25 Unit Rate (ETB)*

DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 5	1	.633[a]	0.4004	0.3789	475.0753	
	2	.731[b]	0.5341	0.4995	426.4611	1.5612

a. Predictors: (Constant), Contract Signed Date
b. Predictors: (Constant), Contract Signed Date, Distance From A.A (Km)
**. Dependent Variable: Sub C30 Unit Rate (ETB)*

DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 6	1	.877[a]	0.7691	0.7660	35.0356	
	2	.890[b]	0.7916	0.7860	33.5112	
	3	.898[c]	0.8068	0.7988	32.4895	1.0463

a. Predictors: (Constant), Contract Signed Date
b. Predictors: (Constant), Contract Signed Date, Distance From A.A (Km)
c. Predictors: (Constant), Contract Signed Date, Distance From A.A (Km), Total No of Stories or Floors
**. Dependent Variable: Sub Formwork Unit Rate (ETB)*

DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 7	1	.802[a]	0.6428	0.6380	6.9853	
	2	.841[b]	0.7078	0.6998	6.3613	
	3	.856[c]	0.7334	0.7222	6.1184	2.0490

a. Predictors: (Constant), Contract Signed Date
b. Predictors: (Constant), Contract Signed Date, Total Floor Area (m2)
c. Predictors: (Constant), Contract Signed Date, Total Floor Area (m2), Contract Type
**. Dependent Variable: Sub Rebar Unit Rate (ETB)*

Source: SPSS output from collected data

Table 12. Model Summary - Selected Super Structure Work Items

Model Summary *

DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 8	1	.796[a]	0.6330	0.6278	500.1800	
	2	.828[b]	0.6851	0.6761	466.6017	
	3	.841[c]	0.7073	0.6946	453.0815	
	4	.852[d]	0.7257	0.7095	441.8671	
	5	.862[e]	0.7435	0.7244	430.4271	1.1874

a. Predictors: (Constant), Contract Signed Date
b. Predictors: (Constant), Contract Signed Date, Contract Type
c. Predictors: (Constant), Contract Signed Date, Contract Type, USD to ETB Exchange Rate
d. Predictors: (Constant), Contract Signed Date, Contract Type, USD to ETB Exchange Rate, Total No of Stories or Floors
e. Predictors: (Constant), Contract Signed Date, Contract Type, USD to ETB Exchange Rate, Total No of Stories or Floors, Distance From A.A (Km)
**. Dependent Variable: Super C25 Unit Rate (ETB)/m3*

DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 9	1	.613[a]	0.3762	0.3490	540.3122	
	2	.733[b]	0.5369	0.4948	475.9740	2.0909

a. Predictors: (Constant), USD to ETB Exchange Rate
b. Predictors: (Constant), USD to ETB Exchange Rate, Distance From A.A (Km)
**. Dependent Variable: Super C30 Unit Rate (ETB)*

DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 10	1	.867[a]	0.7509	0.7477	41.4333	
	2	.875[b]	0.7663	0.7601	40.3992	
	3	.882[c]	0.7781	0.7692	39.6258	1.5065

a. Predictors: (Constant), Contract Signed Date
b. Predictors: (Constant), Contract Signed Date, Distance From A.A (Km)
c. Predictors: (Constant), Contract Signed Date, Distance From A.A (Km), Plot Area (m2)
**. Dependent Variable: Super Formwork Unit Rate (ETB)/m2*

DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 11	1	.822[a]	0.6758	0.6715	6.8231	
	2	.858[b]	0.7355	0.7283	6.2047	
	3	.871[c]	0.7593	0.7494	5.9596	1.9428

a. Predictors: (Constant), Contract Signed Date
b. Predictors: (Constant), Contract Signed Date, Total Floor Area (m2)
c. Predictors: (Constant), Contract Signed Date, Total Floor Area (m2), Contract Type
**. Dependent Variable: Super Rebar Unit Rate (ETB)/Kg*

DV	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
DV 12	1	.819[a]	0.6705	0.6645	61.6128	
	2	.837[b]	0.7007	0.6896	59.2628	
	3	.853[c]	0.7282	0.7128	57.0041	1.8447

a. Predictors: (Constant), Contract Signed Date
b. Predictors: (Constant), Contract Signed Date, USD to ETB Exchange Rate
c. Predictors: (Constant), Contract Signed Date, USD to ETB Exchange Rate, Quantity (m2)
** Dependent Variable: Super Class B 200mm thick HCB Unit Rate (ETB)/m2*

Source: SPSS output from collected data

The statistical procedures used to measure the performance of the models include The Coefficient of Determination (R^2) and The Coefficient of Correlation (R); (Al-Zwainy et al.

2013). This is due to the fact that, the R square value indicates how much of the outcome's variability is explained by the independent variable predictors included in that particular model. For example, the R^2 value for DV 12 is 0.7282, indicating that 72.82% of the variation in the unit rate is explained by predictors in that model.

Table 13. Coefficient of Determination (R2) and Coefficient of Correlation (R) summary

Dependent Variable	R	R^2
DV 1	0.874	0.7647
DV 2	0.952	0.9062
DV 3	0.635	0.4031
DV 4	0.840	0.7053
DV 5	0.731	0.5341
DV 6	0.898	0.8068
DV 7	0.856	0.7334
DV 8	0.862	0.7435
DV 9	0.733	0.5369
DV 10	0.882	0.7781
DV 11	0.871	0.7593
DV 12	0.853	0.7282

The subsequent section of the SPSS output related to the model parameters is displayed in tables 14 and 15. Since stepwise regression was implemented, SPSS gives the output parameters for every model. However, since our focus will be on the parameters for the final model, the other outputs are excluded from the tables below.

The unstandardized value of B represents the unique impact of each predictor on the model. They indicate the extent to which each predictor influences the outcome when the impacts of all other predictors are kept unchanged (Field, 2009). Thus, these values indicate the connection between unit rates for the selected DV and the key IV during which the effects of all other predictors are kept unchanged. For example, for each Km increment in distance from AA, unit rate for DV 1 decrease by 0.296 birr/m^3. On the other hand, for every increase in No of stories, unit rate for DV 3 increases by 88.035birr/m^3. For every 1Km increase in distance from AA unit rate for DV 5 decrease by 1.246 birr/m^3.

Since the t-test associated with the unstandardized B value for all dependent variables is significant ($p<0.05$) their respective independent variables create crucial impact to the model.

Table 14. Regression Coefficients for Selected Sub Structure Work Items

Coefficients *								
DV	Model	IV	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	VIF
DV 1	4	(Constant)	-41858.647	3450.773		-12.130	.000	
		IV 6	3.160E-06	.000	.765	12.405	.000	1.130
		IV 10	346.220	99.577	.208	3.477	.001	1.068
		IV 2	-.296	.127	-.149	-2.334	.022	1.211
		IV 9	11.566	5.097	.136	2.269	.026	1.068
*. Dependent Variable: Sub C5 Unit Rate (ETB/m3); IV 2. Independent Variable: Distance From A.A (Km); IV 6. Independent Variable: Contract Signed Date; IV 9. Independent Variable: Function of The Building; IV 10. Independent Variable: Contract Type								
DV 2	2	(Constant)	-74839.887	7093.217		-10.551	.000	
		IV 6	5.642E-06	.000	.877	10.672	.000	1.080
		IV 8	380.375	155.305	.201	2.449	.027	1.080
*. Dependent Variable: Sub C15 Unit Rate (ETB/m3); IV 6. Independent Variable: Contract Signed Date; IV 8. Independent Variable: Client Type								
DV 3	2	(Constant)	-17271.936	7874.733		-2.193	.038	
		IV 5	88.035	25.908	.537	3.398	.002	1.005
		IV 6	1.397E-06	.000	.379	2.396	.025	1.005
*. Dependent Variable: Sub C20 Unit Rate (ETB/m3); IV 5. Independent Variable: Total No of Stories; IV 6. Independent Variable: Contract Signed Date								
DV 4	3	(Constant)	-50372.618	5486.781		-9.181	.000	
		IV 6	3.813E-06	.000	.671	9.341	.000	1.121
		IV 10	821.807	152.895	.382	5.375	.000	1.096
		IV 5	33.561	11.784	.212	2.848	.006	1.204
*. Dependent Variable: Sub C25 Unit Rate (ETB/m3); IV 10. Independent Variable: Contract Type; IV 6. Independent Variable: Contract Signed Date; IV 5. Independent Variable: Total No of Stories								
DV 5	2	(Constant)	-44345.858	9163.387		-4.839	.000	
		IV 6	3.456E-06	.000	.681	5.139	.000	1.017
		IV 2	1.246	.448	.369	2.783	.010	1.017
*. Dependent Variable: Sub C30 Unit Rate (ETB/m3); IV 6. Independent Variable: Contract Signed Date; IV 2. Independent Variable: Distance From A.A (Km)								
DV6	3	(Constant)	-7053.598	470.125		-15.004	.000	
		IV 6	5.287E-07	.000	.869	15.191	.000	1.237
		IV 2	.070	.019	.239	3.748	.000	1.537
		IV 5	1.906	.796	.164	2.393	.019	1.766
*. Dependent Variable: Sub Formwork Unit Rate (ETB/m2); IV 2. Independent Variable: Distance From A.A (Km); IV 6. Independent Variable: Contract Signed Date; IV 5. Independent Variable: Total No of Stories								
DV7	3	(Constant)	-1203.123	90.610		-13.278	.000	
		IV 6	9.080E-08	.000	.899	13.524	.000	1.193
		IV 4	.000	.000	-.244	-3.616	.001	1.230
		IV 10	6.967	2.650	.163	2.628	.010	1.037
*. Dependent Variable: Sub Rebar Unit Rate (ETB/Kg); IV 4. Independent Variable: Total Floor Area (m2); IV 6. Independent Variable: Contract Signed Date; IV 10. Independent Variable: Contract Type								

Source: SPSS output from collected data

Table 15. Regression Coefficients for Selected Super Structure Work Items

Coefficients *								
DV	Model	IV	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	VIF
			B	Std. Error	Beta			
DV 8	5	(Constant)	-149704.481	33253.758		-4.502	.000	
		IV 6	1.127E-05	.000	1.538	4.495	.000	3.579
		IV 10	824.119	188.164	.298	4.380	.000	1.209
		IV 7	-107.781	46.183	-.806	-2.334	.023	3.161
		IV 5	47.797	16.143	.232	2.961	.004	1.611
		IV 2	.559	.259	.162	2.159	.034	1.468
*. Dependent Variable: Super C25 Unit Rate (ETB/m3); IV 6. Independent Variable: Contract Signed Date; IV 10. Independent Variable: Contract Type; IV 7. Independent Variable: USD to ETB Exchange Rate; IV 5. Independent Variable: Total No of Stories; IV 2. Independent Variable: Distance From A.A (Km)								
DV 9	4	(Constant)	1230.145	395.563		3.110	.005	
		IV 6	73.472	17.888	.596	4.107	.000	1.002
		IV 9	2.067	.748	.401	2.764	.011	1.002
*. Dependent Variable: Super C30 Unit Rate (ETB/m3); IV 6. Independent Variable: Contract Signed Date; IV 9. Independent Variable: Function of the Building								
DV 10	2	(Constant)	-8578.981	545.063		-15.739	.000	
		IV 6	6.443E-07	.000	.921	16.064	.000	1.112
		IV 2	.040	.019	.121	2.132	.036	1.080
		IV 3	-.001	.000	-.111	-1.999	.049	1.050
*. Dependent Variable: Super Formwork Unit Rate (ETB/m2); IV 6. Independent Variable: Contract Signed Date; IV 2. Independent Variable: Distance From A.A (Km); IV 8. Independent Variable: Plot Area (m2)								
DV 11	3	(Constant)	-1249.973	87.022		-14.364	.000	
		IV 6	9.431E-08	.000	.905	14.630	.000	1.159
		IV 4	.000	.000	-.229	-3.633	.001	1.200
		IV 10	6.475	2.411	.157	2.686	.009	1.041
*. Dependent Variable: Super Rebar Unit Rate (ETB/Kg); IV 6. Independent Variable: Contract Signed Date; IV 4. Independent Variable: Total Floor Area; IV 10. Independent Variable: Contract Type								
DV 12	2	(Constant)	-23087.691	5041.289		-4.580	.000	
		IV 6	1.751E-06	.000	2.051	4.603	.000	8.719
		IV 7	-18.569	6.894	-1.190	-2.693	.009	3.088
		IV 2	-.004	.002	-.177	-2.316	.024	1.138
*. Dependent Variable: Super Class B 200mm thick HCB Unit Rate (ETB/m2); IV 6. Independent Variable: Contract Signed Date; IV 7. Independent Variable: USD to ETB Exchange Rate; IV 2. Independent Variable: Quantity (m2)								

Source: SPSS output from collected data

Tables 14 and 15 also present certain measures for assessing collinearity in the data, particularly the VIF. Given that all VIF values for all DV in this research are under 10, we can infer that there is no collinearity present in the data.

4.3.2.1 Summary of Regression Models

The unstandardized coefficients (β) and identified independent variables from the regression analysis output were utilized to construct final predictive models. Summary of the models developed for each dependent variable is presented on table 16.

Table 16. Summary of Developed Regression Models

Model for D. Variable	Developed Regression Models
DV 1 =	$-41858.647 + 3.160\mathrm{E}-06 * IV_6 + 346.22 * IV_{10} - .296 * IV_2 - 11.566 * IV_9$
DV 2 =	$-74839.887 + 5.642\mathrm{E}-06 * IV_6 + 380.375 * IV_8$
DV 3 =	$-17271.935 + 88.035 * IV_5 + 3.160\mathrm{E}-06 * IV_6$
DV 4 =	$-50372.618 + 3.813\mathrm{E}-06 * IV_6 + 821.807 * IV_{10} + 33.561 * IV_5$
DV 5 =	$-44345.858 + 3.456\mathrm{E}-06 * IV_6 + 1.246 * IV_2$
DV 6 =	$-7053.597 + 5.286\mathrm{E}-07 * IV_6 + 0.7 * IV_2 + 1.906 * IV_5$
DV 7 =	$-1203.123 + 9.079\mathrm{E}-08 * IV_6 + 1.537\mathrm{E}-04 * IV_4 + 6.967 * IV_{10}$
DV 8 =	$-149704.48 + 1.13\mathrm{E}-05 * IV_6 + 824.12 * IV_{10} - 107.78 * IV_7 + 47.8 * IV_5 + 0.56 * IV_2$
DV 9 =	$1230.145 + 73.472 * IV_7 + 2.067 * IV_2$
DV 10 =	$-8578.98 + 6.443\mathrm{E}-07 * IV_6 + 0.4 * IV_2 - 0.001 * IV_3$
DV 11 =	$-1249.973 + 9.431\mathrm{E}-08 * IV_6 - 1.94\mathrm{E}-04 * IV_4 + 6.475 * IV_{10}$
DV 12 =	$-23087.69 + 1.751\mathrm{E}-06 * IV_6 - 18.57 * IV_7 - 0.004 * IV_1$

Where the dependent variables are:

DV 1 - C-5 lean concrete unit rate (sub structure)

DV 2 - C-15 concrete unit rate (sub structure)

DV 3 - C-20 concrete unit rate (sub structure)

DV 4 - C-25 concrete unit rate (sub structure)

DV 5 - C-30 concrete unit rate (sub structure)

DV 6 - Formwork unit rate (sub structure)

DV 7 - Reinforcement unit rate (sub structure)

DV 8 - C-25 concrete unit rate (super structure)

DV 9 - C-30 concrete unit rate (super structure)

DV 10 - Formwork unit rate (super structure)

DV 11 - Reinforcement unit rate (super structure)

DV 12 - Class B 20cm thick HCB unit rate (super structure)

And independent variables are:

IV1 - Quantity of the dependent variable

IV2 - Distance of the project from Addis Ababa

IV3 - Plot area of the building

IV4 - Total floor area

IV5 - Total number of stories or floors

IV6 - Date the contract was signed

IV7 - USD to ETB exchange rate

IV8 - Client type

IV9 - Function of the building

IV10 - Contract type

Looking at similar work items found on both sub structure and super structure, it can be seen that common independent variables occur. The stepwise multiple linear regression analysis identified the most important explanatory or independent variables for C-25 concrete work in sub structure and super structure are Total number of stories or floors, Date the contract was signed and contract type. On the other hand, distance of the project from Addis Ababa was found to be the only common independent variables for C-30 concrete in sub structure and super structure. Contract signed date and distance of the project from Addis Ababa were found to be influential factors in formwork. Lastly Total floor area, Contract signed date and Contract type were identified while comparing reinforcement work at substructure and superstructure work.

Chapter Five

5. Conclusion and Recommendation

5.1 Conclusion

This research analyzed historical bid data to estimate future unit rate for selected building work items in Ethiopia. The study aimed to develop predictive models for estimating bid unit rate of selected items. These models were created using the data gathered from 80 building construction projects. These models are highly valuable in terms of efficiency and ability to be implemented by ordinary computer software.

To assess the connection between the independent variables and the selected work items (dependent variables), multiple linear regression analysis was performed employing the step-wise analytical approach. This analysis allows for the simultaneous examination of multiple variables and their interrelationships.

The findings indicate that regression analysis has the capability to forecast the unit rate of C-15 concrete (sub structure) with high coefficients of determination R square of 0.906. This result suggests that the established model explains substantial proportion of the variation in the dependent variable and show a strong relationship between the predictor and outcome variables.

On the other hand, the least accurate model was developed for superstructure C20 concrete unit rate with coefficients of determination R square of 0.403, indicating weak predictive performance.

The key cost drivers or independent variables that appear in most of the regression models are contract signed date, distance of the project from Addis Ababa, Contract type, number of stories and USD to ETB exchange rate.

This study has constraints that influence the data analysis. These are; examining limited number of variables due to lack of available data, reluctance of contractors to provide complete information. Another limitation is that the projects used in this research are inadequate in number and have been executed in a wide range of time and represent different type of facilities. Hence, the scope of this thesis is limited to the selected independent variables only. This means we can confidently deduce that from the selected variables, which one affects unit rate significantly than the others.

5.2 Recommendations

It is a widely recognized truth that current and trustworthy databases and information systems that assist estimators are essential for achieving precise cost estimation for various stages of the building construction process. Although using a single formula to estimate unit rate for the selected work items is found to be possible it is highly recommended to include more data to enhance the precision and forecasting ability of the models. Therefore, the models created in this study ought to act as a foundation for additional exploration of the subject rather than generalizing tool beyond the sample projects.

An estimated project cost is assessment of likely expense rather than a precise number. Hence, future research and model improvement shall be done by including more significant variables in addition to reviewing and updating variables periodically. Likewise, non linear relationship should also be considered to increase the accuracy of the model.

Precise estimates are essential for making decisions regarding strategies for potential project evaluation, and resource allocation for further project development. Therefore, improving data records of cost regularly is recommended for contractors.

A broad and dependable cost database must be created through the collaboration of all participants in the construction industry. The database must be updated and recorded frequently in brief time periods to provide accurate information.

Chapter Six

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Appendices

A. Data Summary Example

Sub structure C-5 concrete data summary

Project	Block	Sub C-5 Unit Rate (ETB)	Qty (m^3)	Distance from A.A (Km)	Plot Area (m^2)	Total Floor A (m^2)	No of Stories	Contract Signed Date	USD - ETB exchange rate	Client type	Function of the building	Contract type
P1	1	810.00	9.00	505	1,361.75	27,235.00	4	6/23/2008	9.695	1	7	1
	2	810.00	13.00	505	2,637.76	31,653.12	3	6/23/2008	9.695	1	3	1
	3	810.00	4.00	505	2,164.00	2,194.00	1	6/23/2008	9.695	1	2	1
	4	810.00	12.00	505	900.00	900.00	1	6/23/2008	9.695	1	15	1
	5	810.00	9.00	505	596.87	596.87	1	6/23/2008	9.695	1	20	1
	6	810.00	15.00	505	401.00	1,204.00	3	6/23/2008	9.695	1	6	1
	7	810.00	10.00	505	345.00	609.00	2	6/23/2008	9.695	1	13	1
	8	810.00	15.00	505	711.20	1,802.40	4	6/23/2008	9.695	1	17	1
	9	810.00	5.00	505	520.57	827.05	2	6/23/2008	9.695	1	2	1
	10	810.00	7.00	505	522.97	2,091.92	4	6/23/2008	9.695	1	19	1
	11	810.00	12.00	505	2,500.00	2,500.00	2	6/23/2008	9.695	1	10	1
	12	810.00	12.00	505	22.50	247.50	2	6/23/2008	9.695	1	9	1
	13	810.00	3.00	505	111.51	111.51	1	6/23/2008	9.695	1	14	1
P2	14	1,155.00	11.00	505	460.13	1,380.39	3	4/9/2012	18.093	1	12	1
	15	1,155.00	11.00	505	460.13	1,380.39	3	4/9/2012	18.093	1	12	1
	16	1,155.00	11.00	505	460.13	1,380.39	3	4/9/2012	18.093	1	12	1
	17	1,155.00	11.00	505	460.13	1,380.39	3	4/9/2012	18.093	1	12	1
	18	1,155.00	11.00	505	460.13	1,380.39	3	4/9/2012	18.093	1	12	1
P3	19	1,580.00	57.55	0	1,158.34	13,445.51	14	8/7/2012	18.032	1	17	1
	20	1,580.00	25.63	0	975.84	8,782.56	9	8/7/2012	18.032	1	17	1
	21	1,580.00	25.63	0	975.84	8,782.56	9	8/7/2012	18.032	1	17	1
	22	1,580.00	11.75	0	1,882.80	3,030.31	2	8/7/2012	18.032	1	2	1
P4	23	1,820.00	55.31	0	3,048.00	18,492.25	5	6/6/2012	17.803	1	1	1

Project	Block	Sub C-5 Unit Rate (ETB)	Qty (m^3)	Distance from A.A (Km)	Plot Area (m^2)	Total Floor A (m^2)	No of Stories	Contract Signed Date	USD - ETB exchange rate	Client type	Function of the building	Contract type
P5	24	1,430.80	34.00	738	778.70	1,851.22	5	2/29/2012	17.509	1	17	1
	25	1,430.80	20.00	738	2,085.27	14,596.87	7	2/29/2012	17.509	1	19	1
	26	1,430.80	39.00	738	1,851.22	445.60	3	2/29/2012	17.509	1	15	1
P6	27	940.78	56.00	738	8,365.13	21,689.52	4	6/16/2015	17.803	1	1	1
P7	28	1,460.00	19.25	0	1,158.34	13,445.51	14	7/5/2012	18.093	1	17	1
	29	1,460.00	6.95	0	975.84	9,757.40	10	7/5/2012	18.093	1	17	1
	30	1,460.00	6.95	0	975.84	9,757.40	10	7/5/2012	18.093	1	17	1
	31	1,460.00	28.90	0	1,882.80	3,030.31	2	7/5/2012	18.093	1	2	1
P8	32	85.20	50.35	526	865.70	3,886.23	4	8/10/2011	17.277	3	11	2
	33	85.20	0.90	526	13.81	13.81	1	8/10/2011	17.277	3	8	2
	34	85.20	0.90	526	95.16	95.16	1	8/10/2011	17.277	3	8	2
P9	35	1,054.00	41.00	346	1,500.00	4,650.00	5	5/9/2008	9.637	1	17	1
	36	1,054.00	95.00	346	1,500.00	5,750.00	6	5/9/2008	9.637	1	17	1
	37	1,054.00	35.00	346	1,780.00	6,320.00	5	5/9/2008	9.637	1	17	1
	38	1,054.00	14.00	346	370.00	1,850.00	5	5/9/2008	9.637	1	17	1
	39	1,054.00	23.00	346	1,240.00	3,125.00	4	5/9/2008	9.637	1	15	1
	40	1,054.00	24.00	346	885.00	4,425.00	5	5/9/2008	9.637	1	3	1
	41	1,054.00	4.00	346	200.00	1,000.00	5	5/9/2008	9.637	1	5	1
	42	1,054.00	27.00	346	3,255.00	4,515.00	3	5/9/2008	9.637	1	21	1
	43	1,054.00	18.00	346	450.00	2,250.00	5	5/9/2008	9.637	1	19	1
	44	1,054.00	52.00	346	550.00	2,350.00	5	5/9/2008	9.637	1	19	1
	45	1,054.00	6.00	346	2,830.00	2,830.00	1	5/9/2008	9.637	1	11	1
P10	46	1,007.00	155.00	346	5,295.00	15,885.00	3	12/29/2009	12.697	1	3	1
	47	1,007.00	25.00	346	2,500.00	2,500.00	1	12/29/2009	12.697	1	2	1
	48	1,007.00	12.00	346	720.00	1,440.00	2	12/29/2009	12.697	1	4	1

Project	Block	Sub C-5 Unit Rate (ETB)	Qty (m^3)	Distance from A.A (Km)	Plot Area (m^2)	Total Floor A (m^2)	No of Stories	Contract Signed Date	USD - ETB exchange rate	Client type	Function of the building	Contract type
P11	49	1,167.00	80.00	346	5,000.00	9,190.00	3	4/29/2010	13.581	1	17	1
P12	50	825.00	194.00	346	25,000.00	60,000.00	5	6/21/2007	12.623	1	11	1
P13	51	2,327.60	154.49	0	3,167.00	42,547.64	29	5/14/2015	20.644	2	17	1
P14	52	840.00	54.55	0	1,664.37	11,017.94	14	5/29/2009	12.623	2	16	1
P15	53	3,200.00	146.10	0	2,000.00	20,663.47	11	7/22/2010	13.700	2	16	1
P16	54	1,740.00	43.70	505	840.00	1,505.86	2	9/17/2012	17.938	3	11	2
	55	1,740.00	1.30	505	32.60	32.60	1	9/17/2012	17.938	3	8	2
	56	1,740.00	1.25	505	28.00	28.00	1	9/17/2012	17.938	3	18	2
	57	1,740.00	11.50	505	217.00	217.00	1	9/17/2012	17.938	3	11	2
P17	58	9,510.80	142.08	0	3,649.00	22,968.00	16	11/12/2012	18.243	2	16	1
P18	59	1,085.17	138.65	0	3,649.00	22,968.00	16	1/22/2010	12.797	3	17	1
P19	60	2,096.00	195.00	563	3,849.37	39,723.33	15	1/10/2018	27.210	3	17	1
P20	61	2,400.00	41.20	0	686.00	9,832.00	14	1-Jul-2016	22.018	1	17	1
P21	62	2,200.00	124.76	0	1,978.00	5,891.56	8	7/1/2016	28.259	3	17	1
P21	63	2,200.00	6.78	0	414.18	414.18	1	12/20/2018	28.259	3	17	1
P22	64	2,500.00	16.91	819	1,500.00	1,500.00	1	12/21/2018	20.727	1	17	1
P23	65	3,120.00	37.60	505	1,460.00	5,558.00	4	6/13/2015	23.428	1	12	1
P24	66	3,120.00	33.93	505	1,298.00	9,086.00	7	8/2/2017	23.428	1	17	1
P25	67	2,800.00	66.40	0	1,246.00	11,214.00	9	8/2/2017	21.822	1	17	1
P26	68	3,000.00	248.58	0	6,996.00	41,976.00	6	6/21/2016	27.789	1	16	1
P27	69	2,000.00	56.23	328	781.00	4,833.97	9	9/7/2018	20.400	3	17	1
P28	70	1,800.00	111.90	0	2,552.82	55,768.52	26	2/7/2015	28.585	2	16	1

Project	Block	Sub C-5 Unit Rate (ETB)	Qty (m^3)	Distance from A.A (Km)	Plot Area (m^2)	Total Floor A (m^2)	No of Stories	Contract Signed Date	USD - ETB exchange rate	Client type	Function of the building	Contract type
P29	71	1,800.00	107.35	0	2,147.36	63,260.90	29	2/21/2019	27.968	2	16	1
P30	72	1,800.00	72.00	0	474.00	10,439.02	17	10/17/2018	28.520	2	16	1
P31	73	1,740.00	29.48	588	5,875.00	41,125.00	7	11/23/2017	27.424	1	7	1
P31	74	1,740.00	30.97	588	6,033.00	30,165.00	5	11/23/2017	27.424	1	7	1
P32	75	1,740.00	84.14	98	2,728.71	26,564.65	15	9/28/2017	23.614	1	17	1
P33	76	1,900.00	22.82	0	1,048.00	8,279.65	10	2/7/2018	27.497	2	16	1
P34	77	1,920.00	365.13	591	26,918.50	26,918.50	1	4/19/2018	27.522	1	11	1
P35	78	1,980.00	1,014.84	0	125,977.12	125,977.12	1	4/12/2018	27.522	1	11	1
P36	79	1,900.00	24.80	0	460.00	4,110.00	11	6/20/2018	27.531	3	16	1
P37	80	1,600.00	102.37	505	3,096.66	12,736.83	7	1/24/2019	28.439	1	12	1

B. Correlation outputs

Correlation output dependent Variable 2

Correlations c											
		(DV 2)	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 7)	(IV 8)	(IV 9)
(DV 2)	r	1									
Sig. (2-tailed)											
(IV 1)	r	-.022	1								
Sig. (2-tailed)		.930									
(IV 2)	r	-.907**	-.037	1							
Sig. (2-tailed)		.000	.884								
(IV 3)	r	-.332	.751**	.067	1						
Sig. (2-tailed)		.178	.000	.792							
(IV4)	r	-.235	.659**	.032	.828**	1					
Sig. (2-tailed)		.347	.003	.901	.000						
(IV 5	r	.686**	.238	-.714**	-.013	.237	1				
Sig. (2-tailed)		.002	.343	.001	.959	.343					
(IV 6)	r	.932**	-.107	-.960**	-.303	-.193	.712**	1			
Sig. (2-tailed)		.000	.672	.000	.221	.444	.001				
(IV 7)	r	.870**	.060	-.988**	-.049	.007	.734**	.965**	1		
Sig. (2-tailed)		.000	.812	.000	.845	.978	.001	.000			
(IV 8)	r	.440	.658**	-.238	.044	.177	.491*	.272	.249	1	
Sig. (2-tailed)		.067	.003	.342	.862	.482	.039	.274	.319		
(IV 9)	r	.311	-.007	-.285	-.064	-.070	.563*	.244	.248	.155	1
Sig. (2-tailed)		.209	.977	.252	.802	.783	.015	.329	.320	.540	

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=18

Source: SPSS output from collected data

Correlation output dependent Variable 3

Correlations [c]

		DV 3	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 9)
(DV 3)	r	1							
Sig. (2-tailed)									
(IV 1)	r	.087	1						
Sig. (2-tailed)		.666							
(IV 2)	r	.022	.094	1					
Sig. (2-tailed)		.912	.642						
(IV 3)	r	.153	.951**	.038	1				
Sig. (2-tailed)		.446	.000	.849					
(IV 4)	r	.203	.714**	-.093	.836**	1			
Sig. (2-tailed)		.310	.000	.643	.000				
(IV 5)	r	.510**	-.058	-.028	.003	.342	1		
Sig. (2-tailed)		.007	.774	.892	.986	.080			
(IV 6)	r	.340	.370	.479*	.396*	.416*	-.071	1	
Sig. (2-tailed)		.082	.058	.011	.041	.031	.723		
(IV 9)	r	.186	-.307	.219	-.293	-.321	.330	-.273	1
Sig. (2-tailed)		.353	.120	.272	.138	.103	.092	.168	

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=27

Source: SPSS output from collected data

Correlation output dependent Variable 4

Correlations [c]

		(DV 4)	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 7)	(IV 8)	(IV 9)	(IV 10)
(DV 4)	r	1										
	ρ. (2-tailed)											
(IV 1)	r	.180	1									
	Sig. (2-tailed)	.143										
(IV 2)	r	-.228	-.202	1								
	Sig. (2-tailed)	.061	.099									
(IV 3)	r	.098	.967**	-.137	1							
	Sig. (2-tailed)	.427	.000	.266								
(IV 4)	r	.165	.832**	-.176	.871**	1						
	Sig. (2-tailed)	.178	.000	.152	.000							
(IV 5)	r	.313**	-.053	-.597**	-.136	.107	1					
	Sig. (2-tailed)	.009	.668	.000	.268	.386						
(IV 6)	r	.751**	.364**	-.278*	.269*	.335**	.302*	1				
	Sig. (2-tailed)	.000	.002	.022	.026	.005	.012					
(IV 7)	r	.751**	.364**	-.280*	.279*	.355**	.297*	.983**	1			
	Sig. (2-tailed)	.000	.002	.021	.021	.003	.014	.000				
(IV 8)	r	.468**	-.073	-.119	-.103	-.136	.051	.352**	.372**	1		
	Sig. (2-tailed)	.000	.552	.333	.405	.269	.678	.003	.002			
(IV 9)	r	.142	-.014	-.235	-.054	-.091	.446**	.080	.087	.087	1	
	Sig. (2-tailed)	.248	.908	.054	.660	.460	.000	.517	.483	.480		
(IV 10)	r	.353**	-.096	.230	-.075	-.160	-.266*	.042	.086	.709**	-.133	1
	Sig. (2-tailed)	.003	.438	.059	.543	.194	.028	.736	.483	.000	.278	

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=68

Source: SPSS output from collected data

Correlation output dependent Variable 5

Correlations c											
		(DV 5)	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 7)	(IV 8)	(IV 9)
(DV 5)	r	1									
Sig. (2-tailed)											
(IV 1)	r	.189	1								
Sig. (2-tailed)		.316									
(IV 2)	r	.280	-.148	1							
Sig. (2-tailed)		.134	.434								
(IV 3)	r	.174	.158	.030	1						
Sig. (2-tailed)		.358	.403	.877							
(IV4)	r	.313	.623**	-.078	.792**	1					
Sig. (2-tailed)		.092	.000	.680	.000						
(IV 5	r	.058	.564**	-.350	-.289	.240	1				
Sig. (2-tailed)		.760	.001	.058	.122	.201					
(IV 6)	r	.633**	.517**	-.130	.242	.495**	.345	1			
Sig. (2-tailed)		.000	.003	.492	.198	.005	.062				
(IV 7)	r	.628**	.462*	-.143	.255	.492**	.311	.991**	1		
Sig. (2-tailed)		.000	.010	.451	.173	.006	.094	.000			
(IV 8)	r	.075	.135	-.074	-.160	.094	.477**	.337	.338	1	
Sig. (2-tailed)		.693	.478	.697	.397	.621	.008	.069	.067		
(IV 9)	r	.073	.145	.093	-.174	-.020	.412*	.024	-.016	.258	1
Sig. (2-tailed)		.702	.445	.627	.357	.917	.024	.901	.935	.168	

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=30

Source: SPSS output from collected data

Correlation output dependent Variable 6

Correlations c

		(DV 6)	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 7)	(IV 8)	(IV 9)	(IV 10)
(DV 6)	r	1										
	ρ. (2-tailed)											
(IV 1)	r	.236*	1									
	Sig. (2-tailed)	.039										
(IV 2)	r	-.089	-.265*	1								
	Sig. (2-tailed)	.439	.020									
(IV 3)	r	.105	.942**	-.119	1							
	Sig. (2-tailed)	.363	.000	.304								
(IV 4)	r	.326**	.845**	-.281*	.758**	1						
	Sig. (2-tailed)	.004	.000	.013	.000							
(IV 5)	r	.403**	.168	-.591**	-.098	.423**	1					
	Sig. (2-tailed)	.000	.144	.000	.395	.000						
(IV 6)	r	.877**	.354**	-.267*	.209	.409**	.437**	1				
	Sig. (2-tailed)	.000	.002	.019	.068	.000	.000					
(IV 7)	r	.856**	.354**	-.276*	.227*	.426**	.423**	.984**	1			
	Sig. (2-tailed)	.000	.002	.015	.047	.000	.000	.000				
(IV 8)	r	.325**	-.004	-.189	-.093	.036	.246*	.327**	.365**	1		
	Sig. (2-tailed)	.004	.970	.100	.423	.753	.031	.004	.001			
(IV 9)	r	.231*	.032	-.240*	-.060	.019	.417**	.170	.166	.120	1	
	Sig. (2-tailed)	.044	.786	.036	.604	.871	.000	.139	.148	.300		
(IV 10)	r	.075	-.101	.218	-.071	-.173	-.219	-.013	.033	.647**	-.153	1
	Sig. (2-tailed)	.518	.380	.056	.541	.132	.056	.908	.778	.000	.183	

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=77

Source: SPSS output from collected data

Correlation output dependent Variable 7

Correlations [c]

	(DV 7)	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 7)	(IV 8)	(IV 9)	(IV 10)
(DV 7) *r*	1										
ρ. (2-tailed)											
(IV 1) *r*	.188	1									
Sig. (2-tailed)	.104										
(IV 2) *r*	-.067	-.345**	1								
Sig. (2-tailed)	.565	.002									
(IV 3) *r*	.028	.857**	-.136	1							
Sig. (2-tailed)	.809	.000	.242								
(IV 4) *r*	.084	.847**	-.250*	.816**	1						
Sig. (2-tailed)	.472	.000	.029	.000							
(IV 5) *r*	.144	.255*	-.581**	-.109	.265*	1					
Sig. (2-tailed)	.215	.026	.000	.351	.021						
(IV 6) *r*	.802**	.416**	-.216	.235*	.396**	.354**	1				
Sig. (2-tailed)	.000	.000	.061	.041	.000	.002					
(IV 7) *r*	.803**	.411**	-.226*	.254*	.417**	.334**	.982**	1			
Sig. (2-tailed)	.000	.000	.049	.027	.000	.003	.000				
(IV 8) *r*	.301**	-.014	-.136	-.090	-.020	.238*	.284*	.317**	1		
Sig. (2-tailed)	.008	.903	.241	.437	.865	.038	.013	.005			
(IV 9) *r*	.179	.117	-.223	-.056	-.012	.448**	.154	.148	.116	1	
Sig. (2-tailed)	.122	.315	.053	.633	.921	.000	.183	.201	.320		
(IV 10) *r*	.203	-.149	.213	-.073	-.174	-.241*	-.002	.047	.638**	-.152	1
Sig. (2-tailed)	.078	.198	.064	.532	.132	.036	.984	.690	.000	.191	

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=76

Source: SPSS output from collected data

Correlation output dependent Variable 8

Correlations [c]												
		(DV 7)	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 7)	(IV 8)	(IV 9)	(IV 10)
(DV 7)	*r*	1										
	ρ. (2-tailed)											
(IV 1)	*r*	.156	1									
	Sig. (2-tailed)	.187										
(IV 2)	*r*	-.007	-.211	1								
	Sig. (2-tailed)	.951	.074									
(IV 3)	*r*	.106	.945**	-.141	1							
	Sig. (2-tailed)	.372	.000	.234								
(IV 4)	*r*	.187	.906**	-.176	.863**	1						
	Sig. (2-tailed)	.113	.000	.137	.000							
(IV 5)	*r*	.279*	.051	-.547**	-.124	.160	1					
	Sig. (2-tailed)	.017	.670	.000	.297	.176						
(IV 6)	*r*	.796**	.293*	-.168	.240*	.319**	.303**	1				
	Sig. (2-tailed)	.000	.012	.156	.041	.006	.009					
(IV 7)	*r*	.765**	.317**	-.188	.257*	.348**	.306**	.982**	1			
	Sig. (2-tailed)	.000	.006	.111	.028	.003	.008	.000				
(IV 8)	*r*	.402**	-.053	-.082	-.100	-.083	.098	.336**	.370**	1		
	Sig. (2-tailed)	.000	.654	.491	.400	.488	.408	.004	.001			
(IV 9)	*r*	.170	-.015	-.169	-.061	-.075	.425**	.128	.128	.124	1	
	Sig. (2-tailed)	.151	.898	.153	.608	.526	.000	.282	.279	.296		
(IV 10)	*r*	.245*	-.122	.215	-.079	-.172	-.281*	.021	.068	.700**	-.088	1
	Sig. (2-tailed)	.037	.302	.068	.508	.146	.016	.863	.570	.000	.457	

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=73

Source: SPSS output from collected data

Correlation output dependent Variable 9

Correlations [c]											
		(DV 9)	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 7)	(IV 8)	(IV 9)
(DV 9)	r	1									
Sig. (2-tailed)											
(IV 1)	r	.164	1								
Sig. (2-tailed)		.434									
(IV 2)	r	.426*	-.055	1							
Sig. (2-tailed)		.034	.796								
(IV 3)	r	.118	.483*	-.039	1						
Sig. (2-tailed)		.574	.014	.852							
(IV4)	r	.288	.745**	.048	.808**	1					
Sig. (2-tailed)		.163	.000	.820	.000						
(IV 5	r	.066	.335	-.056	-.308	.183	1				
Sig. (2-tailed)		.755	.102	.791	.134	.380					
(IV 6)	r	.609**	.472*	.043	.212	.455*	.280	1			
Sig. (2-tailed)		.001	.017	.838	.310	.022	.176				
(IV 7)	r	.613**	.432*	.042	.231	.456*	.227	.988**	1		
Sig. (2-tailed)		.001	.031	.842	.266	.022	.275	.000			
(IV 8)	r	.076	.089	.219	-.160	.041	.415*	.331	.338	1	
Sig. (2-tailed)		.719	.673	.293	.444	.845	.039	.106	.099		
(IV 9)	r	.169	.086	.154	-.151	.024	.497*	.186	.149	.304	1
Sig. (2-tailed)		.421	.684	.462	.473	.910	.012	.373	.478	.140	

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=25

Source: SPSS output from collected data

Correlation output dependent Variable 10

Correlations c												
		(DV 10)	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 7)	(IV 8)	(IV 9)	(IV 10)
(DV 10)	r	1										
	ρ. (2-tailed)											
(IV 1)	r	.284*	1									
	Sig. (2-tailed)	.011										
(IV 2)	r	-.109	-.371**	1								
	Sig. (2-tailed)	.337	.001									
(IV 3)	r	.064	.583**	-.121	1							
	Sig. (2-tailed)	.575	.000	.290								
(IV 4)	r	.257*	.824**	-.285*	.758**	1						
	Sig. (2-tailed)	.022	.000	.011	.000							
(IV 5)	r	.374**	.486**	-.594**	-.096	.424**	1					
	Sig. (2-tailed)	.001	.000	.000	.400	.000						
(IV 6)	r	.867**	.447**	-.264*	.206	.402**	.436**	1				
	Sig. (2-tailed)	.000	.000	.019	.068	.000	.000					
(IV 7)	r	.838**	.466**	-.274*	.225*	.419**	.421**	.984**	1			
	Sig. (2-tailed)	.000	.000	.015	.047	.000	.000	.000				
(IV 8)	r	.358**	.131	-.159	-.100	.007	.219	.329**	.362**	1		
	Sig. (2-tailed)	.001	.250	.161	.381	.953	.052	.003	.001			
(IV 9)	r	.200	.133	-.228*	-.065	.007	.404**	.177	.172	.159	1	
	Sig. (2-tailed)	.077	.244	.044	.570	.954	.000	.119	.130	.162		
(IV 10)	r	.066	-.160	.232*	-.076	-.185	-.239*	-.011	.035	.646**	-.104	1
	Sig. (2-tailed)	.564	.159	.040	.506	.102	.034	.922	.761	.000	.361	

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=79

Source: SPSS output from collected data

Correlation output dependent Variable 11

Correlations c												
		(DV 11)	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 7)	(IV 8)	(IV 9)	(IV 10)
(DV 11)	*r*	1										
	ρ. (2-tailed)											
(IV 1)	*r*	.191	1									
	Sig. (2-tailed)	.097										
(IV 2)	*r*	-.080	-.308**	1								
	Sig. (2-tailed)	.487	.007									
(IV 3)	*r*	.031	.692**	-.135	1							
	Sig. (2-tailed)	.789	.000	.240								
(IV 4)	*r*	.072	.859**	-.249*	.824**	1						
	Sig. (2-tailed)	.536	.000	.029	.000							
(IV 5)	*r*	.106	.411**	-.561**	-.101	.270*	1					
	Sig. (2-tailed)	.360	.000	.000	.382	.018						
(IV 6)	*r*	.822**	.421**	-.214	.232*	.364**	.306**	1				
	Sig. (2-tailed)	.000	.000	.062	.043	.001	.007					
(IV 7)	*r*	.820**	.434**	-.224	.251*	.383**	.285*	.982**	1			
	Sig. (2-tailed)	.000	.000	.050	.028	.001	.012	.000				
(IV 8)	*r*	.319**	.020	-.113	-.098	-.056	.167	.279*	.313**	1		
	Sig. (2-tailed)	.005	.860	.328	.396	.626	.146	.014	.006			
(IV 9)	*r*	.190	.125	-.212	-.060	-.021	.419**	.155	.150	.139	1	
	Sig. (2-tailed)	.098	.277	.064	.604	.856	.000	.178	.192	.229		
(IV 10)	*r*	.203	-.185	.227*	-.079	-.184	-.254*	.004	.052	.664**	-.100	1
	Sig. (2-tailed)	.077	.107	.048	.497	.108	.026	.974	.653	.000	.387	

**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=77

Source: SPSS output from collected data

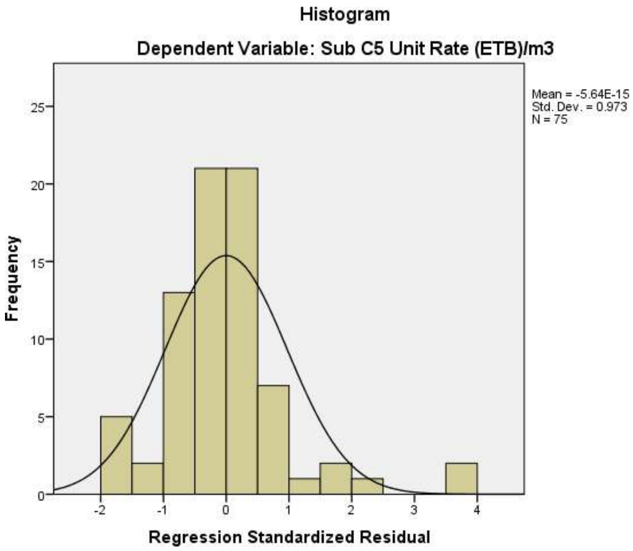
Correlation output dependent Variable 12

Correlations c											
		(DV 12)	(IV 1)	(IV 2)	(IV 3)	(IV 4)	(IV 5)	(IV 6)	(IV 7)	(IV 8)	(IV 9)
(DV 12)	r	1									
Sig. (2-tailed)											
(IV 1)	r	.133	1								
Sig. (2-tailed)		.324									
(IV 2)	r	-.118	-.236	1							
Sig. (2-tailed)		.381	.078								
(IV 3)	r	.128	.855**	-.185	1						
Sig. (2-tailed)		.342	.000	.168							
(IV4)	r	.307*	.811**	-.234	.857**	1					
Sig. (2-tailed)		.020	.000	.079	.000						
(IV 5	r	.402**	.031	-.531**	-.157	.138	1				
Sig. (2-tailed)		.002	.822	.000	.245	.306					
(IV 6)	r	.819**	.328*	-.229	.279*	.466**	.440**	1			
Sig. (2-tailed)		.000	.013	.086	.036	.000	.001				
(IV 7)	r	.779**	.304*	-.232	.290*	.471**	.423**	.987**	1		
Sig. (2-tailed)		.000	.021	.083	.029	.000	.001	.000			
(IV 8)	r	.385**	-.027	-.316*	-.048	.092	.555**	.345**	.352**	1	
Sig. (2-tailed)		.003	.840	.016	.720	.497	.000	.009	.007		
(IV 9)	r	.187	-.070	-.219	-.071	-.077	.434**	.128	.135	.234	1
Sig. (2-tailed)		.164	.606	.102	.601	.569	.001	.344	.318	.080	

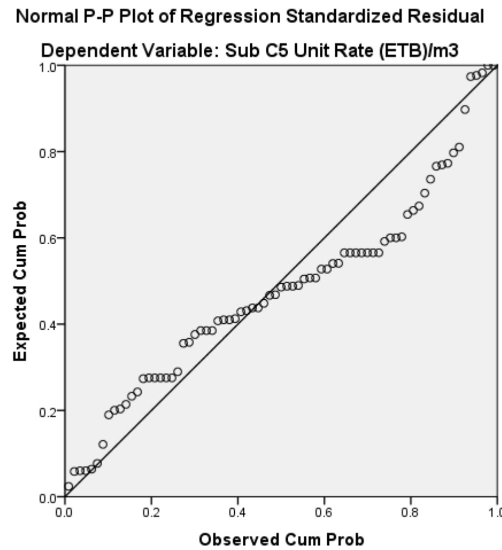
**. Correlation is significant at the 0.05 level (2-tailed).*
***. Correlation is significant at the 0.01 level (2-tailed).*
c. Listwise N=57

Source: SPSS output from collected data

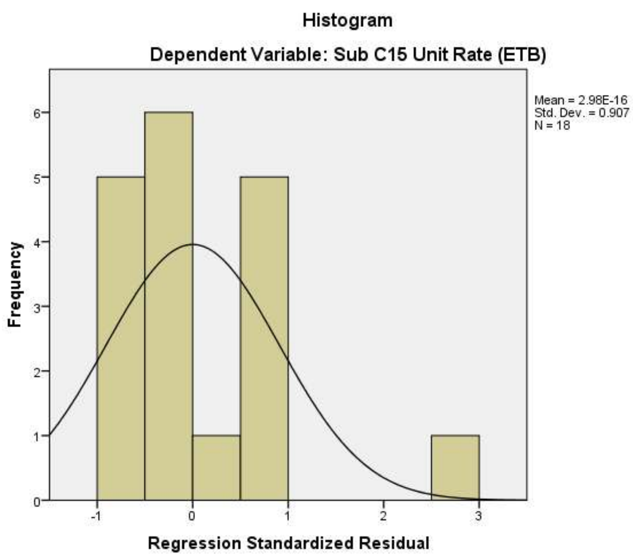
C. Statistical plots associated with the fit diagnostics



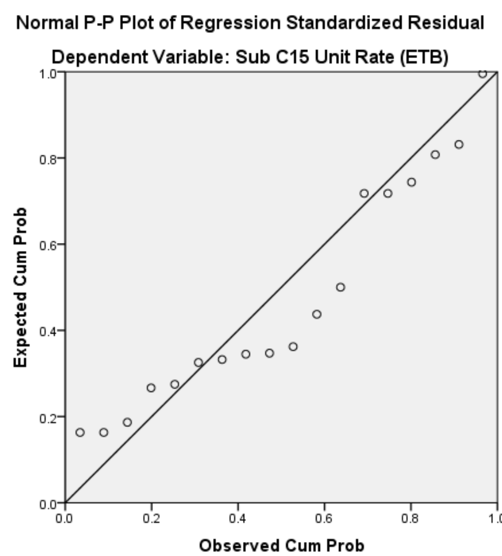
Dependent Variable 1 Histogram



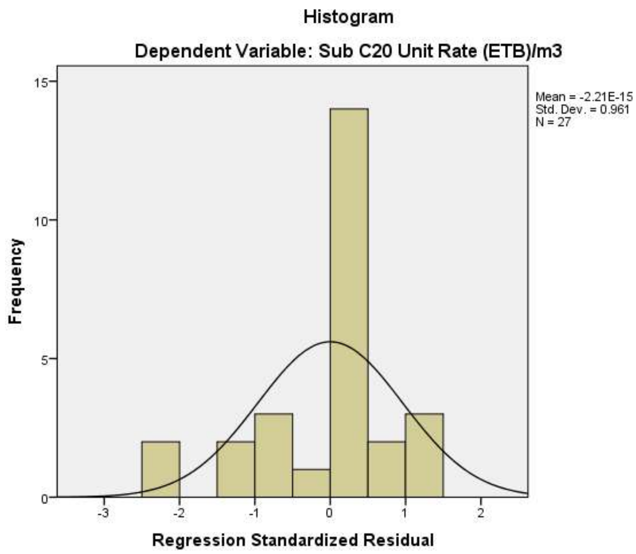
Dependent Variable 1 Normal P-P plot of Regression Standardized Residual

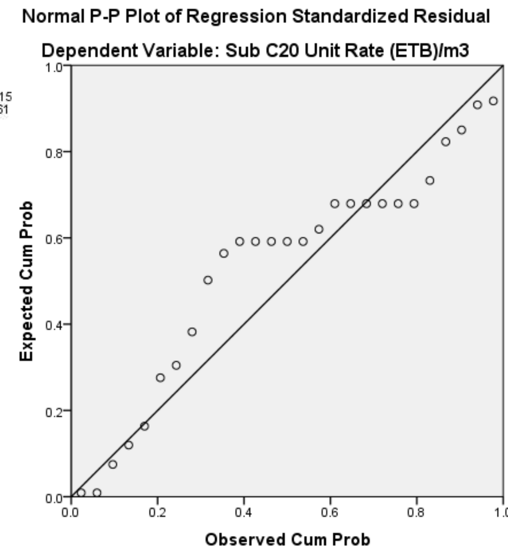


Dependent Variable 2 Histogram



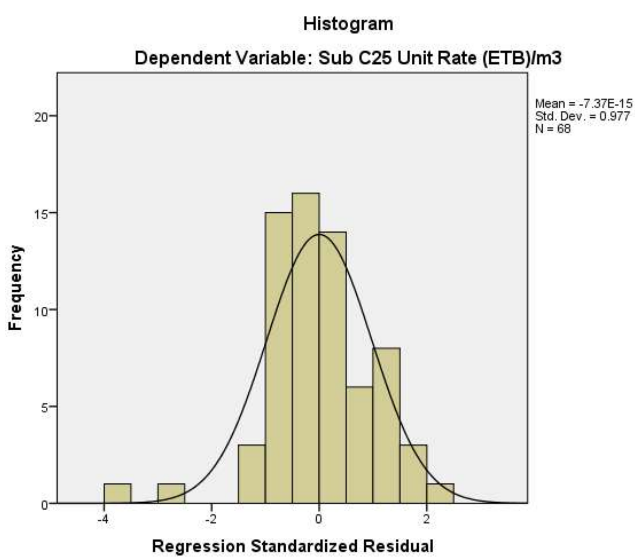
Dependent Variable 2 Normal P-P plot of Regression Standardized Residual

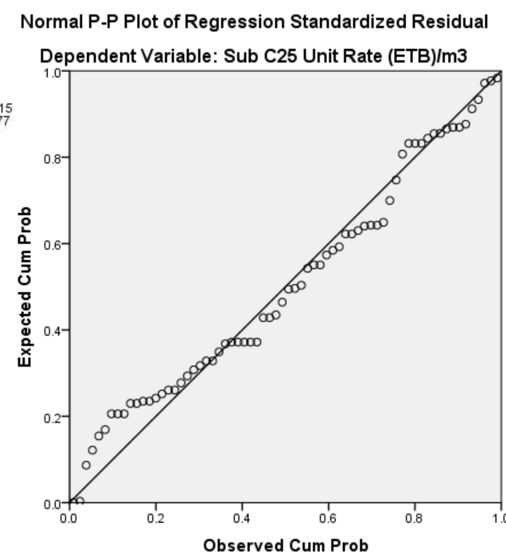




Dependent Variable 3 Histogram

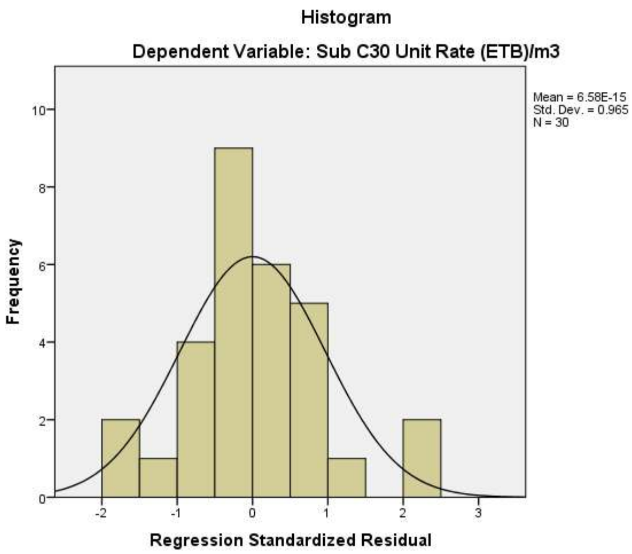
Dependent Variable 3 Normal P-P plot of Regression Standardized Residual



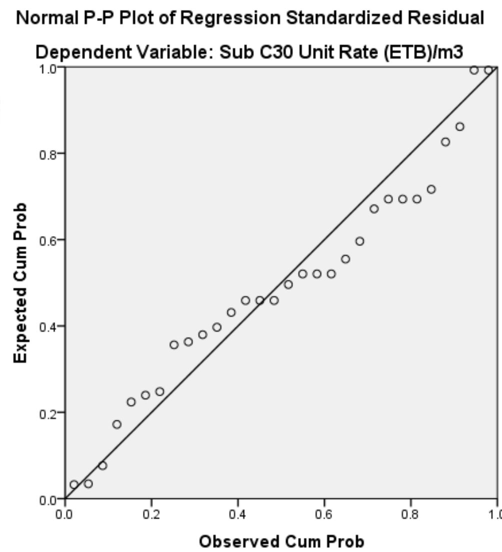


Dependent Variable 4 Histogram

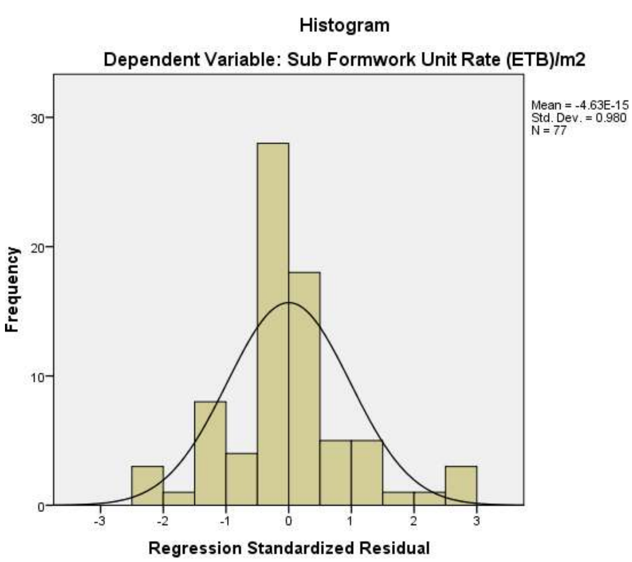
Dependent Variable 4 Normal P-P plot of Regression Standardized Residual



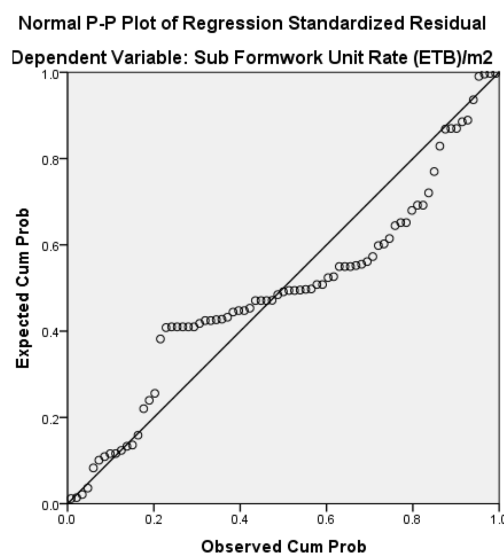
Dependent Variable 5 Histogram



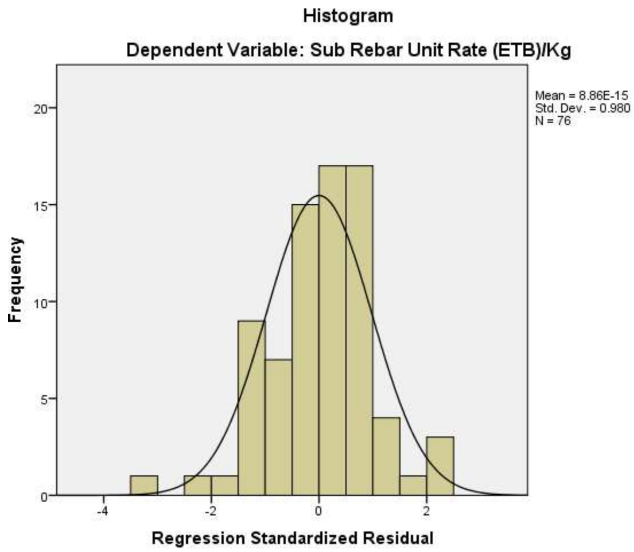
Dependent Variable 5 Normal P-P plot of Regression Standardized Residual



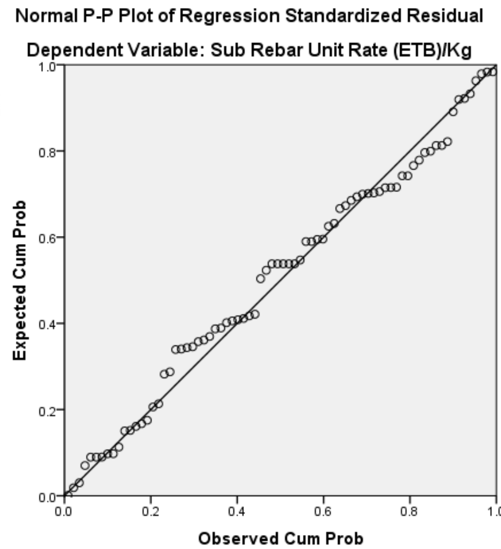
Dependent Variable 6 Histogram



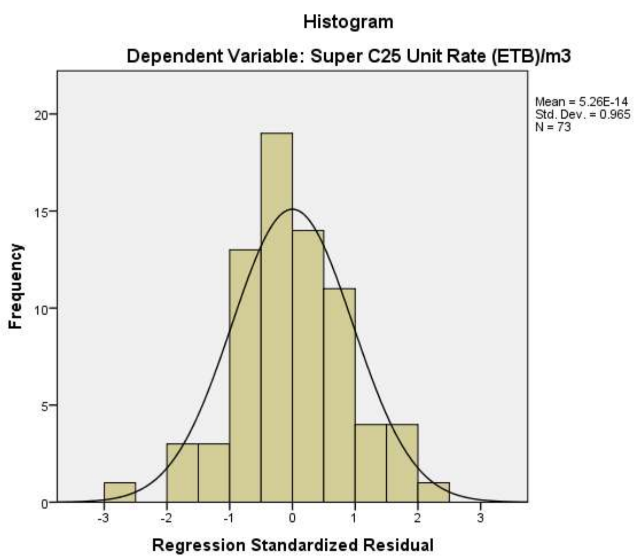
Dependent Variable 6 Normal P-P plot of Regression Standardized Residual



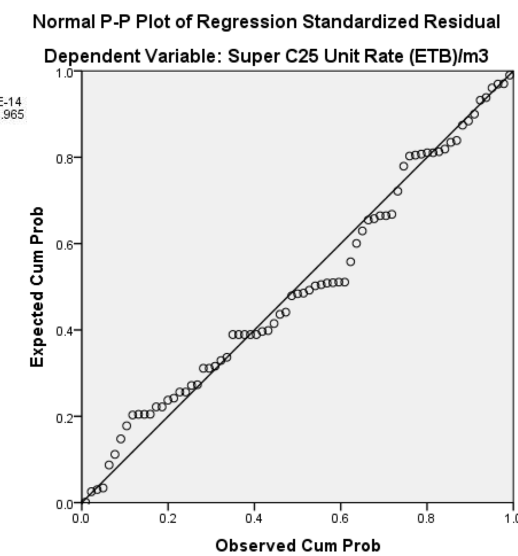
Dependent Variable 7 Histogram



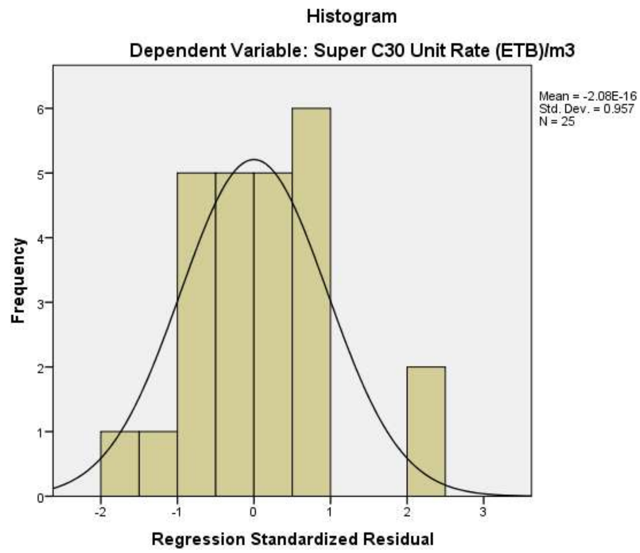
Dependent Variable 7 Normal P-P plot of Regression Standardized Residual

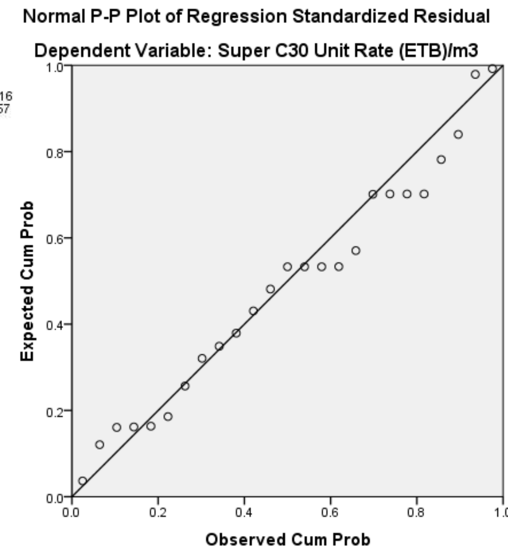


Dependent Variable 8 Histogram



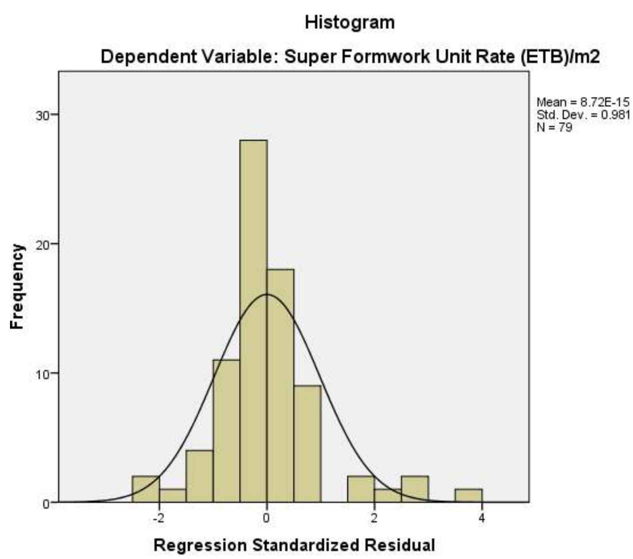
Dependent Variable 8 Normal P-P plot of Regression Standardized Residual

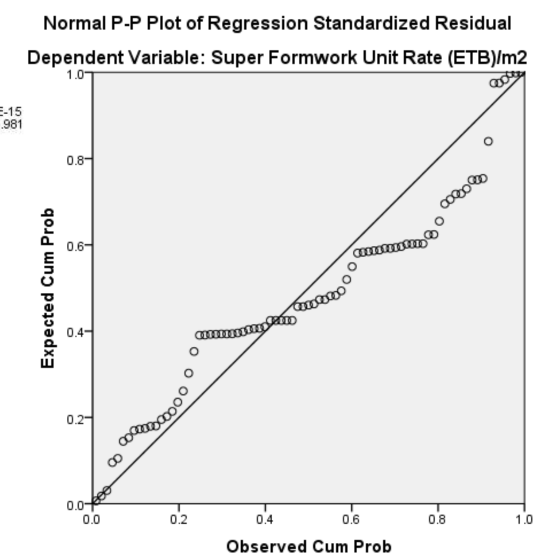




Dependent Variable 9 Histogram

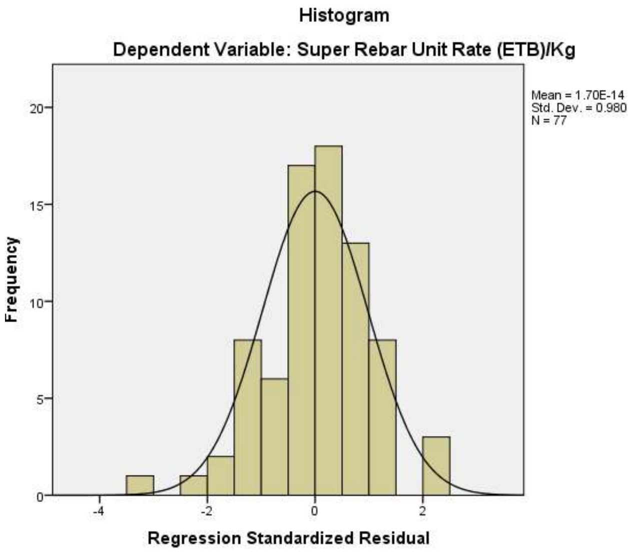
Dependent Variable 9 Normal P-P plot of Regression Standardized Residual



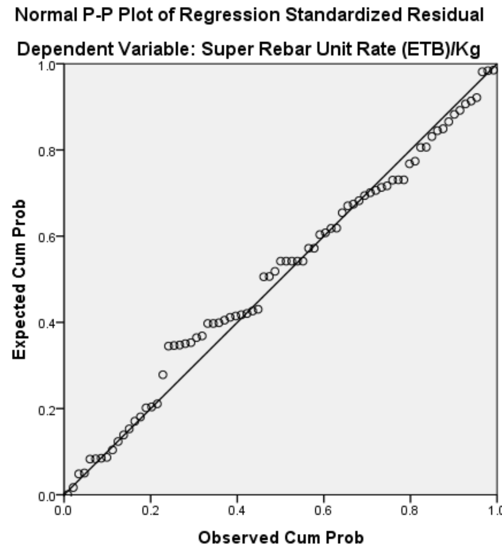


Dependent Variable 10 Histogram

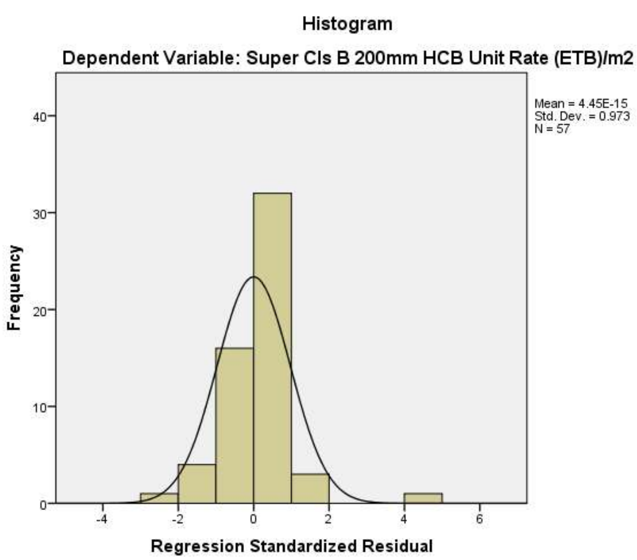
Dependent Variable 10 Normal P-P plot of Regression Standardized Residual



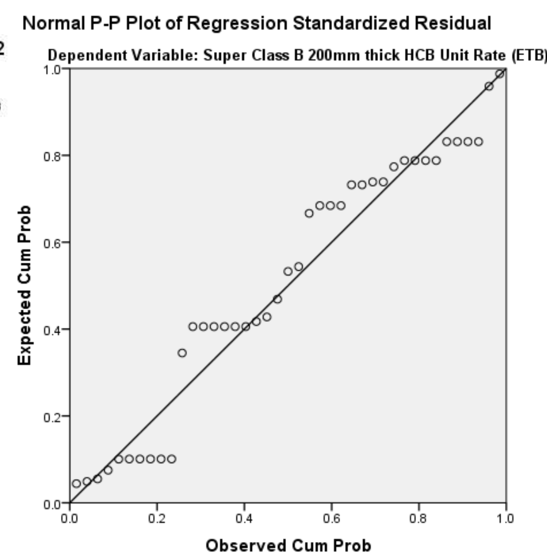
Dependent Variable 11 Histogram



Dependent Variable 11 Normal P-P plot of Regression Standardized Residual



Dependent Variable 12 Histogram



Dependent Variable 12 Normal P-P plot of Regression Standardized Residual