# THE INFLUENCE OF ESTIMATOR ATTITUDE ON PROJECT COST RELIABILITY

**by**

**CHARLES AFETORNU**

A Doctoral Thesis
Submitted in partial fulfilment of the requirements
for the award of
Doctor of Philosophy of Loughborough University

MARCH 2011

ACKNOWLEDGEMENTS

First and foremost, I thank the Almighty God for His mercies, favours, grace and guidance throughout this research. My profound gratitude goes to Dr Francis Edum-Fotwe for his insightful supervision, thoughtful criticism, creative suggestion, encouragement and support throughout the research period. Special thanks also go to Dr. Daniel Darku for his excellent assistance as my local supervisor in Ghana, and Togbe James Klu for being a wonderful mentor.

I would also like to thank Professor Antony Thorpe, the Head of Department of Building and Civil Engineering, Loughborough University and the entire staff for all their general and specific support and guidance throughout the research.

I am exceptionally grateful to my wife Joyce and children, whose love, understanding and encouragement sustained me throughout the period of study. My thanks go to my mum, Christine, brothers and sisters, and all those who provided moral support and backing throughout the research. I particularly wish to recognise the invaluable contribution made by Mr and Mrs Samuel Osuteye for their support and numerous helpful gestures during my stay in UK.

Finally, I wish to extend my gratitude to my employers Ministry of Roads and Highways of Ghana for sponsoring the research and to the Chief Director, Mr. A. T. Essilfie, for his morale boosting encouragement and backing throughout the research period. I would also wish to express my thanks to Mr. J. Osei Asamoah, the former Chief Director of the Ministry for approving my participation in the staff development programme and for his immense encouragement.

## Table of Contents

# List of Tables

# List of Figures

# ABSTRACT

The reliability of project estimates is dependent on a number of factors that can be classed as exogenous or endogenous to the estimator. The exogenous factors comprise information, environment, technology, methods and processes, which are external to the estimator. The endogenous factors reflect personal characteristics associated with the estimator and consist of aspects such as judgement, preferences and personality. Construction's effort to improve the estimating function has addressed both the practice of, and process of delivering the estimate. Much of the effort, however, has been addressed at aspects of estimating that can be considered classed under exogenous factors. This includes the use of technology to improve both the accuracy of computation and the speed for generating the estimate. Notwithstanding progressive improvement achieved in estimating from addressing such exogenous factors, most project-oriented industries still suffer from unreliable estimates. Although the problem of unreliable estimates is a worldwide phenomenon, it reflects more starkly in many developing economies, where its effect is much more striking. Understanding the root causes of the persistence of unreliable estimates would therefore, call for a focus on factors other than the exogenous ones that most improvement and development efforts have focus on.

The study, which formed the basis of this thesis adopts the position that any improvements in reliability, beyond what the exogenous-based developments have achieved so far, lies in the contribution that estimators can make by addressing their endogenous factors. For that position to be valid, the study showed that the personality characteristics of various estimators produce different levels of reliability. Three endogenous factors, experience, qualification, and personality archetype (or trait) were employed to explore the relationships with estimating reliability.

A quantitative research approach was adopted for the investigation, as the nature of evidence required was primarily objective, to substantiate the argument that different levels of particular endogenous factors produce different reliabilities in estimating. Data for the study was obtained from Ghana. Two categories of sample data were collected through stratification of the population, followed by systematic sampling methods. The two samples were a control group, comprising estimators with more than or equal to ten years experience; and an observed (or study group), made up of estimators with less than ten years experience. An instrument based on a self-reporting protocol was developed and utilized in the elicitation of data from both groups. Thirty-five responses were obtained for the control group of estimators, and sixty-one responses were received

through the workshops organised for the observed groups. In addition, a designed exercise for the observed group was conducted simultaneously with the administration of the instrument to enable the classification of the estimating reliability for each respondent.

The results of study showed that there was evidence to suggest a strong relationship between qualification and estimating reliability. In addition, the findings from the study indicated no conclusive evidence that the more experience you gain, the more your estimating reliability improves. The finding on experience indicates that the type of experience acquired must be relevant to estimating practice before it can influence reliability. The outcome from the analysis of personality archetype and reliability showed a strong relationship between trait type and reliability. The evidence suggests that an estimator's personality archetype has a significant influence on their estimating reliability. The finding on the effect of personality goes to explain why different estimators with the same or similar experience and qualification, exposed to the same set of information, deliver different levels of reliability in estimating. This important finding of the relationship between estimating reliability and personality archetype could account for the "missing link" in the effort to improve estimating practice. By incorporating the endogenous factor into the criteria for recruiting estimators, organisations will be able to gain a better level of reliability in the estimates produced by their staff.

# CHAPTER ONE

# INTRODUCTION

## 1.0 BACKGROUND

The production of reliable estimates in the construction industry fulfils an essential role in the management of projects, and forms an important issue within the national economy. This is because the construction industry employs many people and therefore, has a significant impact on the macroeconomic stability of every country. Equally, the construction industry is responsible for a large percentage of the Gross Domestic Product (GDP) and Fixed Capital Formation in every country (GFCF) (Turin, 1973; Edmonds, 1979). In many developing economies, the contribution by construction to the national economy exceeds 10% of GDP. For example, the road sector alone accounted for 9% of the total GDP for Ghana (NTPG, 2005). The level of GDP contribution by construction in many developing economies becomes even more significant when compared to equivalent contribution from the manufacturing, which ranks much less than that of construction. The construction industry in such economies therefore, has a direct impact on the fiscal budget of the national government. It is therefore, not surprising that many national governments tend to use the construction industry to regulate activity of their economies. In periods of excessive economic growth, construction activities promoted by the public sector are reduced in order to dampen the level of activity within the national economy (Hillebrandt, 1985). Equally, when economic activity is low, national governments tend to increase construction activities in order to boost the level of economic activity.

Cost estimates for construction and physical projects form the basis of government planning and budgeting in any fiscal year. For example, the Government of Ghana relies on the estimates produced by various Agencies in planning for roads programme as part of the effort in generating its fiscal budget. In addition, development partners (donors) use the estimates as the basis of their own budgets for providing loans or grants to the Government of Ghana on specific developmental projects. Therefore, the importance of reliable cost estimates could not be overemphasised for effective management of the Government’s fiscal budget and for achieving its set development targets and objectives. Several researchers such as Touran and Lopez (2006), Skitmore and Thomas (2002), Tas and Yaman (2005), Williams (2003), Wong and Hui (2006), and Edwards and Bowen (2005) concur on the role estimating plays in the planning and budgeting of any economy. The importance of the role of estimating demands that the output from their composition has to be reliable in order to make them credible. In practice however, the required levels of reliability in many instances is not attained for construction projects (Afetornu et al., 2009)

The problem of a lack of reliable project cost estimate, especially in the construction industry, is a worldwide phenomenon. The effects of such unreliability are normally a source of concern to many governments as they strive to achieve their planned development programmes (Davey, 2000). In particular, where the outturn budget on construction projects exceed the initial budget, it is often common to attribute the cause of such overruns on the projects in a large measure to unreliable estimates (McCaffer and Bainbridge, 1978). The presence of such cost overrun can lead to a disruption in the fiscal budget of many governments in developing countries. In such a situation, it is common to find that funds from other sectors of the economy are ‘diverted’ to make up the budget shortfall of the construction sector in order to realise the physical development objectives. This is a typical scenario in the study environment, Ghana, where it is common to find several public sector funded projects abandoned halfway through the construction period. Such abandoned projects are usually completed by ‘raiding’ funds from other sectors of the economy (NTPG, 2005). From the end-user perspective, the abandonment of public physical schemes deprives communities of the benefits and services a completed project would provide. Equally, the policies and balanced programmes of national governments are compromised for the sector where funds are ‘raided’ from to shore up the budget shortfall from construction. The problem of reliable project budget is not unique to countries in developing economies such as Ghana alone, but shared widely by all countries. By the same token, private sector executives that are served by the construction sector depend heavily on these estimates in making their own business decisions. Cost estimates therefore, form a key element in the planning and management of the private sector initiated projects, and estimators expend considerable effort preparing the ‘right’ estimates to support that decision.

In Ghana, road construction projects are funded either locally by the central government, or through external support mainly form Donor Agencies (which are normally referred to as Development Partners in Ghana), or the combination of the two. The external support comes mainly in a form of loans or grants that are extended to the Government of Ghana. Development schemes that are funded by Donor Agencies require stringent accountability that has implications for the reliability of the estimates generated to support the case for a project. The funding from the Donor Agencies is critical to economies such as Ghana for their development activity, so the production of the estimates have to be sufficiently reliable in order to avoid damaging the national credibility with the funding bodies.

In Ghana, cost estimates for public sector construction projects are prepared based on the option of 'first principles' estimating. Such an approach normally involves considerable time and relies on personnel experienced in estimation to be able to produce a reliable project cost estimate. The problem, however, is the limited number of estimators against the relatively high number of cost estimates prepared for projects annually to support development schemes in Ghana. The load on each estimator is, therefore, very high and often implies working under time constraint and pressure. Different estimators respond to the work related conditions in their own way, resulting in diverse estimating outcomes. Coping with such work pressure is often dealt with uniquely by different estimators, and could account for a significant contribution to their ability in producing reliable estimates. As such, it could be argued that the production of reliable estimates could be influenced by personality of the estimators involved. Understanding of the influence of estimator trait on their decision making orientations could provide an important link to achieving the reliability desired for project cost estimates.

Although, many of the causes of unreliability for project cost estimates are well established, the persistence of budget overruns suggests an inadequacy of such factors alone, and/or how they are applied in establishing estimates. Since most estimators are meticulous in their application of the 'tools of their trade', the persistence of unreliability would appear to be more related to the adequacy of the established factors in accounting for the variability in and consequently the reliability of project cost estimates.

Previous researchers and authors such as Walker et al. (2010), Greenwood et al. (2008), Hamza and Greenwood (2007), Afetornu and Edum-Fotwe (2005), Price and Newson (2003) and McCaffer and Edum-Fotwe (2003), who explored the nature of unreliable cost estimates for construction projects focussed predominately on factors that can be described as exogenous or external to the estimator. Such an orientation to improving reliability for cost estimates appears to be based on an implied assumption that the estimator has no subjective influence on what comes out from the process. While such an external focus has achieved considerable improvements, the efforts made to overcome the influence of such exogenous factors have not eliminated the problem of unreliable estimates. It would seem reasonable, therefore, to argue that other factors that are endogenous or internal to the estimator may hold the key to a more effective attainment of reliability for project estimates.

## 1.1 RESEARCH QUESTIONS

The argument that endogenous factors could hold the key for achieving improved estimating reliability to address current lapses in the production of cost estimates raises the following important research questions.

i. What are the theories and practices of estimating that account for the relatively high levels of unreliable project cost estimates?
ii. What are the estimating practices and constraints that inhibit the realization of reliability in project cost estimates in Ghana?
iii. What are the internal factors that influence reliability and how are they measured?
iv. Does the individual estimator's personality attributes have an influence on reliability of project cost estimates?
v. Are there other estimator attributes that influence reliability of project estimates?

An effective response to these questions would cover an examination of current practices in estimating as well as a demonstration of significant linkages between estimating reliability and estimator endogenous factors. The five questions provided the basis of the aim of the study and the objectives pursued for the research that formed the basis of this thesis.

## 1.2 RESEARCH AIM AND OBJECTIVES

The aim of the research was to explore linkages between estimator endogenous factors and the reliability of project cost estimates in order to establish the nature and scale of relationship between the two variables. The main aim of the research was achieved by pursuing the following objectives that respond more closely to the research questions.

i. Conduct a comprehensive review of literature to establish the state-of-the-art in estimating theories and practices.
ii. Accomplish a wide-ranging review of estimating practices for the study environment along with the constraints that attend to those practices.
iii. Complete a thorough assessment of personality attributes along with the tools, systems and developments that have transpired in other fields of study, with the view to identifying appropriate methods and tools for addressing and evaluating the endogenous characteristics associated with key decision makers such as project cost estimators.
iv. Establish whether acquired endogenous characteristics of estimators, using experience and qualification as proxies, have an influence on the reliability of project estimates.
v. Investigate whether natural endogenous characteristics, which is reflected as personality archetypes, produces distinctive reliability attainments for different estimators.

The effective completion of the above objectives provides a new channel for considering the improvement of reliability for project cost estimates in construction.

## 1.3 THE RESEARCH METHODOLOGY

To achieve the aims and objectives of the project, careful consideration was given to the activities in the research process. The flow chart in Figure 1.1 shows the research process adopted for this study, and illustrates the series of iterations that attended an otherwise linear set of key tasks.

The research process commenced with the identification of the research topic. This was preceded by a preliminary review of previous works and suggested improvements in the primary subject area of the research in order to provide an initial focus for the study. Once the focus of the study had gained sufficient definition in the area of estimating reliability, attention shifted to a more thorough review of developments and progress on the subject of the thesis. At this detailed review stage, a greater emphasis was placed on articles from journals, conference proceedings and internet searches, as these sources provide more recent developments that are cutting-edge in the subject area.

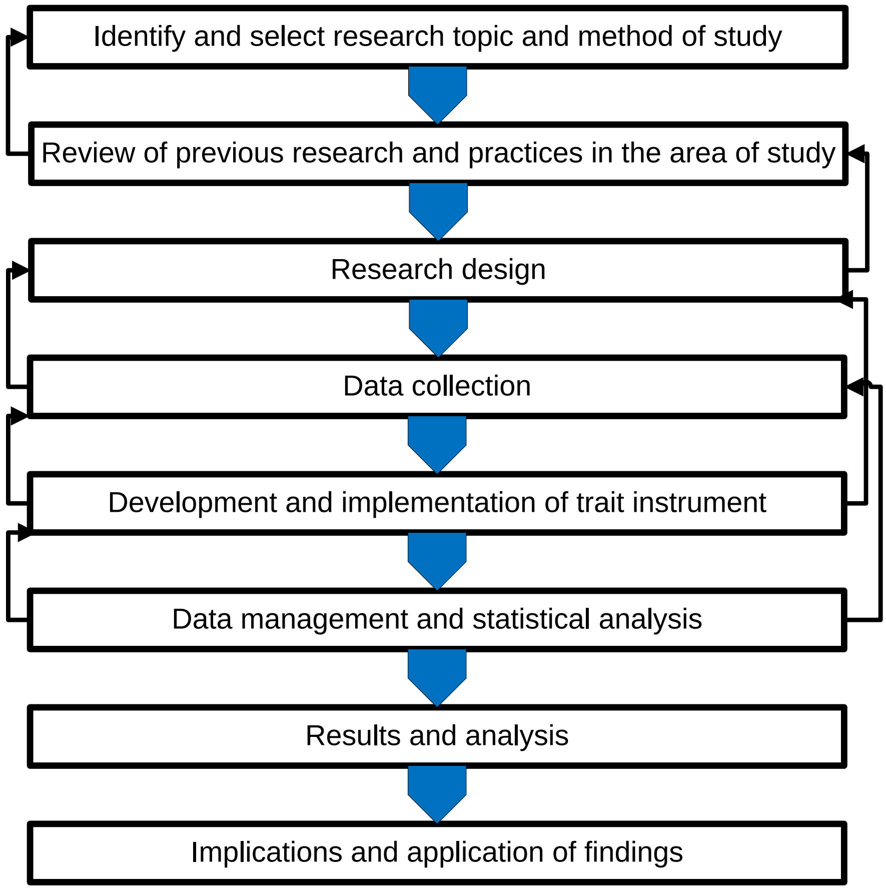



**Figure 1.1: Flow Chart of the Research**

The know-how, theories, principles and lessons learned from the review were subsequently used in the design of the concept of the research; elicitation of data; analysis of data; and, application of the results from the research. The principal research method adopted for the study was a quantitative approach to enable the establishment of systematic and potential quantifiable causation. The implemented method relied on the development and utilisation of an appropriate personality assessment tool, as well as the deployment of a statistical package for analysis of data collected from the study. The empirical phase of the study was supported by deskwork to identify relevant academic work that informed the investigative tools and procedures, as well as subsequent results from the analysis. The data for the research were obtained from workshops organised for estimators within the road sector of the construction industry in Ghana. The nature of the study called for the composition of a sample that would reflect similar conditions and work environment to enable the effective measurement of the phenomena of interest in the study. The use of estimators from roads sector provided a set of uniform conditions and standards of work in order to ensure data consistency. Such an approach minimised the influence of work regime and environment on reliability. It also made it possible for any measured variability in reliability to be associated with estimator endogenous characteristics. The essential data derived was in response to hypotheses that was proposed in order to explore influence of endogenous factors on estimating reliability.

### 1.3.1 Hypotheses

The influence of estimator endogenous factors on reliability was established by developing appropriate proxies to enable quantitative analysis of any data collected to be performed. The proxies were employed in composing the principal research hypotheses. In total, three hypotheses were proposed to explore the separate influences of qualifications, experience and personality archetypes on reliability. These were as follows:

***QUALIFICATION***

In one sense, qualification is a reflection of individual competency and proficiency to undertake a task. The qualifications of estimators are standardised, and is expected to correlate positively with competency and proficiency. Competency and proficiency are endogenous characteristics of the estimator. The test of the influence of qualification on reliability was therefore, to provide evidence of causation for the defined endogenous influence on reliability. Estimating practice in Ghana relies on a number of entry levels into a career or profession. Those with Polytechnic qualification progress differently from those with University qualification. The proposed hypothesis was to test if defined entry level qualifications reflected different measures of influence on estimating reliability. To investigate this, the null hypothesis and the alternate hypothesis were formulated as follows:

Null Hypothesis: "there is no systematic difference in reliability across various qualifications" and

Alternative Hypothesis: "there is a systematic difference in reliability across various qualifications".

***EXPERIENCE***

The quality and nature of experience gained over the same number of years varies from estimator to estimator. This makes experience a personal and hence an endogenous factor to the estimator. The hypothesis formulated to ascertain if experience gained by estimators influenced their reliability differently was as follows:

Null Hypothesis: “there is no systematic difference in reliability across various defined ranges of estimator experience”, and
Alternative Hypothesis: “there is a systematic difference in reliability across various defined ranges of experience”.

***PERSONALITY ARCHETYPE***

While the two foregoing hypotheses address endogenous factors that are deemed as estimator-acquired, personality archetype, unique to each estimator, explores a factor that is considered natural to the estimator. The proposed hypothesis investigated the relationship between the personality archetype of the estimator and their levels of reliability in estimating.

Null Hypothesis: “there is no systematic difference in reliability across various personality traits” and
Alternative Hypothesis: “there is a systematic difference in reliability across various personality traits”.

The three hypotheses are covered in much more detail subsequently in the relevant section within the thesis.

## 1.4 DATA SOURCE AND ANALYSIS

The data for the research were obtained from the road sector of Ghana. An instrument developed in the form of a self reporting questionnaire was used in collecting the key data for the research. Two sets of data were collected through a series of workshops that was organised solely for the purpose of the data gathering exercise. The first set of data was responses to the questionnaire instrument and the second set of data was cost estimates produced by the respondent estimators as part of an experiment to establish individual attainment of reliability. The analyses performed on the data employed a designed personality assessment tool structured appropriately to address the work circumstances of the estimators and supported by statistical analyses. The instrument adopted the classification of the ‘Big Five’ personality tool, which categorises individual personality trait as one of Extraversion, Agreeableness, Openness, Neuroticism, or Conscientiousness. The ‘Big Five’ classification also recognises that an individual trait could reflect a mix of varying degrees of the categories, and thus, making each personality unique in a way. The tool adopts the dominant trait reflected by an individual as their natural trait. As such, an Extraversion estimator could also have a recessive element of Openness and/or Neuroticism.

## 1.5 KEY FINDINGS

Estimating practice in Ghana generally reflects a rule-of-thumb approach and consequently suffers from a lack of consistency in reliability.

The research established that within the limitations of the data collected, there is evidence of endogenous factors influencing the level of reliability achieved by estimators. The findings also indicate that in making the transition from inexperienced to experienced estimator, significant trait changes take place in the personality measures of Extraversion and Agreeableness, while that of Openness and Neuroticism only showed a marginal change. Most notable in the results was that Conscientiousness reflected an insignificant change, which appears to suggest that the Conscientiousness trait is a natural attribute that characterises estimators.

The findings suggest a strong relationship between qualification and reliability while and that there is no conclusive evidence that the more years of experience an estimator gains the more reliable their estimate becomes.

Furthermore, the findings confirm the possibility of a strong evidence of estimator personality archetype influencing their estimating reliability. This particular finding goes to explain why different estimators with similar years of experience and qualification, exposed to same set of information, deliver different levels of reliability of cost estimates. The existence of such a strong link equally accounts for the inadequacy of only exogenous factors in overcoming the lack of estimating reliability. This important finding therefore, is the “missing link” for improving estimating practice in construction.

### 1.5.1 Practical Use of Findings from the Research

The findings from the research have established that the personality trait of individual estimators has a significant influence on the reliability of the project cost estimates that they prepare. The findings can be useful to construction project practitioners and government officials who are responsible for the realisation of reliable project cost estimates. The practical implications of these findings are as follows.

i. The study has established that estimating practice can be improved significantly beyond current levels of attainment in reliability by addressing estimator endogenous factors.
ii. A different type of training would be required to augment the level of reliability attainment for estimators, which is currently oriented towards addressing predominantly exogenous factors. This may call for a different form of career development programme that incorporates factors such as personality archetypes.
iii. The relatively weaker relationship between estimator experience and estimating reliability necessitates the introduction of periodic evaluation of estimators in the form of a “fit to practice” assessment for each estimator, at say every five (5) years during the progress of their career.
iv. In view of the high workload on estimators, the public sector may consider it appropriate to train more estimators through increasing tertiary institution provision for academic and training programmes that offer estimating. Such a measure would help to redress over the long term, the current situation whereby the pressure on estimators does not facilitate the acquisition of relevant experience. However, consideration should be given to the financial demands and constraints that such additional provision could imply for the public sector, as well as the individual estimator prior to commencing any such trainings scheme.

## 1.6 THESIS STRUTURE AND CONTENTS

The thesis is divided into ten chapters as illustrated by Figure 1.2, which presents a schematic for the layout of the thesis. The content of each of the chapters is outlined in brief within the subsequent parts of this section.

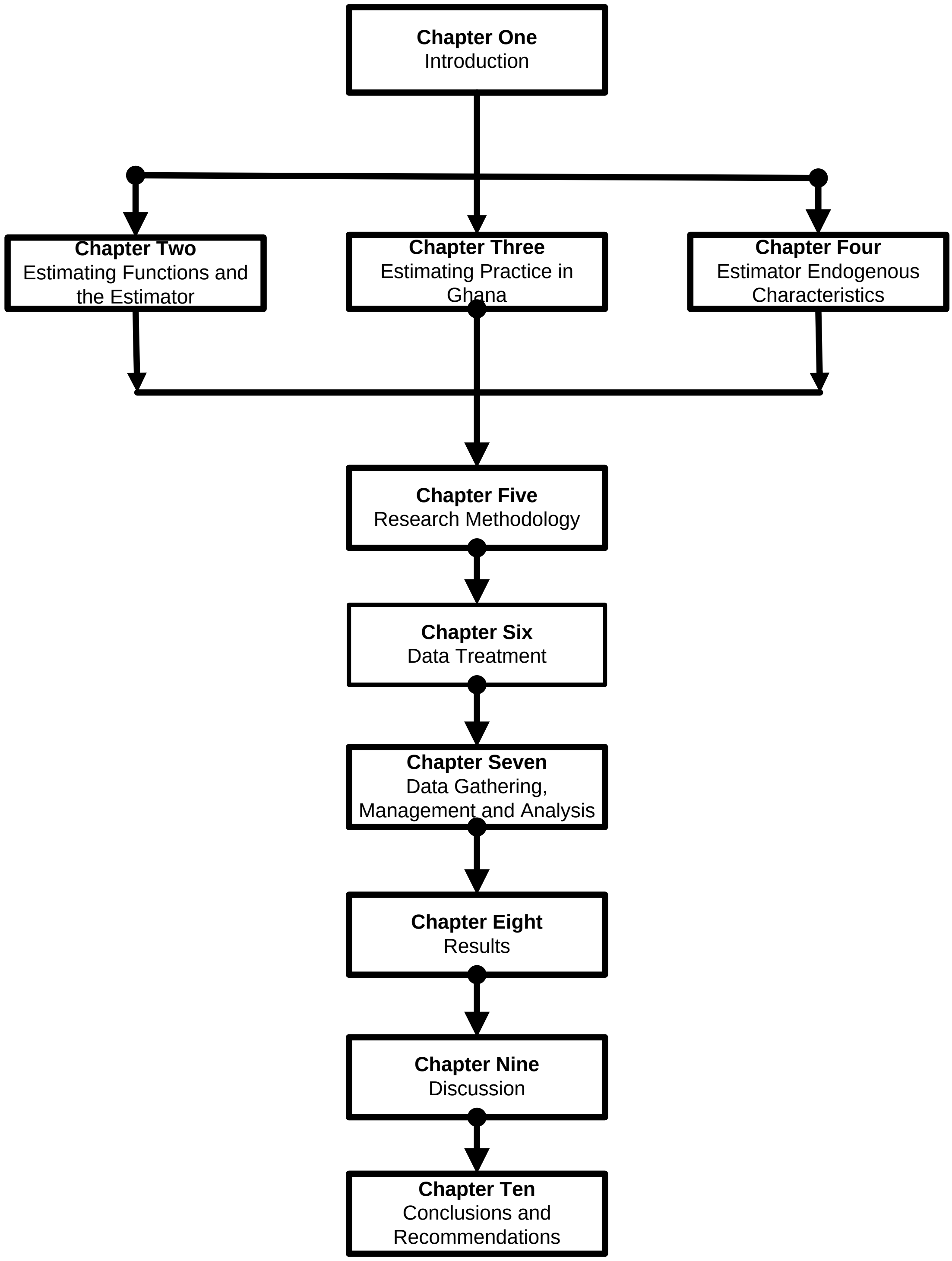



**Figure 1.2: Thesis Layout**

**Chapter One** forms the summary of the whole research. It commences with the background of the research by identifying the problem that necessitated the research study. The chapter highlights the problems that exist in estimating practice in the developed and developing economies. The chapter also presents the research aim and objectives, the process for executing the research, as well as the adopted methodology.

The key findings from the study and their significance are discussed, along with a brief consideration of the practical implications and potential use to which the results of this study by construction practitioners and the government.

**Chapter Two** reviews the estimating function and practice, and how practices in estimating affect reliability of project cost in construction. It begins with a look at the definitions and concepts associated with estimating functions as well as the role of estimator in the delivery of construction projects. The chapter also presents who an estimator is, the qualifications required to become an estimator, career development for the estimator, and reliability attainments at different career stages of an estimator. The chapter also covers the generic factors that influence reliability of cost estimates. These factors have been categorised as internal or endogenous, and external or exogenous to the estimator involved in generating the project cost. The chapter additionally addresses the exogenous factors and makes the argument that when factored out, the remaining influence that affects reliability is the decision-making orientation of the estimator. The review demonstrated a lack of research effort on how endogenous factors that relate to personality characteristics of the individual estimators contribute to the reliability of project cost estimates.

**Chapter Three** explores the estimating practices in the study environment - the Ghanaian construction context. The chapter starts by providing an overview of the various institutions and economic drivers that influence estimating practice in Ghana. It explores the factors that affect reliability of project cost estimates in developing economies and more specifically, Ghana. The first part of the chapter focuses on the construction sector in Ghana with particular reference to the road sector. The chapter also discusses the procedures adopted in the preparation of cost estimates in both the private sector and the public sector from the perspective of the Ghanaian construction sector. It also explores the working conditions and other exogenous factors that characterise estimating practice in Ghana. The chapter concludes with a demonstration of the absence of any focus on the behavioural characteristics of estimators in decision making in Ghana.

**Chapter Four** concentrates on the behavioural characteristics of estimators. It commences by considering the historical developments in behaviour characteristics, which is a part of the discipline of psychology, and examines the measurement of personality traits of individuals. The chapter also presents and discusses different types of psychometric testing instruments available for assessing personality characteristics as regards their alignment to the measurement of estimator trait. The chapter concludes by establishing the argument that the reliability of cost estimates is largely dependent on the behaviour characteristics of the individual estimator as it relates to their decision-making orientation.

**Chapter Five** examines the historical and current developments in research methods within the construction research fraternity. It opens by assessing relevant literature on the methodological theories and perspectives of previous studies in the area of study and how these theories was applied in formulating the research concept. It also presents the research methods available and in common use within the construction fraternity, and the reasons of selecting a quantitative method. The chapter identifies that the individual estimator experience and personality traits as positive or negative and argues that, in both cases, the influence on the reliability of project cost estimate is significant. The chapter also discusses the development and characteristics of the data elicitation instrument used in the research and its relevance to the study.

**Chapter Six** reports on the different forms of data elicitation and justifies use of a structured questionnaire approach. The chapter also reflects on the different techniques of sampling from a population and the advantages and disadvantages of each technique, and explains the purpose of the use of a stratified sampling technique followed by systematic sampling adopted for the research study. A fuller detail of the three hypothesis tested in the study is provided, as well as the criteria for accepting the outcome of each test.

**Chapter Seven** describes the source of data for the research and covers the procedure that was adopted in the elicitation of data and how the risks identified in the process were mitigated. The chapter also presents the data collected for the research, its characteristics and management. In particular, basis of the case for treatment of data on cost estimates that were transformed to z-score in order to view the relative differences. The chapter explains the results from the bivariate analysis performed on the trait variables to explore degree of co-linearity. It also presents a descriptive analysis of the data collected for the whole study. Additionally, the outcome of the analysis conducted with the developed personality instrument for establish dominant trait leanings among the individual estimators is provided. The chapter ends with the analysis of the three (3) principal hypotheses that were tested with ANOVA to ascertain the influence of qualification, experience and personality archetypes on reliability.

**Chapter Eight** presents the results of the analysis, which is provided in two fold. First, the results from the personality testing along with supporting charts are considered. The chapter secondly delves into the results from the ANOVA.

The results from the analysis are discussed in much more detail in relation to their importance for improving estimating reliability in **Chapter Nine**.

**Chapter Ten** presents the conclusions and recommendations of the research. The chapter commence with a re-cap of the research questions and the aims and objectives of the research. The chapter also covers the main accomplishment of the research study. A number of recommendations based on the findings from the research are proposed for the realisation of reliable project cost estimates. This is followed by the limitations of the findings from the study and suggestions for further research.

# CHAPTER 2

# THE ESTIMATING FUNCTION AND THE ESTIMATOR

## 2.0 OVERVIEW

This chapter presents a review of the estimating function and reliability of project cost estimates. It commences by looking at various concepts and definitions associated with the estimating function and in particular, the role of the estimator in achieving reliable estimates. More specifically, the chapter explores who an estimator is, the qualifications required to become an estimator, the career development of the estimator, levels of reliability associated with different stages of the estimator's career progressions, and the relationship between the general competency of an estimator and their attainment of estimating reliability. The chapter also covers a review of the generic factors that influence reliability of project cost estimates. These factors have been categorised as internal (endogenous) or external (exogenous) to the individual(s) involved in the estimating exercise.

## 2.1 DEFINITIONS AND CONCEPTS OF ESTIMATING

CIOB (1997) defined cost estimation as the technical process of predicting cost of construction. A reliable estimate is the most essential part to the success of any project and ensures that final cost at the completion of the project compares favourably with the initial budget at the start of the project (Arditi and Patel, 1989). Achieving such reliability in estimating enables the client to forecast its cash flow during the implementation of the project (Kaming et al., 1997). Unreliable cost estimates on projects often lead to budget shortfalls and cost overruns during the implementation stage (Colmer et al., 1999). In some instances, it results in the abandonment of projects because of such overruns. The adverse effect of such abandonment on the immediate communities and other stakeholders could not be over-emphasised. For example, the socio-economic impacts of unreliable estimates can be adverse consequences such as financial difficulty that affects the immediate project parties, as well as other secondary stakeholders of the project (Afetornu and Edum-Fotwe, 2005).

According to McCaffer and Edum-Fotwe (2005), major clients are increasingly demanding more cost certainty, in other words reliability of the estimates that determine the cost, for construction projects. One way of addressing the demand for reliability is by the use project contingency, to cater for any anticipated overspend in order to achieve zero cost growth. In the past, the basis of establishing contingency amounts on projects has been by rule-of-thumb (McCaffer, 1976). Although there has been awareness of the effects of unreliable estimates on construction project for some time, the solutions available for handling its causes, especially in predicting cost into the future, have not altered much over the years. Several commentators have argued that the current situation on the prediction or estimation of project costs is unsatisfactory, and need to embrace other contemporary solutions from fields outside construction (Tah et al., 1993; Morris and Hough, 1989; Franks, 1998; Ibbs, 1984; Gray and Hughes, 2001; Burke, 2003; Levy, 2002; Touran, 2003). As the estimator is the key professional involved in establishing the cost of the project and its associated contingency it becomes essential to explore their role in looking for options to improve estimating reliability. More specifically, there is a need to understand who the estimator is, and how their role and contribution can facilitate the production of more reliable cost estimates.

### 2.1.1 The Estimator

Estimators are professionals in the occupation of pricing new projects and addressing cost related issues in the construction industry. As professions, they are largely creatures of public demand. Chalkley (1990) argued that the continuing recourse to professionals by the public is what keeps professions in existence. Professionals are required to fulfil the expectations of the public in terms of professionalism, competence, and willingness to serve (Chalkley, 1990). The current economic situation seems to have posed many challenges to the professions and more specifically to cost estimators associated with construction projects. Allegations, such as poor service quality, irresponsible servicing attitude, professional negligence and denial of fault among others, are increasingly, made against cost estimating professionals (GhIS, 2007). Within construction, such accusations are epitomised by expressions such as ‘if the project is financially successful, *estimating was very good*; if the project is a financial failure, site management poor'. This gives the notion that estimators are above blame (GhIS, 2007).

In recent times, there has been a growing public expectation of 'value for money' that has increased the demand on the estimating professional to be more reliable in the output of their work. This is because the actions and inactions of estimating professionals in their work can have a significant effect on the outcome presented in an estimate. Equally, in estimating, construction professionals are required to understand the expectations of the public. Continued public (customer) satisfaction therefore, becomes one of the important ethical demands placed on estimating professionals, and therefore, the pre-requisite to improving the quality of service delivered by the practitioners of the profession (GhIS, 2007).

According to Naylor et al. (1980) such ethical demands call for a perception of one's self-role, of the roles of others, of one's behaviour, and of the direct and indirect outcomes of one's behaviour in fulfilling their profession. Fan et al. (2001a) explored the ethical behaviour of professionals in the construction industry and concluded that quantity surveyors (a dominant group making up the estimating profession) face ethical dilemmas. In particular, they argued that quantity surveyors in different reference groups have diverse and important ethical factors influencing their decision-making. The study by Fan et al. (2001a) supports an assertion that significant deviations exist in ethical perception between young and old quantity surveyors. Although the analytical tools deployed by Fan et al. (2001a; 2001b) reflect a rather simplistic and rudimentary, their findings are noteworthy. In particular, their study indicates that different subgroups of professional estimators may have significantly different ethical perceptions. Their ethical perceptions may have an effect on the individual estimator's decision-making orientations when preparing cost estimates for projects.

The estimator is a person who does the work of predicting the cost of a future event. Estimators are people with academic qualifications in estimating related programmes, such as construction economics, cost engineering, commercial management, quantity surveying, construction engineering, civil engineering, building engineering, building technology, construction technology, and construction estimating. These programmes are offered in Polytechnics, Universities and other tertiary institutions. The level of educational attainment by the estimator often determines the entry point for their career and sometimes the route that the estimator progresses through in their career development. In Ghana, estimators are mostly quantity surveyors who are a group of professionals that studied estimating related subjects in any of the country's tertiary institutions. The starting grade of a quantity surveyor in Ghana is dependent on the level of educational qualifications attained. Typically, it would range from Technical Officer, to Chief Technical Officer for Polytechnic qualifications, and Assistant Quantity Surveyor, to Chief Quantity Surveyor for university qualifications. These grades are in accordance with the Civil Service Law in Ghana (GCSGA, 2001). The qualifications to become a quantity surveyor in Ghana are similar to other economies in the British Commonwealth of Nations (CASLE, 2000).

Notably, engineers and other professions who studied estimating related subjects as part of their academic programme also provide estimating services in Ghana. However, the quantity surveyors are the dominant group of estimators in the country (The Quantity Surveyor, 2010). This is attributed to the educational structure whereby the estimating subjects are mostly taught as part of the quantity surveying profession in higher education. Estimating as part of the engineering curriculum transpires only in pre-university tertiary programmes.

Typically, estimators gain experience through their day-to-day activities as they progress in their career, and their level of experience determines the nature of responsibility they discharge. Other means for gaining experience include on-the-job training. In both cases, what determines the level of experience gained would be the project opportunities to which the individual estimator is exposed. As such, the experience gained over the same number of years will vary from estimator to estimator. In estimating, a significant proportion of the decisions made are influenced by the estimator's judgement, which draws on the experience of the individual estimator. Since educational attainment determines their exposure to, and nature of opportunities, an estimator's qualification can also influence their decision-making. It can be argued therefore, that the level of reliability in the decisions that the estimator makes is influenced, as demonstrated in the above discussion, by their experience and qualification.

## 2.2 PREVIOUS RESEARCH WORK

Several previous research studies have contributed towards achieving quality estimates on construction projects. These include Davey (2000), Fine (1974), Hackway and Humphrey (1992) and Mei-Yung et al. (2005). Davey (2000) established that cost overruns often represented symptoms of inadequate planning and budgeting for projects, which in turn is a derivative of the reliability of costing data employed for estimating the project budget. Mei-Yung et al. (2005) associated stress experienced by estimators with a significant impact on the decision that estimators make. Mei-Yung et al. (2005) also identified critical stressors as excessive workload, role conflict, job ambiguity, and work environment among others. Notwithstanding these progressive achievements, situations such as unreliable estimates manifested as cost overrun remain on most construction projects (Afetornu et al. (2006). In Ghana, it is not uncommon to find projects that overrun their initial budget by between 50% to as much as 500% in some cases (MRH, 2010). For example, in the road sector the budget-overrun situation has on several occasions, led to the abandonment of public sector initiated projects mid-stream (MRH, 2010). This often distorts the development programme of the central Government, who is the major client (accounting for about 98% of all road projects in Ghana) and consequently produces an adverse performance for the whole economy (NTPG, 2005).

According to Davey (2000), cost overruns often represent symptoms of inadequate planning and budgeting for the projects, which in turn could be a consequence of reliability of costing data employed for estimating project budget. The quality of data employed for estimating presents an exogenous contributory factor to the reliability of the estimate. An unreliable project estimate is often a major contributory factor to exceeding the planned budget.

In Ghana and many developing economies, the funding of road sector projects is by either the central government or external donor agencies. The funding stakeholders depend on the reliability of the project estimates to plan their own internal funding allocation for the project they support. When estimates are unreliable, their budgets can become distorted, and cause them considerable difficulty. The importance of achieving acceptable levels of reliability to maintain national credibility with the donor agencies as well as other funding bodies is of paramount consideration the government of Ghana (MRH, 2010). However, similar considerations exist for all national governments, as any overrun tends to cause both political and economic embarrassment. The problem associated with the inadequacy in estimates and the concomitant budget overruns on projects is a worldwide occurrence. For example, the development of the infrastructure and facilities for the London 2012 Olympic Games experienced a quadrupling of its initially proposed budget (Rosenhead, 2007). The development of the Palaces of Hollyrood in Edinburgh created considerable controversy with its budget growth of over 800% (Fraser, 2004). While there are many factors that contributed to the extraordinary budget overrun for the Hollyrood project, it provides a classic case of the difficulty that attends estimating for projects of that scale and complexity. Equally, it illustrates the argument that the phenomenon of budget overrun is not unique to developing economies. The relevance of the non-uniqueness of project budget overrun, imply that solutions found in advanced economies can be adapted to address that of a developing economy.

The foregoing review of previous research work in the area of estimating and the developments that have transpired to influence its improvement over time can be categorised into two perspectives. These are improvements in the **quality of information** to support estimators, and improvements in the **processing of the estimate** (Shashn and Al-Khald, 1992). The former often draws on factors that address the judgement of the estimator, and the latter by the speed and accuracy in the computation of the estimate. Both categories of improvement qualify as exogenous attributes of development as they focus on elements out with the estimator. The next section of this chapter explores some of the notable traditions, practices and contributions aimed at estimating processing and quality of information. It covers the generic estimating process, techniques, tools, procurement types and the time significance of information for estimating.

## 2.2.1 Process and Methods

Cost estimating by contractors in construction often involves pricing Bills of Quantities (BOQ) prepared from standard methods of measurements. In Ghana, and most developing economies, it is common to find the practice whereby estimators provide the pricing of the BOQ on a consulting basis to contractors who usually do not have the expertise in-house. In such situations, the estimator would have little knowledge or experience regarding the policy and practices of the company to which they are providing the pricing service. The consultancy approach to generating project estimates presents the first source of unreliability for project costs in Ghana.

Hegazy and Moselhi (1995) argued that generally, contractors devise their own methods of estimating which in many cases reflect inaccurate and unstructured practices. According to Hegazy and Moselhi (1995), these methods are dictated by the quality of software the estimator uses, and are based solely on the experience of individual contractors. As far back as the mid 1970s, Fine (1974) argued that it is the finished product rather than the process that dictates tender prices. The process involves the key steps as well as the key staff who contribute to the delivery of the product. Through research, the key steps have received a high degree of definition. The level of influence that key staff have on the contractor price reliability, is however, not addressed in any of the previous studies nor in any improvement effort aimed at estimating. While some attention has been devoted to improving the method and process of achieving reliability in cost estimating, no significant consideration has been directed at the behavioural characteristics and decision-making orientations of the individual estimators (Afetornu and et al., 2009). As such, the effect of the personal characteristics and attitudes of the estimator on the reliability of the project cost estimate is still unknown regarding the extent, if any, of the influence that might exist. The establishment of the influence of these estimator endogenous factors on the reliability of project cost could potentially open a significant avenue for improvement in the delivery of project cost estimating.

In the UK, The Code of Estimating Practice issued by Chartered Institute of Building (CIOB) documents all the estimating functions (CIOB, 1997). The Code details activities and procedures required to achieve a comprehensive composition of an estimate as it reflects in the UK. By contrast, there is no guide to follow by contractors in Ghana and most developing economies (GhIS, 2009). Estimating practice in these countries therefore, relies heavily on the experience of the estimator complemented by the conventions and approaches by institutions in the public sector that procure construction projects. The number of experienced estimators per head of population is rather low in these countries (CASLE, 2000). The relative low numbers is a situation that makes the role of the estimator very important, and therefore, elevates the question of the reliability for project estimates quite substantially.

Some of the process improvement efforts include the work of Horner and Zakieh (1993, 1995). Both of these studies proposed and advanced the notion of identifying cost significant items as the basis for estimating to minimise pricing of bulk items in the Bills of Quantities. The potential setback of such an approach lies in a Bill of Quantities with a substantial non-significant work items. Elcin and Hakan (2005) equally investigated the a cost estimating model by relying on significant work packages using the 80-20 rule established in the Pareto principle which posits that eighty percent (80%) of the effect is caused by twenty percent (20%) of the causes. Using this Pareto principle, Elcin and Hakan (2005) applied the concept to a construction project to establish that 20% of the work items in the Bills of Quantities contributed 80% of the total construction project cost. While such methods are useful for estimating project costs and budgets, their relevance is seen more from their application to the pre-feasibility, feasibility, and concept design phases of the project. This is because at the project planning stage, which includes the three phases, issues relating to major structural systems, material selection, and methods of construction are made. However, there would not be sufficient detail to enable a more reliable forecast of the project out-turn cost or budget. As such, the cost of construction is determined at this stage by conceptual or approximate estimating methods. Kouskoulas and Koehn (1974) identified that the conceptual estimation can also be employed to develop contingency plan, financial plan, risk management plan, and establish best construction methods. In many advanced economies, contractors mostly apply the conceptual method for their cost estimation. The reliability of the outcome from the estimating exercise depends heavily on the practical knowledge of the estimator in the work for which the cost estimate is being prepared (Akintoye and Fitzgerald 2000; Carr, 1989). The use of this method therefore, demands adequate numbers and calibre of estimators with experience in the field of estimating to achieve a good level of reliability. In a developing economy context, particularly where there are a limited number of experienced estimators, such an approach at achieving reliability presents major practical difficulties and an economic challenge. Furthermore, there is an implied assumption that different estimators with equal levels of experience will generate the same estimate given the same information and resources.

Hackway and Humphrey (1992) identified imperfection in estimating methods, estimating errors, and oversights as some of the causes of unreliability in project cost estimating. While the computerisation of the manual aspects in the mid and late 1980s helped to minimise computational errors, it did not overcome other human judgement based errors such as adopting the wrong detail or specification. Hackway and Humphrey (1992) further argued that estimators should specialise in specific methods for which they can develop adequate knowledge and dexterity. While such a solution would help to overcome some of the technical knowledge constraints associated with particular projects, it would involve a higher level of overhead to cover all the areas of specialisation in which a company may have to operate. Moreover, the problem of estimating errors and oversights could also be attributed to the limited time available for cost estimating. In some cases, estimators are not able to achieve their desired level of diligence in their work due to such time constraints, and thus, causing unreliability in cost estimating (Hackway and Humphrey (1992). The impact of the individual estimator on the reliability of the cost estimates in all these circumstances is high. Understanding the behaviour characteristics of the individual estimator in decision-making could be of paramount importance in addressing such inaccuracies in cost estimates on construction projects, and thereby pave a way for the improvement of reliability for project estimates in construction.

## 2.2.2 Estimating from Standard Systems

Uman (1990), investigated the use of standard systems in developing project cost and indicated that several difficulties attended estimates developed from standard systems in the construction industry. Some of the difficulties were attributed to the diversity in the methods, and circumstances of suppliers, contractors and workforce that have to be addressed in estimating. Prior to the work of Uman (1990) in developing cost estimates from standard systems, Beeston (1983) had proposed the use of several methods for deriving each estimate with the contractor maintaining records of each of the methods and their associated outcome. According to Beeston (1983), the use of multiple options would allow the contractors to select the best method or a combination of different methods to achieve a high degree of reliability in their estimate. Shashn and Al-Khald (1992) supported the position on the use of multiple methods and argued that the contractor's previous experience on the type of project, irrespective of the size of the project as the main factor that affected the reliability of cost estimation. Shash and Al-Khald (1992) categorised factors that affected the reliability of cost estimating as other contextual factors including bidding situations, financial issues, project characteristics and the process used in deriving the cost estimate. The works of Shash and Al-Khald (1992); Beeston (1983) as well as that of the other investigators concentrated on the physical factors that influence reliability of cost estimates. These physical factors typically reflected the external circumstances in which the estimator is placed and hence, are exogenous. If all the external influences are factored out, then the main feature that appears to influence reliability would be aspects that relate to the internal characteristics of the estimator, in other words endogenous factors. The endogenous factors relate to the decision-making orientations of the individual estimator and its influence on reliability of cost estimates could be important in understanding why different estimators given the same conditions, resources and information generate different estimates. By factoring the endogenous dimensions into their analysis, Shash and Al-Khald (1992) Beeston (1983) could have considerably enhanced their study of the constraints in achieving reliable estimates for construction.

Daschbach and Apgar (1988) made the case for developing separate solutions of cost estimating methods for preparing various types of cost estimates to serve different purposes. They however, did not address the relationship between the different methods of cost estimating they proposed, and the reliability that could be achieved by pursuing such an approach. Earlier studies by other investigators had focused on the reliability of estimates in relation to the type of work and their intended use (Vergara and Boyer, 1974). In their work, Vergara and Boyer (1974) demonstrated that the precision of estimates depended on the type of work and the intended use and not exclusively on the adopted method. Although this seems reasonable, the influence of the estimator's attitude on the desired reliability of project cost estimate was not considered in arriving at the conclusion drawn by both Vergara and Boyer (1974) and Daschbach and Apgar, (1988). It is important to point out at this stage that the driving force behind any estimate is the estimator. This is why the actions and inactions of the estimator could potentially have a significant effect on the reliability of estimates. Research on reliability of cost estimates that do not address the contribution that the endogenous element associated with the individual estimator's behavioural characteristics in decision-making can make to the achievement of reliability, therefore, addresses only a part of the problem.

The method of estimating using Bills of Quantities (BOQ) was studied by Akpan (1987). The principal finding from the investigation was an argument that project costing method based on Bills of Quantities (BOQ) ignored the project scheduling tools such as the network scheduling technique. Akpan (1987) attributed inaccuracies in project cost estimates to the lack of awareness of the methods and delivery schedule by estimators, which reflects information inadequacy for decision making. According to Akpan (1987), there is no visible relationship between the items in the Bills of Quantities and the time in which any of the work items would be carried out. This is a reflection of the lack of integration between the various functional activities involved in the delivery of construction projects. Recent technological developments, such as n-D modelling for visual realisation of the project that embraces multiple dimensions, carry considerable potential to address some of the shortcomings arising from the lack of integration between different work sections and functions in the delivery of a construction project. However, these solutions exist in a mature form only at the research level, and will need the training of a critical mass of estimators who do work in the emerging technological opportunities, for the benefits of any integration to impact on the estimating practice.

### 2.2.3 Cost Estimating Models

Several researchers such as Koenigseker (1982), Kouskoulas and Koehn (1974), Wilmot and Cheng (2003), and Yu and Lai (2003) have argued over the years that establishing reliable cost for construction projects is difficult by the use of conceptual cost estimating method. Some of them advocated for the need to automate the programming of the estimate by develop costing models that addressed the shortcomings of the traditional conceptual methods (McCaffer and Bainbridge, 1978). Burke (1993) reported that, the quality of the estimate is a manifestation of the best approximation based on the available time and information, the techniques employed, and the expertise and experience of the estimating personnel. According to Burke (1993), the desired reliability achieved depends on the level of detail available. Burke (1993) concluded that the amount of information available on the project, such as the detailed scope of work, clear conditions of contract, detailed specification, and identification and mitigation of risk and uncertainty in the project are the prerequisite for achieving accurate and reliable cost estimate for the project

One of the more recent developments in the delivery of construction projects is the opportunity to use tools that rely on Building Information Models (BIM) to predict the behaviour, performance or appearance of the as-built solution through visualisation, simulation and analysis. In particular, Organisational BIM plan and Project BIM plan are the two categories of BIM technologies that Eastman (2008) suggested could carry the potential for substantial industry-wide uptake. Eastman (2008) argued that the Organisational BIM plan could help companies in developing organisation-wide deployment of the BIM technologies. The Project BIM plan could facilitate the identification of the key project team, the processes and the dependencies in delivering the solution from design to construction, as well as assign roles and responsibilities in a collaborative communication environment aimed at reducing cost. BIM technology could therefore, offer a way to bring together the work of the various parties in the construction project to enhance the otherwise isolated solutions involved in delivering the client's demand from the briefing through design to the construction stage (Eastman, 2008).

Based on the current trend of innovation it is easy to appreciate that the use of BIM would bring about improvements and benefits for construction stakeholders within the immediate future. Among the projected benefits that could be associated with BIM would be improved communications and collaboration between the design and construction teams. Such an improvement would help to minimise unreliable project information that is arises from a lack of integration and is identified as a major cause of unreliable estimates. Since the essential feature of BIM technology involves integration and modelling of project information to achieve optimisation, it therefore, stands to reason that properly implement it could make possible faster delivery of projects in a cost effective way. The potential of BIM in bringing about improvements for the estimating practice could equally be substantial. Should that transpire, the industry could witness a transition in the process and methods employed in generating project cost estimates. In particular, by incorporating cost and performance data in BIM model elements, it would become possible to establish quickly the estimate of a project using several scenarios for delivering the project.

Although the current development of BIM technology has the potential to be effective in connection with cost data, accuracy with which information is processed, and other physical parameters of the project, it does not address the behavioural characteristics of the individual estimators involved in deploying the technology. In general, BIM models generate what the human beings have configured them to do. Since much of the practice in design and delivery of solutions in construction tend to address the exogenous aspects and not the endogenous factors, the same orientation currently characterises the use of BIM technology. The exogenous orientation would mean that BIM models would carry the potential for greater efficiency and not necessarily overcome the human-induced contributions to unreliability in project cost estimates.

## 2.2.4 Techniques for Estimating

Historically, while much of the estimating effort in construction have centred around the ‘first principles’ approach, the emergence of techniques such as parametric estimating from the middle of the last century have helped to transform the landscape of estimating. The parametric approach to cost estimating has its origins in the World War II period (Shash and Al-Khaldi, 1992). The war caused a demand for military aircraft in numbers and models that far exceeded the volumes that the aircraft industry had capacity to cope with. In response to the demand, T. P. Wright in 1936 provided a number of equations to apply in predicting the cost of airplanes over long production runs. The underlying theory of the Wright equations is known today as the *learning curve* (Daschbach and Apgar, 1988). According to Ostwald (1992), the learning curve equations of Wright were also applied by industrial engineers to predict the unit cost of airplanes. This essentially rendered the equations as an estimating tool. Using the learning curve approach for estimation required the computation of a first unit cost as a key input. While the learning curve technique proved useful for predicting the behaviour of recurring cost, there was no acceptable method for generating what the first unit cost might be. Prevalent practices included detailed labour-hour and material estimating, which essentially ignored the latent contributions to the cost of producing the first unit (Shash and Al-Khaldi, 1992). Equally, there were no common methods for estimating the non-recurring costs associated with aspects such as research, development, testing and evaluation in the pre-production phase of aircraft product development (Shash and Al-Khaldi, 1992). In particular, these non-recurring phases in aircraft development map onto the pre-production phase in construction and could potentially have contributed some insights on estimating for non-site based activity.

The development of the method of Cost Estimating Relationship (CER) by Rand in 1950 attempted to address the limitations of the learning curve. The combined initiatives of T.P. Wright and Rand became the foundation of the current technique of Parametric Cost Estimating (Shash and Al-Khaldi, 1992; Daschbach and Apgar, 1988). The development of the parametric cost estimating was assisted in no small measure by the need of the Department of Defence (DoD) of the United States of America to reduce its cost of procuring military hardware. Much of the effort to reduce cost focused on optimising the unit cost of a product by applying Business Processing Reengineering (BPR) principles. BPR involves the reengineering of a process or the functions of an organization by interrogating its contributing activities, and then re-ordering and revising them to bring about incremental improvement (DeMarco, 1994). The fundamental purpose of the concept could be summarised simply as *doing more with fewer resources*. Its application enabled the development of relatively more optimal and reliable cost estimates. The work of De-Marco (1994) led to the attainment of greater reliability in the estimating effort within the manufacturing industry. The BPR technique depended on a principle that is captured in the following five basic steps.

i. Create an organization for improvement
ii. Develop an understanding of the process
iii. Streamline the process
iv. Model, implement, measure, and control
v. Design and implement continuous improvement

The third step offers an opportunity for several iterations that potentially enables the outcome of the process to mature in reliability and improvement. The third step also provides the key phase that facilitates the action, which conceptually makes the BPR technique parametric.

Watson and Kwak (2004) have argued that the parametric technique is a more credible method for producing reliable and supportable contractor estimates, and equally yields a more cost-effective estimating process solution. The technique relies on the use of one or more Cost Engineering Relationships (CERs) and associated logical linkages to form the basis of deriving a cost estimate. The parametric cost estimating principle involves defining the technical, physical, or other quantifiable attributes of the product as a bases for its measurement. According to (Kwak and Watson, 2005), the parametric estimating is a technique used by both contractors and the Government in planning, budgeting, and performance stages of the acquisition process because of its simplicity matched by its reliability. In general, non-parametric estimating systems do not connect technical features of a product (parameter) and cost elements, and where it is the case the connection does not achieve any substantial precision (Watson and Kwak, 2004).

However, the current use of the parametric technique is yet to incorporate the influence of the individual estimator's behavioural characteristics in decision making on the reliability of the cost estimate. This is because there are no formal and recognised solutions for quantifying and incorporating such subjective variables in an objective parametric technique. It is possible to argue therefore, that it a higher level of reliability in the use of parametric estimating could have been realised if the influence of estimator personality can be factored into the derivation of the estimate.

The reliability of estimates produced from parametric techniques is heavily dependent of its *cost realism*. Cost realism is the system of logic, the assumptions about the future, and the reasonableness of the historical basis of the estimate. The estimating procedure involves confronting many questions, and for which, assumptions are made by the estimator. For example, the assumption-making is reflected in the estimator's ability to assess risk and analyse issues, and largely has an effect on the reliability of the estimate produced. Some of the frequent questions that the estimator encounters in using the parametric technique in estimating have been listed below.

i. Are the assumptions used in the estimating process reasonable?
ii. Has the historical database used been normalized to account for external and commercial parameters such as inflation?
iii. Is the cost estimate logical? Does it make sense in the context of the product or service being estimated?

iv. Does the estimate display a bias toward being too low or too high? If so, how is this bias displayed in the estimate?
v. Is the cost estimating organization motivated to produce an inordinately high or low estimate in order to serve its own purposes?
vi. If the product reflects a fixed price from a sole source, has the historical data that forms the basis of the estimate been “cherry picked” to produce an unreasonably high cost estimate by the contractor, or an unreasonably low one by the client?
vii. If the programme is competitive, has the contractor or client created far too optimistic expectations?

In particular, unreasonable biases and expectations from contractors and clients often feature in the cost estimating process (ref). These biases, often personal, would continue to drive the quality of the output from the estimating process into the future. The biases create unknown conditions that contribute to the difficulty of the job cost estimating. All the same, by making sound assumptions, employing quality historical data, and exercising unbiased judgement on the part of estimators, it should be possible to achieve desired high levels of reliability with the use of the parametric technique for construction. The high levels of reliability could be made possible if the estimator’s behaviour characteristics in decision-making can be factored into the derivation of the estimating outcome. The achievement of reliability on cost estimates is therefore, heavily dependent on research establishing the individual estimator’s decision-making orientation and how that contributes to estimating reliability. Unfortunately, the influence of the individual estimator’s behavioural characteristics in decision-making is yet to be established and so it is not considered in estimating project cost.

### 2.2.5 Whole-Life Costing and Estimating Reliability

Whole-life costing (WLC) is essential in determining the options that will give value for money. The WLC approach is becoming a de facto requirement for most construction projects, with clients demanding viable WLC solutions as a basis for schemes at the conceptual stage of design. Effective WLC depends on the reliability of the estimates that produced for the various options employed for comparative analysis. In practice, the data for producing the estimates are not easily obtainable or readily available to the analyst performing the WLC task. The absence of sufficient data acts as a major barrier to the application of WLC to projects in construction and places more emphasis on the personal judgement that the analyst can exercise. Kishk and Al-Hajj (2000) for example developed a 5-step framework for implementing WLC in the design stage of construction projects. They identified the main features of this framework as a resource database and a project database. The resource database contains data for several options of the design in order to develop a number of design alternatives, which is subsequently transferred to the project database for storage and future use, as well as use in the effective management of the development. Kishk and Al-Hajj (2000) investigated the development of IT applications for WLC. Their work unearthed the difficulty that attended the application of WLC due of data insufficiency. In particular, they saw the use of a comprehensive IT infrastructure as a way of overcoming the lack of data sufficiency. Their prime argument was that the insufficiency of data was driven by at least two factors; scope of data, and the temporal nature of data. What they did not address was how the analyst made use of the data available, and how different analysts behaved given the same insufficiency of data.

## 2.2.6 Monte Carlo Estimation

The Monte Carlo Estimation is based on the use of the Monte Carlo simulation. Monte Carlo Simulation provides a method for pricing cost estimate boundaries with reasonable degree of objectivity, and hence reliability. Monte Carlo simulation derived its name from Monte Carlo, Monaco, where the primary attraction is gambling or games of chance (Vose, 1996). The random behaviour in games of chance is similar to how Monte Carlo simulation selects variable values to simulate a particular model in a spreadsheet environment. Typically, Monte Carlo models only generate the most likely scenario as the single outcome of the simulation. As an analytical tool that can randomly generate values for uncertain variables to address different scenarios, Monte Carlo models have the potential to take account of any additional subjective variables that are sufficiently defined for quantitative analysis.

The simulation has the main objective of improving the degree of confidence in project estimates. In the Monte Carlo method every cost component that has high degree of variation as to be modelled as a random variable. This means that other cost components that have little variability are usually not considered. This is because a change in the value of such limited variance variables will not bring about a significant enough change in the final cost for it to merit attention. The decision on the threshold of variability that will determine which variables are to be modelled is subject to the choices exercised by the estimator. In the technique, the user does not estimate the project cost using only the normal analytically procedures.  After generating nominal estimates, the simulation stochastically establishes the values of the variables that are represented by probabilistic distribution by taking random samples.  For the value of the modelled costs to be reliable, the technique relies on the accuracy of data and computing power.

The use of Monte Carlo simulation for pricing options was first proposed by Boyle (1977). Amour et al. (1999), Boyle et al. (1995 and 1997), Caflisch et al. (1997), Fu et al. (1999), Glasserman and Lanyon (1999), and Grant et al. (1997) all explored subsequently the use of Monte Carlo simulation in the field of construction, manufacturing, business, and cost estimating.  Together, they shared the view that the technique offered a way of achieving a more objective value for the derivation of their required output variables.  More recently, Chou (2010), I-Tung (2008), Touran et al. (2006), and Ahmed et al. (2007) have demonstrated how the simulation could be applied in establishing cost range for estimates of construction projects.

## 2.2.7 Project reliability determinants

According to Hackway and Humphrey (1992), the reliability of an estimate is dependent on the category of work under which the project could be classed.  For the purpose of their work, Hackaway and Humphrey (1992) categorised the various work sections as follows:

- General project basis;
- Process design;
- Site information;
- Engineering design;
- Detailed design; and
- Field inspection.

The listed categories generally include cost items that are referred to as physical factors. The physical factors could be mitigated to bring about a high level of reliability for any construction cost estimate.  The mitigation effort could include having a well structured organisation, with adequate calibre of staff clearly defined job descriptions and roles.

Bramble and Collaham (1992) also identified the following variables which if not adequately considered could serve as causes of unreliability in cost estimating.

- Failure to evaluate the design
- Failure to evaluate the site
- Failure to coordinate sub-contractors
- Management failure
- Delay from the sub-contractor
- Under tendering
- Failure to schedule and plan
- Inadequate material procurement plan, and
- Inadequate labour force.

The outcome of the work done by Bramble and Collaham (1992) was consistent with that of Hackway and Humphrey (1992). However, in both studies, the no consideration was given to the behavioural characteristics of the individual estimator, and how that affected the choices they exercised.

Chester and Bing (2005) identified the cost of labour, materials, equipment, the characteristic of the contract, and the contracting environment during the execution of the project as factors that greatly affected the final cost of construction projects. The argument of Chester and Bing (2005) was that the intangible factors such as contract environment, were mostly not considered during the preparation of the initial project cost estimate. The cost of resources could be predicted with some high degree of reliability from historical data provided the information itself was reliable. Equally, the intangible aspects could be systematically addressed. For example, the effect of the characteristics of the contract could be mitigated by adopting well-structured contract documentation. A well-structured contract would detail how the sharing of risk among the parties to the contract. Understanding the risk element in the contract would enable the estimator to allocate the appropriate monetary value for the risk in the cost estimate. While any such detailed risk would help to minimise data insufficiency, it is the perception of the estimator for the identified risk aspects that would affect what assumptions the estimate is based upon.

## 2.3 INFORMATION, PLANNING AND WORKLOAD

Inaccurate assumptions made by the estimator arising from improper or inadequate briefing by the client causes unreliability in cost estimating. Barrett and Stanley (1999) analysed the actions and inactions of the client and concluded that the consequence of improper client briefing often accounts for the deviation of the actual project from the project as contemplated at the time of estimate. In such instances, the estimator has to contend with a situation whereby the assumptions that underpin their estimate is not based on what the client actually intended. The reliability of such an estimate decreases as the estimator's assumptions increases the deviation from the intended brief. The briefing stage is primarily involves information sharing. Barrett and Stanley (1999) therefore, agreed with Hackway and Humphrey (1992), and Bramble and Collaham (1992) that reliability in cost estimating is directly proportional to the reliability of the information transmitted to the consulting team during the client's briefing.

The actions of the parties to the construction contract and their representatives affect the desired and expressed reliability in construction cost estimates. Sidney (2002) indicated that the following actions of the engineer/ architect often accounted for inaccuracies in cost estimates on projects.

- Ineffective co-ordination of drawings among mechanical, electrical, fire protection, structural, and architectural trades.
- Conflicts between small and large details and between written information and graphic drawings.
- Lack of communication among the various design consultants, so that a change made by one is not transmitted to the others to determine whether they have any impact on their design.
- Insufficient consultation with owners to afford them the opportunity to participate in decisions that ultimately affect the way in which their program is being developed.
- Insufficient time for proper and a thorough review of all tender documents, because the owner has demanded an unrealistic and compressed timeframe for the drawing, production, and submission of documentation for bidding.

From the findings of Sidney (2002), it could be inferred that reliable estimating, as an activity in its own right, is a prerequisite for achieving the performance such that a project's final cost can be within the estimated cost.

Koushki et al. (2005) researched 450 randomly selected private residential projects in Kuwait and identified several factors that were presented as causes of inaccuracies in project cost estimates. These included contractor-related problems, material-related problems, and owner's financial constraints. Koushki et al. (2005) claimed that no consideration was given to these factors in the preparation of the cost estimates on the projects. The key question to address is therefore as follows: *will the desired improvement in reliability of project cost be achieved, if the factors of Koushki et al. (2005) are incorporated in deriving the estimate*? Anecdotal evidence suggests the view that addressing those factors will lead to an improvement in reliability for cost estimates. However, there is no cogent evidence from a systematic study to support that assertion.

Swee and Moonseo (2005) acknowledged that some special project requirements contributed more to the causes of inaccurate cost estimates on projects. In particular, they alluded to such requirements as high technological level, contractor's specialised skills, and public administered contracts. Other factors identified by Swee and Moonseo (2005) as having significant effect on the final cost of projects were contractor's technical expertise, owner's level of construction sophistication and contractor's financial management ability. According to Swee and Moonseo (2005), these factors are not considered and addressed in the preparation of project cost estimates.

The research of Koushki et al. (2005), Swee and Moonseo (2005), and Min and Pheng (2005) equally did not cover how different human beings behave under the same conditions. The behaviour of the individual estimator in making decisions, which are vital for determining the cost of any project is omitted in all their studies.

### 2.3.1 Workload

In general, the nature and level of project workload can affect the estimator's ability in making sound judgement due to pressure of work. High levels of workload often lead to negative stress on estimators (Cooper and Sutherland, 2006). Mei-Yung et al. (2005) identified stress experienced by estimators as a major cause of unreliable estimates on projects. Some of the critical stressors identified by Mei-Yung et al. (2005) were work overload, role conflict, job ambiguity, and poor work environment. Experiences of high levels of stress by estimators are a regular phenomenon in the Ghanaian context. This is due to the huge number of projects in the public sector for which cost estimates have to be prepared from 'first principles' by a limited number of experienced estimators. Often estimators in that environment have to deliver their estimates on a very rigid time schedule, in part due to frequent interruptions in the procurement programme of the public sector. In the private sector, while such interruptions are seldom, the situation is not any much different. There are instances when most public sector estimators have hardly any time to analyse information sufficiently before making decisions. The effect of such a situation is a preponderance of inaccurate and unreliable cost estimates for those affected projects. Its manifestations include projects cost overruns commonly experienced in most projects, and in some exceptional cases, abandonment of projects half way due to budgetary constrain. Coping with such a 'pressured work environment' requires not only the intellectual but also the personality attributes of the staff that have to produce the estimates.

Some researchers have identified some measures aimed at achieving the reliability desired in construction cost estimates. For instance, Pablo et al. (2001) suggested that the following measures could minimise inaccuracies in construction cost estimating.

- Break down the works into discrete portions and plan engineering accordingly
- Have good definition of the undefined as well as defined
- Ask for competitive unit prices based on preliminary drawings
- Pre-order 80% of bulk materials normally supplied by the contractors in order to minimised mobilisation time.

The measures suggested by Pablo et al. (2001), however, appear not to take into consideration the circumstances in many developing economies where availability of finance and stability of the currency plays a critical role in construction project promotion. For example, the estimator could make allowance for the purchase of eighty percent (80%) bulk material under an advanced mobilisation arrangement within the estimate. However, at the implementation stage, the client might not have funds for such a huge pre-order. Equally, the facility for acquiring such large orders on credit is not particularly developed in such countries, as their economies generally function on a debit purchasing system. These contextual differences necessitate a re-configuration of the findings from studies such as that of Pablo et al. (2001) to ensure their alignment to many developing economies.  The alternative approach would be to investigate the particular phenomenon that forms their research problem as it reflects in the particular economy where they are contemplating the adoption of the findings from such research.

## 2.3.2 Planning at Pre-Contract Stage

Inadequate information and planning at the pre-contract stage can have an influence on the reliability of project cost estimates.  Kayode (1979) and Burke (1993) both make the case for the role that inadequate information plays in project cost reliability.  Kayode (1979) identified factors such as inadequate analysis and inadequate information about the project that transpires at the pre-contract stage, as one of the main contributions to inaccuracies in project cost estimates.  Martin (2005) subsequently emphasised the importance of allocating more time for the early phase planning for any infrastructure development as a means of avoiding unreliability in project cost estimating.  The essential findings of Martin (2005) affirmed the argument of Kayode (1979).  Other investigators who similarly focused on the effect of effective planning on the attainment of cost reliability all concurred with Kayode (1979) (Koenigseker, 1982; Kouskoulas and Koehn, 1974; Wilmot and Cheng, 2003; Yu and Lai, 2003; and Burke, 1993).  The fundamental assumption made by all these investigators is that the individual construction professionals who have to exercise project decisions are *objective* and do not influence the influence the decision outcomes.

Tarek and Halpin (2004) identified unseen sub-surface obstacles, such as lack of contractor experience, and site planning as some of the main problems associated with cost estimating for construction.  While factors such as contractor experience are expressed by the delivery of similar projects, they practically translate as the experience of the individuals the contractor employs.  Tarek and Halpin (2004) identified four techniques in solving these problems, which can be categorised as process-oriented techniques, deterministic and simulation, data oriented technique (DOT), and regression and artificial neural network (ANN).  From their analysis, Tarek and Halpin (2004) concluded that DOT techniques were the most appropriate for addressing reliability projects cost.  In common with other studies on cost reliability, Tarek and Halpin (2004) concentrated on physical factors and objective characteristics that readily lend themselves to measurement.

Gilchrist (1986) was among some of the earlier investigators to link reliability of cost estimates to elimination of needless decision obstacles that often reflect in the delivery of construction projects. Gould and Nancy (2000) agreed with the findings of Gilchrist (1986) and augured for a disaggregation of the high level project activities into sub activities in order that cost, time, and quality-control standards can be set up for each sub-activity and monitored effectively. According to Gould and Nancy (2000) the reliability of cost estimates is vital for monitoring project performance. The estimate, thus, serves as a baseline for the project in defining financial viability and operational performance. Sang-Hoon et al. (2005) also identified some critical practices that were associated with projects cost but were not accounted for in the preparation of construction estimates. To address this problem, Sang-Hoon et al. (2005) advocated for more prudent project planning at both the pre-contract and the implementation stages of the project cycle. Since those practices of prudence essentially involve project professionals, understanding their behavioural characteristics should form part of the measures for addressing the problem.

### 2.3.3 Cost Data and Information

The importance and reliability of cost data on the reliability of cost estimates on construction project was buttressed by Frank (1994), Seeley (1983) and Killingsworth (1988). Frank (1994) Seeley (1983) and Killingsworth (1988) among others have argued that reliable cost estimate could only be established after the preparation of as-built drawings for the project. Their argument is founded on an estimating practice that reflects the 'first principles' approach and exposes the problem of providing reliable early cost estimates by that approach. The development of Building Information Model (BIM) hold considerable potential for providing solutions that could address the lack of reliability of early cost estimates. The use of the BIM technology to generate early cost estimates will be facilitated by current offerings of cost databases in the UK that can serve as libraries for BIM once the required modelling associations are established.

In developing economies such as Ghana, such cost databases are generally not existent. Where they do exist, such information would be classed as confidential and would not be readily available and accessible most estimators. With the exception of the large companies operating in Ghana, which are mostly foreign owned, local companies in Ghana tend not maintain their own cost data. The decision not to have in-house cost libraries is driven by the cost of maintaining the database as well as the technological know-how required to exploit them efficiently. Where firms hold such cost databases they, naturally, have been reluctant in making it available for wider public usage due to competition among the companies. In order to generate reliable cost estimates for construction projects, especially at the early stage, the availability of such cost data is very essential. The inability of the private companies operating in Ghana to develop their own cost data has created a situation whereby they have become heavily dependent on only officially published cost indices. The official cost indices are produced by the Ministry of Roads and Highways for road sector projects, and the Ministry of Natural Resources and Works and Housing for building projects. These public institutions generate their data from the consultant's cost of projects and the reliability of the data depends heavily on the person compiling them.

Availability of information in the right amounts and of the right quality has a significant impact on reliability of construction cost estimates. For instance, the work of Chua and Shen (2005) recognized that unreliable information contributed in a large measure to inaccurate estimates on projects. The problem of unreliable information is common in the construction industry in Ghana where data on previous projects are not kept and such records are maintained, most of the vital information is omitted. This situation is shared by many developing economies where computerised data handling is not the norm for constituting project cost estimates. Even where the information exists in the volume and quality required, it is the interpretation and the decisions that the estimator makes from such information that is essential to the realisation of a reliable cost estimate. In such a situation, the decision-making orientation of the estimator could significantly affect the reliability of estimates. The existence of unreliable estimates in many advanced economies notwithstanding the availability of reliable information provides strong evidence that addressing estimator-exogenous factors alone would not be adequate for achieving reliable cost estimates. This calls for better understanding of estimator-endogenous factors that relate to the individual estimator's behavioural characteristics in decision-making to establish how that affects reliability of project cost estimates.

## 2.4 EXTERNAL CONSTRAINTS IN ESTIMATING

There are a number of constraints that hinder the achievement of reliable project cost estimates. Some of these constraints are project related issues and others arise because of the environment from which the estimate is produced. The subsequent discussion in this section addresses various external constraints that are considered as inhibiting the realisation of reliable project cost estimates.

## 2.4.1 Inflation

The reliability of cost estimate was reviewed in relation to inflation, which is a major economic feature in many developing countries. Inflation is the term used when paper money loses value. Many theories abound as to the causes of inflation, the most widely acclaimed being the increase in the stock of money compared with the quantity of goods available. The review identified several investigators that studied the effect of inflation on reliability of cost estimates. Akpan and Odinaka (2001) conducted studies on the causes of inaccuracies in estimates of public buildings. In their research, Akpan and Odinaka (2001) associated the main causes of inaccuracies in cost estimates of public projects in developing economies with rising cost of project inputs, such as materials and labour, which are difficult to predict. According to Akpan and Odinaka (2001), the effect of the price rises of inputs is inaccuracies in the estimates, especially the ones produced for lump sum projects in developing economy. Akpan and Odinaka (2001) ruled out inadequacy of project management as the cause of unreliable cost estimates for the sample of projects employed in their study. The key findings of Akpan and Odinaka (2001) were in disparity to the position that Burke (1993) arrived at in studying drivers of performance in project delivery, and advocated for proper project management to ensure the elimination or minimisation of unreliable project cost estimates. Since effective implementation of project management is widely acclaimed as a positive determinant of cost reliability, it may be inferred that the conclusion drawn by Akpan and Odinaka (2001) might be more reflective of the context of their case study.

The study of Akpan and Odinaka (2001) was limited to public buildings. This is a significant limitation, which could be addressed by expanding similar studies to cover private buildings in the same economic environment. It is generally known that private clients employ more rigorous implementation of project management in the delivery of their projects compared to public sector clients. The robust orientation of private clients is in part driven by the profit motivation in that sector. The approach of the private sector could provide useful insights on achieving cost reliability for public sector clients.

The findings of Akpan and Odinaka (2001) were also limited to a developing economy where the currency is not stable. This is not always the case for every developing economy. In Ghana for example, the interbank exchange rate has been relatively stable against most of the international currencies over the past decade with only minor volatilities that are usually instigated by global financial shifts. However, notwithstanding the relative stability, project cost estimates in Ghana are affected by a lack of reliability. It may therefore, be inferred that the reliability of project cost estimate is determined by factors, which are beyond physical conditions of the estimator's external environment.

Other researchers such as Oti (1988) were of the opinion that factors, such as government fiscal and monetary policies and inflation, within the economy contribute significantly to a lack of reliability in project cost estimates. According to Oti (1988) these factors are difficult to predict in an unstable economy as reflected in the economies of most developing countries. The inability to predict these factors with a degree of certainty emphasises the importance that individual decision makers can bring to project cost estimating in these countries.

One of the most important causes of the lack of reliability in project cost estimates within many developing economies is the rising cost of materials and labour as a direct consequence of inflation (Akpan and Odinaka, 2001). A common feature of the influence of inflationary pressure on construction projects in developing economies is the use of a fluctuation clause to adjust the agreed cost of works in response to changing market prices. In particular, the use of fluctuation clauses is prevalent on public sector projects and less so for private sector initiated schemes. Public sector schemes tend to be large in scale and span several years, thus, making them more susceptible to annual changes in the economy with each national budgetary round. Private sector projects tend to be of a smaller scale and often take one year or less to complete, thus, making them less sensitive to such annual price variations.

Dormbusch and Fisher (1993) identify three types of inflation that the construction industry can experience. The first of these is a low-level steady inflation that is easy to predict and, is commonly associated with many developed economies. This steady type is referred to as *single digit inflation*. The second type is a moderate inflation of around twenty percent (20%) a year that reflects in many middle-income economies. The third type is an extreme rate of inflation that can go up to one hundred percent (100%) and beyond, referred to as *runaway inflation*, and commonly experienced in many third world economics. In recent times only a few developing economies have more than 100% inflation. These countries are mostly countries that are not practising good governance and so the climate for efficient management of construction projects is non-existent. The majority of developing countries currently have inflation rates nearing the middle-income level, with a few reflecting the single digit steady type. In Ghana for example, the inflation figures released by the Statistical Services of Ghana showed consistent single digit rate from 2010 to 2011. Notwithstanding the wonderful inflationary performance of countries such as Ghana, it has to be acknowledged that single digit rate in developing countries is more of an exception than the rule. As such, governments in developing economies have to do more work to bring inflation rates down to a reasonable level, in order to enable the construction industry manage its negative effect on project cost reliability.

The behaviour of inflation on the cost of projects is of particular importance. In some instances, inflation could be predicted with reasonable reliability, and accounted for in the initial estimate of the project. In other situations, it may be completely unexpected and, therefore, causes serious cost overruns on projects. An investigation conducted by Pohl and Mihaljek (1992), who surveyed 1,015 World Bank projects, concluded that the nominal cost overruns attributable to inaccuracies in cost were primarily due to unexpected inflation, which was not adequately provided for in the initial estimate of the projects.

The effect of inflation on cost of construction projects in steady state economies is adjusted for by the use of a *price index*. In the UK for example, construction projects typically employ a single price index known as “overall price index” to allow for price increases that affect the project. In Ghana, individual price indices of various input resources are employed to derive a composite formula that is subsequently applied to compute the level of adjustment of the contractors’ price. However, experience has shown over the years that the compensation paid to contractors in Ghana from the application of the derived composite adjustment formula is often not at par with the actual increases recorded for the input resources in the market.

Wang and Mei (1998) argued that price fluctuations of individual cost items do not vary simultaneously in the same way within the market. From their investigation, Wang and Mei (1998) demonstrated the limitation of trying to achieve cost reliability by applying a single overall price index. They made the case that the reality of fluctuations in market prices for the different resources is not adequately reflected by adjusting the construction cost with the use of a single overall price index. They further argued that it is possible to moderate the shortcomings associated with the use of single index by separating the quantities from the prices of the individual work items. This is because a number of factors interact to influence the quantities of any cost item, including, the method of construction, the dimensions of the structural design, as well as prevailing conditions on the site. "*It is conceived that the quantities for a construction project remain unchanged (or similar) as the same (similar) work is performed by the same (similar) workforce under the same (similar) conditions*" (Wen-Der, 2006). Wen-Der (2006) also acknowledged that the value of any cost element, designated by input resources, would not change as long as one constructs the same structure using the same method and under the same production conditions. However, the unit prices of any cost item will fluctuate according to the changes in the market forces from time to time. In particular, price inflation in Ghana tends to reflect strongly for all imported input than they do for locally produced resources. The differential rates accounts for the difficulty in employing a single price index for construction in Ghana.

## 2.4.2 Idle Time

To determine the cost component of resource inputs for a project, the estimator makes some allowances to cater for unavoidable unproductive utilisation. For material resources, such unavoidable additional resource may reflect as material lost in processing. For labour and plant, it may reflect as idle times, when the resource waits for inputs from preceding activities. During this stage, the estimator has to confront several assumptions related to the adequacy of allowance to compensate for the unproductive utilisation. The ability of the estimator to make effective decisions for such unproductive utilisation depends in part on the perceptions of performance and decision preferences of the estimator. These perceptions and preferences are generally subjective and personally driven by the estimator.

The importance of idle time on reliability of cost estimates was demonstrated by several studies into the factors that influence cost reliability. They include investigations conducted by Rogge and Tucker (1984), Vorster and de la Garza (1990), Yates (1992), Chalabi and Camp (1984), and Abd. Majid and McCaffer (1997). For example, Abd. Majid and McCaffer (1997) indicated in their study of factors that contributed to inexcusable delay on projects an association between inadequate allowances made for idle time in project cost estimating, and subsequent developments such as equipment breakdown.

The problem of equipment breakdown is of importance in many developing economies. In Ghana and most developing economies, it is common to find construction contractors relying on overage equipment from the developed economies to deliver projects. This is, basically, due to the prohibitive cost of new plant equipment and, without help, unaffordable by many contractors in developing economies. While manufacturers would provide nominal information on productivity for the different models and makes of their equipment, they assume an average level of performance. Equally, the manufacturer performance data assume ideal and supportive working conditions, such as regular routine maintenance. The use of plant hardly reflects these assumed conditions in many developing economies with a consequence of sub-optimal utilisation. The lack of adequate record keeping on equipment performance by individual project organisations means adds to the problem of having a cogent basis for estimating decisions. For instance, the problem is made worse by the frequency of breakdown associated with the use of plant in Ghana, although such breakdown usually varies with the make, model, and age of the equipment. In addition, the frequency of equipment breakdown is contingent upon the usage and the equipment management plans adopted by the project organisation and directly proportional to the level of experience of the equipment operator.

Given the multiplicity of influencing factors, it is common and expected to find that the level of allowance for resource utilisation vary from estimator to estimator. This is due to the individual estimator's preferences exercising decision choices.

The problem of inadequate allowance for idle time in the unit rate built-up could be minimised if contractors are encouraged to have regular and scheduled maintenance on their fleet of equipment. Unreliability in cost estimating associated with inadequate allowance of idle time due to plant breakdown are more pronounced in smaller companies, who are unable to afford the cost of maintenance. Most of the larger firms have a well-structured maintenance system and often reflect a reasonable level of practice. Again, unreliability in cost estimating associated with idle time due to equipment breakdown is more pronounced where the firm owns their own equipment. Where equipment is on rental, then the risk of such breakdown becomes the responsibility of the equipment hire firm.

One of the benchmarks for assessing the project's performance is the time or duration it takes to accomplish the construction work. Since the performance of a project is attributable, predominantly, to the efficiency of project organisations in utilising both human and material resources, the cost estimates could be employed as a proxy to predict the duration of a construction project. The more the reliability of the estimated cost the superior the predicted time would be, compared to the actual durations. Bromilow and Henderson (1976) produced a model for forecasting construction time, which was derived by accepting the strong correlation between project cost and duration. Equation 2.1 presents the model where ***T*** is the estimated construction project duration, ***C*** is the overall project cost at completion, and ***B*** and ***K*** are constants.

$$T = K \times C^{B} \qquad \text{Eq. 2.1}$$

***B*** describes how the project size affects time performance, and ***K*** portrays the general level of time performance for a million dollar spend on the project. ***B*** and ***K*** values that they generated from the projects they investigated is shown in Equation 2.2.

$$T = 313 \times C^{0.3} \qquad \text{Eq. 2.2}$$

Ireland (1980) also produce a similar model by adopting the fundamental concept of Bromilow and Henderson (1976) to predict magnitude of the relationship between project cost and its overall project duration from analysis conducted on twenty-five (25) high rise buildings in Australia as shown in Equation 2.3.

$$T = 219 \times C^{0.47} \qquad \text{Eq. 2.3}$$

The values obtained by Ireland (1980) for the constants ***K*** and ***B*** as depicted in Equation 2.1 were 219 and 0.47 respectively. ***T*** is the estimated contract duration and ***C*** is the cost of the project after completion in the Ireland (1980) model. The use of 25 projects presents a statistical limitation of the predictive powers of the Ireland model.

### 2.4.3 Physical Factors

The level of influence of the physical factors on reliability of cost estimates varies. Al-Harbi et al. (1994) conducted studies to identify physical factors that contributed significantly to the reliability of cost estimates. Al-Harbi et al. (1994) revealed several factors, which were grouped and ranked in order of importance as listed below.

i. Tough competition
ii. Contract period
iii. Incomplete drawings and specification
iv. Incomplete project scope definition
v. Unforeseeable changes in material prices

vi. Change in owner's requirements
vii. Current workload
viii. Errors in judgement
ix. Inadequate production time data
x. Lack of historical data for similar jobs
xi. Lack of experience in similar projects

The incidence of the physical factors could be controlled by having a well-defined estimating procedure, adequate time for preparation of drawings, regular contact with the client at every stage of the design process in order to incorporate any changes to the client's own requirements. The effect of tough competition could be mitigated by pricing realistically even if that might result in not wining the tender. Contract periods are fixed on most projects without consideration of the work content and the terrain and geographical location on the project. Fixing contract period with experience from similar projects will contribute to the mitigation of potential negative effects from the contract period on the reliability of estimates. Similarly, issues pertaining to the lack of historical data and experience from similar project could be mitigated by having a well-structured estimating department, with well-defined procedures in data management together with good calibre and adequate numbers estimating staff.

Adamu (2003) investigated the effect of increasing road project cost and time certainty, mainly from the client's perspective, and how any improvement affected the reliability of cost estimating in construction projects. Adamu (2003) affirmed that good contract procurement and management strategies, which include allocation of sufficient design/tender periods, review of design to identify and resolve errors and omissions prior to tendering, as well as proper planning and control were all essential to achieving the level of certainty required in cost estimating. Adamu (2003) contended that addressing these factors could result in an improved situation whereby the project cost at initiation stage will be at par with the final cost at completion of the project.

The research of Adamu (2003) agreed with that of Al-Harbi et al. (1994) that unreliability in cost estimating on projects could be eliminated or minimised with proper pre-contract documentation and sufficient levels of management involvement at the estimating stage of the project. Generally, the negative effects of the factors identified by Al-Harbi et al. (1994) and Adamu (2003) on the quality of estimates could be minimised with a good practices in estimating procedures and qualified and experienced staff. Although Al-Harbi et al. (1994) and Adamu (2003) agreed on the importance of the 'right' people for the desired reliability in project cost estimate to be achieved, they did not address per se, the influence of the behavioural characteristics of the people, which in this case is the estimator, on the reliability of cost estimates.

### 2.4.4 Knowledge in the Area of Estimating

The effect of the knowledge of estimators in the area of specialisation in which estimates are prepared is equally a prerequisite for achieving a reliable cost estimate. Carr (1989) indicated that unreliable cost estimates were the results of staff estimating in an area where the estimator often had little knowledge (both technical and operational). Akintoye and Fitzgerald (2000) conducted a survey of cost estimating practices in the United Kingdom and concurred with Carr (1989) on the importance of experiential knowledge in the area of estimating on the reliability of project cost estimates. The judgement of the estimator in such situations could be influenced by the amount of knowledge they have from projects of similar nature. The works of Akintoye and Fitzgerald (2000) and Carr (1989) on the estimator's knowledge could have considered the influence of estimator-judgement on the reliability of project cost estimates.

The estimator's *practical* knowledge of the method of construction of particular types of work is also vital for realising reliability of cost estimates. The survey by Akintoye and Fitzgerald (2000) established the necessity of having adequate practical knowledge of the work type to be estimated. They proposed that the major causes of unreliability in cost estimating continue to be a lack of practical knowledge of the construction process by those responsible for the estimating function. They further suggested that factors such as insufficient time to prepare the cost estimate, poor tender documentation and wide variability of subcontractor prices contribute to the variability in reliability.

### 2.4.5 Time Sufficiency

The influence of insufficient time for preparing cost estimates is more pronounced in unplanned procurement of works, goods or services. The importance of planning on the realisation of reliable durations for construction activities has been emphasised by Johansen and Greenwood (1999). Johansen and Greenwood (1999) produced a lean construction model for planning aimed at fixing the duration for activities to a reasonable degree of accuracy.

### 2.4.6 Pressure from Superiors

In many developing economies, politicians often make promises for electoral gain, which later translates to pressure on the estimators to deliver project cost estimates in very short time and to substantiate the solutions that the politicians proposed. For example, prior to elections in Ghana, numerous promises made by politicians to deliver various infrastructure developments had to be fulfilled within a limited time in order to maintain the credibility of the political administration. The workload situation is more severe due to the limited number of experienced estimators in these developing economies. In such instances, the estimator exercises judgements, which are often suboptimal due to the level of fatigue from intense work and pressure from superiors to meet the demands of the politicians. Faced with such a situation whereby the estimator has to turn around cost estimates in little or no time, the practical effect is often an inability to analyse documentations thoroughly in order to make an informed decision. The effect of time pressure also reflects in the design aspects of the solution adopted for the project and, which often lead to numerous cost overruns arising from design changes on the project. The adverse effect of inadequate time for estimating could be moderated by ensuring that only projects included in the national strategic procurement plan are implemented. In addition, increasing the number of experienced estimators employed to discharge the function could help the departments affected to maintain levels of capacity to cope with any demand hikes that arise. One method for achieving growth in numbers is by providing incentives for students that have enrolled on estimating programmes in the tertiary institutions to consider joining the relevant public sector departments that address project cost estimating.

Akintoye and Fitzgerald (2000) also indicated from their survey that the larger contractors rated the causes of inaccurate estimating lower than the other groups of contractors interviewed in the survey. Akintoye and Fitzgerald (2000) attributed this to the fact that large contractors often had well-organised estimating departments with clearly defined functions than their smaller and medium counterparts.

A number of other studies have also stressed the importance of reliable cost estimates of construction projects as the basis for making most financial decisions at the pre-contract stage and during the progress of site production works (Afetornu et al., 2006; Walker and Hampson, 2003; Abubakar, 1992; and Pohl and Mihaljek, 1992).

## 2.4.7 Risk identification and Assessment

The proper identification and assessment of risks associated with construction cost during estimating can assist in achieving the desired reliability. There are particular critical risks that have to be analysed and appropriately accommodated for in estimating the cost of construction projects. Kalidindi and Thomas (2002) and Thomas (2003) established the following critical risks as pertinent to achieving that reliability in the estimating outcome.

i. Traffic revenue
i. Delay in land acquisition
ii. Demand risk
iii. Delay in financial closure
iv. Completion risk
v. Cost overrun risk
vi. Debt servicing risk
vii. Political risk

Thomas et al. (2006) confirmed the findings of Kalidindi and Thomas (2002) and Thomas (2003) on the importance of making adequate allowance to mitigate the risks that can be associated with estimates of project cost. Thomas et al. (2006) consequently developed a risk assessment framework, for evaluating the effects of critical risk on estimating the cost of *Build Operate and Transfer* (BOT) road projects. The period of concession associated with most BOT projects is thirty years and over. The effect of a particular risk factor to a BOT project will differ from that of the conventional construction project for which the involvement by the developer only spans up to the completion of the physical works.

The risks associated with the delivery of construction projects have been explored in several investigations by many researchers. Lewis and Greenwood (2002), Hasrak and Shaked (2000), Han and Diekmann (2001), Kapila and Hendrickson (2001), Ashley and Bonner (1987), Pheng and Hongbin (2003) discussed the effect of risks on the forecast of construction project cost in the international market and under Private Finance Initiative (PFI) and Public Private Partnership (PPP) procurement arrangements. The importance of risk in PFI/PPP projects was emphasised by Lewis and Greenwood (2002). Lewis and Greenwood (2002) identified design risks and liability for site conditions as the most important risks that should receive for PFI/PPP construction contracts. Political risks associated with international projects were analysed by Ashley and Bonner (1987).

Ashley and Bonner (1987) evolved a conceptual influence diagram for analysing political risk in the preparation of tender for international projects. Other researchers such as Kapila and Hendrickson (2001) identified the most critical risk related to the financial aspects of international projects and provided measures on how these risks could be mitigated to ensure a more reliable estimation of projects cost in the international market.

The risks associated with projects in developing countries are usually very high for most international contractors. This could be attributed to some inherent tendencies that characterise these countries. They include political instability of governments in the developing countries, instability of the currency particularly where international contractors are paid in local currency. Another tendency is the lack of experienced artisans in numbers sufficient to deliver many of the complex projects, and as a result necessitating the introduction of expatriate expertise for quality delivery of the project, and thus, increasing the cost of the project. In addition, input resources such as most processed materials and equipment have to be imported to run the project from developed economies. This situation makes the delivery of projects in developing countries very susceptible to the level and stability of exchange rate associated with their local currency. The ability to predict the cost of works is affected by the currency rate prevailing at the time of acquisition of resource inputs. In addition, any volatility in the global financial markets is translated to the project as a result of the input resource dependency on imported alternatives. Jaselskis and Talukhaba (1998) investigated the bids of international contractors in Kenya and concluded that inherent such risks impacted heavily on the bid prices of international contractors. According to Jaselskis and Talukhaba (1998), government instability and shortage of adequately trained craftsmen were some of the inherent risk that need to be accounted for in preparing tenders on international projects. Jaselskis and Talukhaba (1998) noted further that if the inherent factors are not sufficiently assessed and adequately allowed for in the bids submitted by international contractors it could result in serious lack of reliability in their price.

Dickmen and Birgonul (2006) also discussed the work of a number of previous authors on the risks associated with international projects. They proposed that, the report compiled by Ranko Bon on risks information associated with international contractors that policy-makers and construction professional apply to ensure accurate preparation of project cost estimates on international projects should form the basis for defining a way forward. Their primary argument was that the report of Rank Bon obtained contributions and responses from a wide range of experts across the world, thus, making it applicable to most international situations. Earlier, Chen and Messner (2003) had argued that expert opinion from different countries should be gathered by survey for a more objective assessment and comparison of risks associated with international contractors and how these should be addressed systematically in the preparation of cost estimates for international projects.

Ibrahim et al. (2006) investigating the allocation of risks in public private partnerships (PPP) projects in Nigeria, identified unstable government, inadequate experience in PPP and availability of finance as the three most important risk factors that affect PPP projects in Nigeria. The reliability of PPP projects in Nigeria would therefore, depend on the extent to which these risks are managed.

In their work Lewis and Greenwood (2002), Hasrak and Shaked (2000), Han and Diekmann (2001), Kapila and Hendrickson (2001), Ashley and Bonner, (1987), Pheng and Hongbin, (2003) Ibrahim et al. (2006), Dickmen and Birgonul (2006), and, Chen and Messner (2003) all did not address the aspect of overheads. In particular, the effect that overheads of international contractors have on their tenders when tendering for international projects in developing economies. It may be argued that the most international contractors tend to associate higher levels of risk to projects in the developing economies and consequently allocate disproportionate monetary values to mitigate those categories of risks. In Ghana, recent developments point to a lowering in tender figures quoted by Chinese contractors as compared to their international competitors for international projects. The disparity in the tender prices from other international contractors to that of the Chinese contractors is due to the level of monetary allocations for risk and overheads. In some instances, the disparity could account for as much as ten to fifteen percent of the total tender accepted by the client. The question is why such a big variance should occur between the international contractors tendering for the project since the risk associated with the project has been assessed competently and sufficiently by all of them. The huge disparity between the international contractors' tender prices for international projects in the developing economies may be explained the significant effect that the individual estimator's judgement can have on what constitutes risk.

## 2.5 CONSTRUCTION INNOVATION AND ESTIMATION

The role of innovation in achieving significant improvements in construction has been slow as compared to that of manufacturing (Egan, 1998). The improvement of the construction sector is of great concern to national governments in both developed and developing economies. The question is how construction performance can be improved on a sustainable basis. The argument made by Egan (1998) was that construction should move away from making efforts at achieving absolute innovation and focus on relative innovation. The rationale is that on its own, construction displays sufficient levels of innovation. However, compared to that of manufacturing, innovation in construction is seen as woefully inadequate to act as a driver for accelerated improvement and productivity growth (Latham, 1994).

In 1990s, efforts were made in the UK to transform the construction sector with particular emphasis on re-configuring its project delivery from the traditional functional approach to that of a manufacturing process (M4I, 2000). The transformation effort was part of a general agenda to stimulate innovation across different industrial sectors within UK that was spearheaded by the Innovative Manufacturing Initiative (IMI) (Graves et al., 1998). The programme for the construction sector was entitled Construction as a Manufacturing Process (CMP), and was aimed at stimulating construction to emulate the productivity and operational gains that characterised the transition from a functional to process orientation by the manufacturing sector (McCaffer and Edum-Fotwe, 2003).

Innovation in construction sector could be grouped into two categories namely technical and socio cultural. Improvement in both categories is needed if the desired accelerated innovation in construction is to be achieved. Studies on how construction can achieve accelerated innovation predominantly focus on the technical factors, and not much attention has been given to the socio-cultural factors. The socio-cultural aspect relates to the personal characteristics of individual estimators, and includes making decisions in their work environment. For example, Hamza and Greenwood (2007) researched on the impact of procurement methods on delivery of environmentally sensitive buildings and concluded that innovation in that context will include early freezing of designs to enable contractors mitigate schedule-related risk. The driving force behind any procurement activity involves the estimator, and their role in achieving any anticipated innovation would be critical.

There are a number of innovations in the delivery of design, which are starting to take hold in the construction industry. Greenwood et al. (2008) identified the use of integrated designs for the delivery of major infrastructure projects in UK. In investigating the importance of innovations Walker et al. (2010) identified the merits and demerit to the project consortium in the use of standardisation in design.

In the UK, many organisations have had exposure to changes in the processes employed for the delivery of their projects. Price and Newson (2003) accepted the notion that the process changes in delivery of projects that is taking place in most organisations reflect the transformational type. Price and Newson (2003) advocated for more of such transformational change for construction organisations and argued that emphasis on effective innovations in the construction industry should focus on business strategies. The innovations in the construction organisations are equally vital for the realisation of reliable budget on projects. According to Price and Newson (2003), the advocated change will require a blameless culture, and a revolution in the way risk management transpires in construction. They include innovations in the quality of writing construction specifications to minimise ambiguous project information. Often the specifications are employed to establish the project cost estimates. Therefore, the reliability of project cost estimates could influence the quality of specifications adopted for the project. Kululanga and Price (2005) explored specification-writing capabilities of contractors operating in Malawi. They identified the writing of construction specifications as one of the greatest challenges that construction contractors in Malawi have to face. Kululanga and Price (2005) developed a management instrument that could aid construction contractors in specification writing, which they argued had the potential of improving the reliability of project cost estimates.

Innovations in construction organisations could improve reliability of estimates. However, the processes are driven by people, and therefore, the influence of the behavioural characteristics of the key professionals would significantly affect the outcome of any innovative efforts.

## 2.6 ESTIMATING IN NON-CONSTRUCTION

In the non-construction sector, such as aerospace and general manufacturing, different methods are used in estimating the cost of any activity (NASA, 1995). The methods employed tend to vary from sector to sector, and also from company to company. The use of different practices is driven by many factors such as the company's established procedures (NASA, 1995). The subsequent sub-sections present some of the predominant non-construction estimating practices.

## 2.6.1 Parametric Cost Estimation

A parametric cost estimating is a method of cost estimating that is mostly use in the manufacturing sector. Although there are examples of the use of parametric estimating in the construction sector, in general it is on a smaller scale compared with its use in the manufacturing sector. NASA (1995) described parametric cost estimating as a technique that employs one or more cost estimating relationships (CER) and associated mathematical relationships and logic to establish the cost of any proposed project. The estimate is based on a technical, physical, or other characteristic that can be objectively associated with an element or the whole of the project. The fundamental purpose of the process involved in applying the technique is to establish a clear linkage between cost and a product's technical parameters. Characteristics of the project employed in parametric cost estimating within the construction sector are usually the cost sensitive constituents of the particular project. Without this linkage, a product cost cannot be effectively defined. The essential difference between the parametric and non-parametric estimating systems is that estimating in non-parametric systems do not necessarily require a linkage of any cost sensitive constituent element of the project, and where they are established, it is often done without any substantial precision. The key terminologies used in parametric estimating are addressed in the subsequent sub-section.

### *2.6.1.1 Cost Estimating Relationships*

Cost Estimating Relationships (CER) are mathematical expressions that relate the cost of a independent variable with one or more dependent variables. The associated estimating procedure involves forecasting the cost of a project based on the CER and the model developed from relationships are forms of forecasting real world cost for a future state of a proposed project (NASA, 1995). As such, the output estimate has a probability of being within a given percentage of the final cost of completion. The reliability of this method of estimating is reliant on the dependability of the project cost data. The better the dependability and consistency of the project cost data employed for the model, the closer the estimate would be to the final cost at completion of the project. In the use of CER for estimating practice, no amount of complicated mathematical formulas could compensate for a deficient data. It is therefore, paramount that a considerable time is devoted to the collection of such input cost information to ensure that the data has consistency and is viable for a dependable database.

The uncertainties of producing a realistic cost estimate within a given percentage of the final actual project cost is often translated as price risk. These uncertainties can be grouped into two major categories. The first category is uncertainty faced by any organisation to perform as planned due to unexpected scope changes in resource or scheduling affecting the effort to produce the design or product. This risk could be mitigated through an effective and improved specification and better communication between the stakeholders. The second category is uncertainty associated with the development and the usefulness of any cost model. The mitigating measures for the risks associated with the second category of uncertainty are indicated in Table 2.1.

**Table 2.1: Uncertainties and Mitigations Measures in Estimating**

| Item | Uncertainty | Mitigation Measures |
|---|---|---|
| 1 | Uncertainty associated with omission of a key cost driver | Development of historical cost data by well defined Work Breakdown Structure (WBS) |
| 2 | Mis-specification of the form of the model equation | Careful review of in-house and industrial data |
| 3 | Modelling limitations associated with a lack of data | Expert opinion and availability of relevant data |
| 4 | Data consistency across multiple project databases | WBS which are standardised across projects; the definition of system engineering and project management should be consistent for the cost model |

*(Source: NASA, 1995)*

Sometimes, the uncertainties arise as a consequence of human behaviour. For example, factors such as omission of key element, or miss-specifications could be a result of the professional estimator not being meticulous in their work. This therefore, reinforces the importance of the attitude of the professional estimator in discharging their roles. The mitigation measures identified against the risk associated with lack of data often involve human judgement. Such judgement is influenced by the general behaviour characteristics of individuals, their decision-making orientations as well as their level and scope of professional experience. Valid CERs have to be based on sound statistical concepts for them to provide the strengths that attend their use. NASA (1995) identified the strengths and weaknesses of CERs and these are presented in Table 2.2.

**Table 2.2: Strengths and Weakness of CERs**

| Item | Strength | Weakness |
|---|---|---|
| 1 | CERs are quick and easy to use. | CERs are sometimes too simplistic to forecast costs.<br>Generally, if one has detailed information, the detail may be reliably used for estimates.<br>If available, another estimating approach may be selected rather than a CER. |
| 2 | CERs can be used with limited system information. | Problems with the database may mean that a particular CER should not be used.<br>While the analyst developing a CER should validate that CER.<br>Source documentation used in cost model will have to be reviewed prior to usage of the model. |
| 3 | CER derived from an accurate database can be relied upon to produce quality estimates. | |

*(Source: NASA, 1995)*

### *2.6.1.2 Parametric Cost Model*

This is group of cost estimating relationships used together to estimate entire cost proposals or significant portions of the project. The technique relies on linkages that include many inter-related CER, reflecting both cost-to-cost and cost-to-non-cost dependencies. The parametric cost model is used by the government of the United States of America and the contractors in planning, and budgeting for projects and programmes. The technique enables government contractors to expedite the production of early project estimates by using proven models that rely on parametric techniques.

### *2.6.1.3 Cost Realism*

Cost realism is the system of logic, the assumptions about the future, and the reasonableness of the historical basis adopted for establishing an estimate for a project. NASA (1995) presented some of the cost realism factors applied in their use of parametric cost estimating as follows:

i. Reasonableness of the assumptions used in the estimating process;
ii. Normalisation of the historical database used to account for external and contextual parameters such as inflation;
iii. Logical basis of the cost estimate regarding the sense it makes in the context of the hardware or software product or service being estimated;
iv. Managing biases that the estimate may display toward being too low or too high;
v. Managing organisational motivation to produce an inordinately high or low estimate in order to serve their individual purposes other than that of the project; and
vi. Misuse of the historical basis data by "cherry picking" to ensure the cost estimate obtained is unreasonably high (contractor) or unreasonably low (auditor or government customer).

The nature of response to these realism factors is often more subjective than the objective aspirations of CER, and can have a significant impact on the reliability of cost estimates produce from parametric cost estimating. Notwithstanding this obvious subjective influence reflected by the listed realism factors above, the technique of estimating by this method often ignores the effect that endogenous factors associated with the behavioural characteristics of professionals in their decision-making orientation. The inclusion of such endogenous factors in the technique could contribute to a more reliable cost estimate.

### 2.6.2 Interpretation of "Quality"

The importance of quality in estimating for manufacturing facilities was emphasised by Render et al. (2005). Render et al. (2005) investigated what constitutes good manufacturing practices in the validation of constructed pharmaceutical facilities. They concluded that the success of manufacturing facilities is determined by time of completion, cost of facility and quality. They further argued that quality is difficult feature to measure and its "*...meaning ... can be elusive, and ... is at the root of the problem of successful validation of pharmaceutical buildings*" (Render et al., 2005). According to Render et al. (2005), construction project managers consider quality as a measure of workmanship whiles in the manufacturing sector it is considered in terms of assurance and regulatory compliance. Render et al. (2005) concluded that the under-estimation of the input cost by the construction project manager is often due to the differences in the meaning of what constitutes quality. The research of Render et al. (2005) shows the importance of the definitions on the reliability of manufacturing facilities.

## 2.7 PROJECT COST CONTINGENCY

The occurrence of inadequate project cost estimates for projects implemented in the construction industry is a common phenomenon (Skitmore and Marston, 1999). Such inadequacy in the estimates usually leads to cost overruns on projects. The inability of the client to pay for unbudgeted overruns is often the source of friction between clients and contractors on the issue of price or budget variations. Although the causes of project cost overrun are well known, the methodology used in handling its evaluation, especially with regard to *contingency* allocation on projects is at best described as inadequate (Sohail and Edum-Fotwe, 2000). The use of contingency in construction provides a clear and tacit acknowledgement of the perennial problem of inadequate project cost estimates compared with the final cost in the delivery of construction projects.

Contingency allowances are established in order to compensate for the unfavourable decisions that cause unreliability in project cost estimate. The difference between the budget and the final cost of projects is attributed to the effect of the inaccuracies in the budget produced on the project. In particular, while the establishment of budget estimates for projects is often conducted from first principles, the allocation of contingency to account for possible cost overrun is either a lump sum or a simple percentage. Understanding the nature and factors that account for the inaccuracies in project cost estimates will assist in establishing more reliable project costs. Equally, an appreciation of the relationship between project budget estimates and final budget for completed projects should provide insights on the general profile of budget contingency to adopt for different scales of projects (Assaf et al., 1995; Sultan, 1999).

Contingency allowances are provided in estimates of project costs to cater for events unforeseen during estimating. The use of contingency sums on project cost has no scientific basis. Causes of cost inaccuracies in project cost estimates are covered relatively well from the physical perspective. However, there are little published data on the basis of contingency allocation on projects to compensate for the unfavourable deviations from the estimated cost of projects from the budget. The amount provided for contingency sums in project cost estimates is dependent on the experience of the estimator, and the extent to which the estimator manages the project cost data on past projects. Afetornu (2005) made an attempt to establish such a framework for allocation of contingency sums on projects in order to obtain more certainty on cost of projects. Afetornu (2005) employed forty past projects from the road sector of Ghana. The cost data from the forty (40) past projects were modelled to produce a relationship between estimated project cost and the contingency allowance on the project at completion.

## 2.8 SUMMARY

The literature review in this chapter has identified several factors that influence reliability of project cost estimates. These factors can be categorised either as exogenous or endogenous to the estimator. The review has revealed that the work of most previous authors and researchers on the causes of unreliability in construction cost estimates predominantly addressed the exogenous or external dimension. The external factors identified in the review include conditions in the work environment, inflation, actions and inactions of other parties to the construction contract, availability and reliability of information on projects and pre contract planning. Other factors identified include, reliability of design drawings, workload, project Management, availability and reliability of cost data, maintenance level on equipment, availability and adequate number of experienced estimators, pressures from superiors, risk and procurement type. The review demonstrated that while efforts have been made in construction to address the identified exogenous factors, unreliable estimates still affects the sector. Equally, the effects of unreliable project cost estimates are still attend most projects within the manufacturing and IT industries, where more mathematical and objective options are employed for estimating. The argument therefore, is that the residual contribution to unreliable project estimates may well lie beyond the current consideration of external factors that most studies have addressed.

The review also established measures to mitigate the effects of the exogenous factors on reliability of construction cost estimates. Some of the measures identified include proper project management, adequate number and calibre of estimators, clear and defined brief from clients, detailed working drawings, well structured planning of work environment, and proper project management from parties on the project and their representatives.

The availability of technologies such as Building Information Model (BIM) is fostering opportunities for a minimisation of the influence on estimating reliability from undependable project information. However, continuous existence of unreliable estimates in recent times identified in the review provides strong evidence that the technological solution BIM presents can achieve a faster programming of the estimates and not necessarily its reliability.

The review demonstrates that the ‘missing link’ in achieving reliable estimates could well be the influence of the endogenous factors associated with the estimator. The review revealed that there was no evidence of any investigator addressing the influence of these internal factors on reliability. Consequently, the focus of this research is to investigate the influence of these endogenous factors on the reliability of project cost estimates.

The next chapter will explore how these practices and concepts reflect in the environment from which data is sourced for this study, and would entail a detailed coverage of estimating practices in Ghana. It would also address how current estimating practices in the country affect the reliability of project cost estimates. Furthermore, it will identify contextual factors that make estimating in the country different from estimating in other economic contexts.

# CHAPTER 3

# ESTIMATING PRACTICE IN GHANA

## 3.0 OVERVIEW

This chapter explores the estimating practices in Ghana and delves into the causes of unreliable project cost estimates in the construction sector of the country. The chapter commences by portraying the importance of the construction sector to the national economy of Ghana. This is followed by a review of the construction sector in Ghana with particular reference to the road sector. The chapter also presents a discussion of the organisations responsible for the implementation of road projects in the public sector and addresses some of the shortcomings that contribute to unreliable cost estimates. The chapter examines the estimating procedures in Ghana from both the private sector and the public sector perspective.

## 3.1 GHANA IN CONTEXT

Ghana is located in West Africa with its capital city as Accra. The country sharea a boundary to the east with the Republic of Togo, on the west with Cote D'ivoire, on the north with Burkina Faso and with a coastal boundary on the south by the Gulf of Guinea. Ghana is divided into ten (10) geographical regions. Figure 3.1 shows the ten (10) geographical regions of Ghana.

The sectors responsible for the construction sector in the public sector are divided into. Ministry of Roads and Highways is responsible for the roads and the related infrastructure whiles the Ministry of Natural Resources, Water Works and Housing is responsible for water and the related facilities. The road sector alone accounted for nine percent (9%) of Ghana's Gross Domestic Product (GDP) in 2005 (NTPG, 2005). This figure buttressed the importance that the government of Ghana attaches to the road sector. Figure 3.1 shows the map of Ghana indicating the ten (10) geographical regions and the trunk road network.

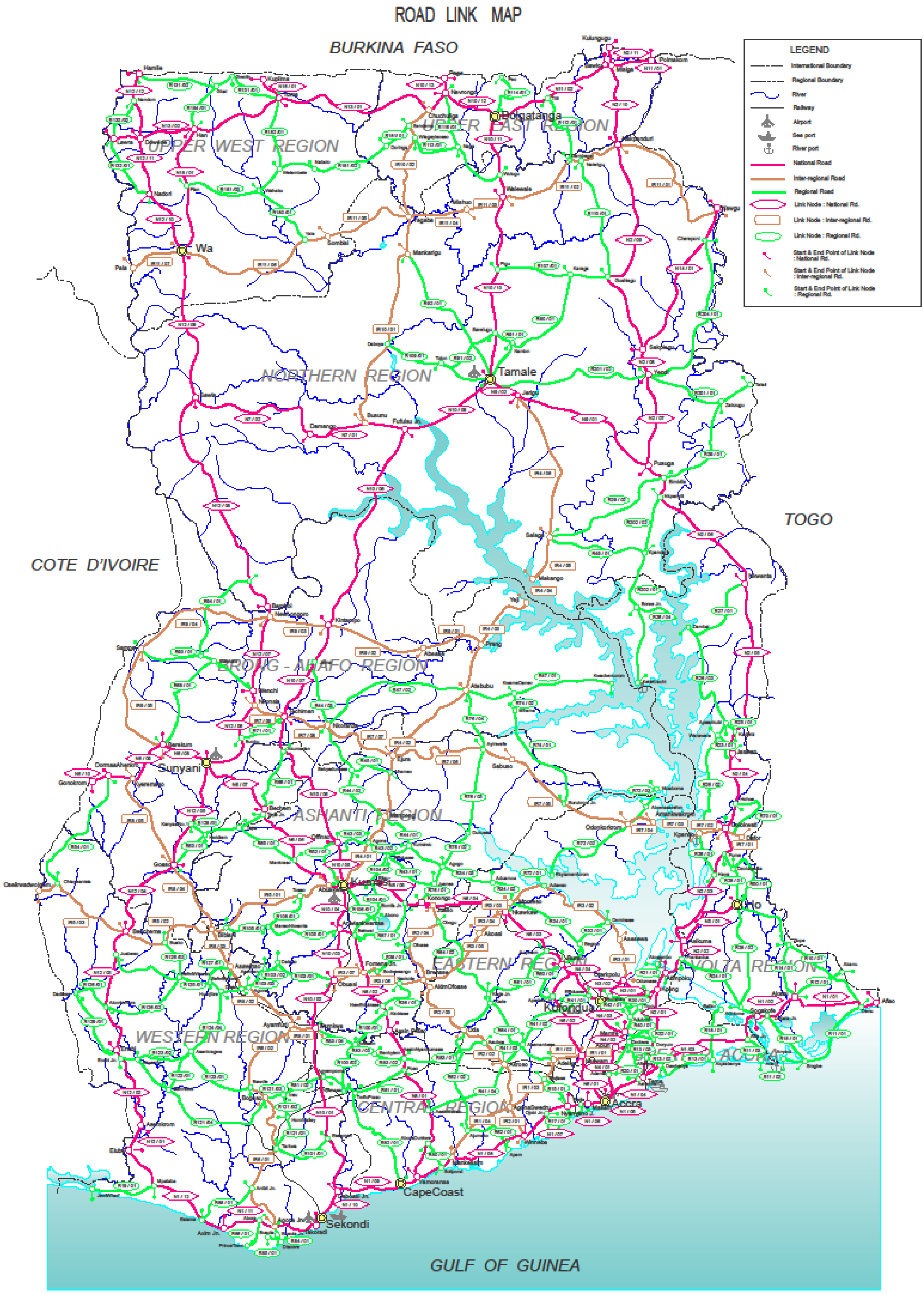
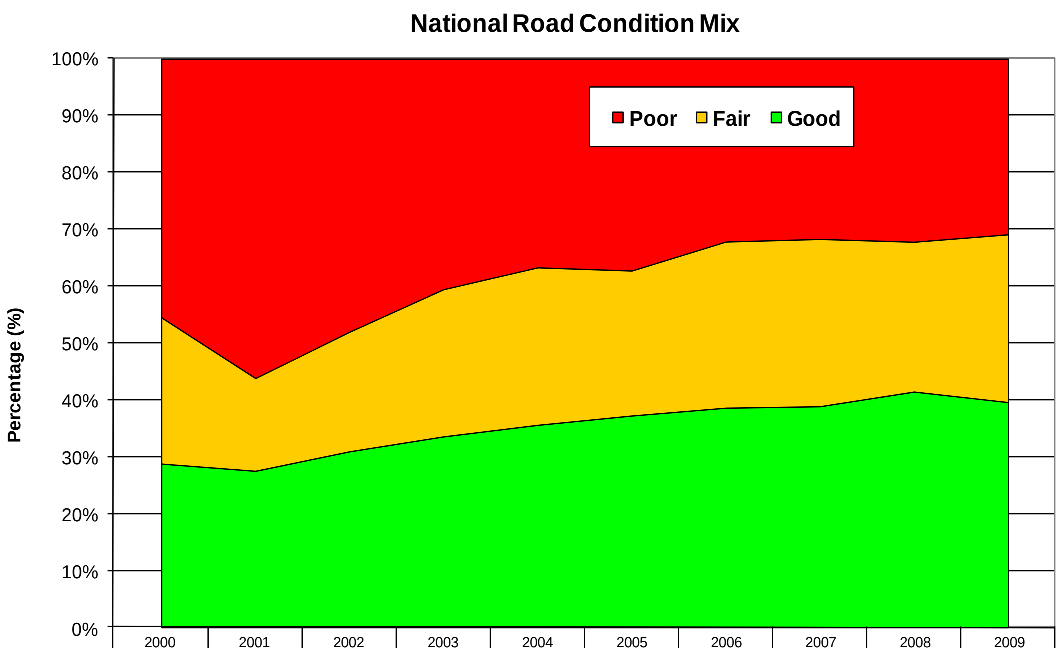



**Figure 3.1: Map of Ghana (Regions and Trunk Roads network *(Source: Ghana Highway Authority)***

Ghana is a developing economy. Infrastructure development is therefore, paramount for such a developing economy to achieve middle-income status, and therefore, calls for huge investments in infrastructure development. Ghana has predominantly an agriculturally based economy. Cash crops like cocoa, coffee and sheabutter have to be transported to the ports for export in order to earn foreign income for the development projects. Similarly, the food crops have to be transported to the cities for the city dwellers in order for farmers and rural dwellers to earn revenue to improve their living standards. The transportation of these crops requires a network of good roads across the length and breadth of the country. However, the road network in Ghana is rather inadequate to meet the transportation requirements due to a number of factors. First, the condition of the existing network is best described as being in very deplorable state. Second, the length of the network only caters for a third of the capacity that the country needs (MRH, 2010). Third, the class of major routes is limited, and often does not provide for alleviating routes should any link road between two major towns close down because of an emergency. This is evident from the road condition mix obtained from the Ministry of Roads and Highways of Ghana, the sector responsible for the development and maintenance of road infrastructure in Ghana. Road network in Ghana is divided into three classes namely, urban roads, feeder roads and trunk roads. Figures 3.2 and 3.3 show the road condition mix and network size of road portfolio in Ghana respectively.

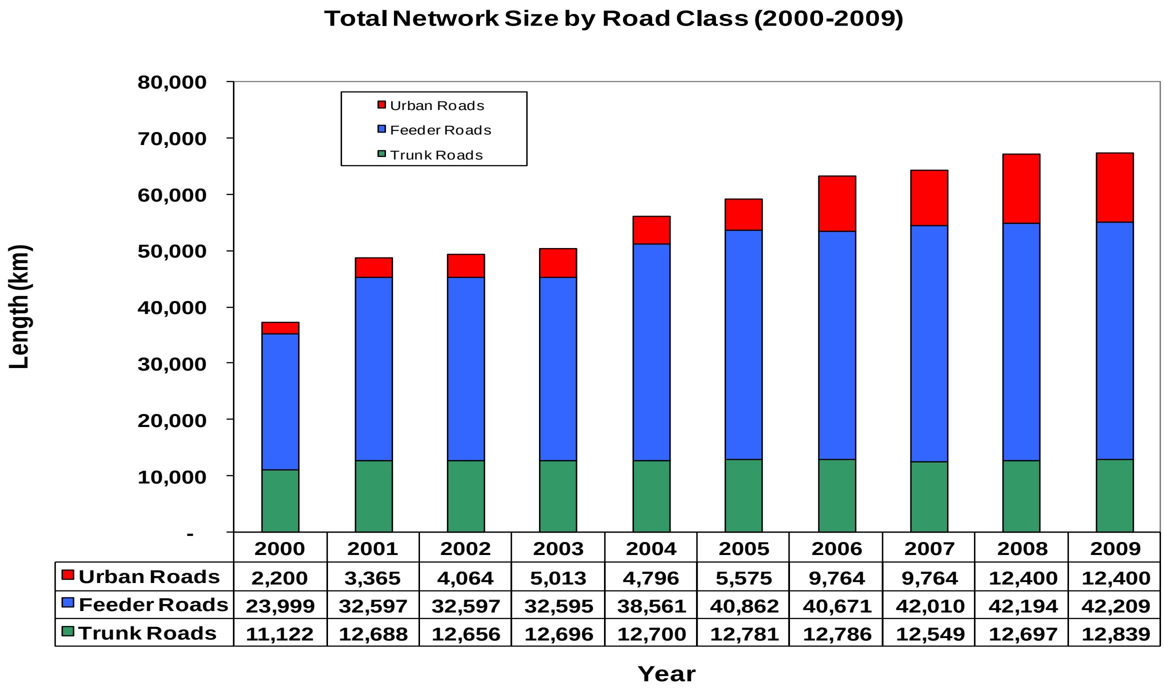



| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| Poor | 45.5% | 56.1% | 48.0% | 40.5% | 36.7% | 37.2% | 32.1% | 31.7% | 32.2% | 30.9% |
| Fair | 25.8% | 16.4% | 21.1% | 25.9% | 27.8% | 25.6% | 29.3% | 29.5% | 26.4% | 29.6% |
| Good | 28.8% | 27.5% | 30.9% | 33.5% | 35.6% | 37.2% | 38.6% | 38.8% | 41.4% | 39.6% |

Year

**Figure 3.2 Condition Mix of Ghana's Road Network (*Source: Ministry of Roads and Highways-Ghana*)**

Figure 3.2 shows that only 39.6% of the total road network was in good condition in 2009, having improved gradually from 27.5% in 2001. However, a large proportion (60.4% of the road network in Ghana are in deplorable state and require upgrading. In addition, the network size has increased over the years in each of the classes of road network as shown in Figure 3.3. The government therefore, has to invest additional capital to improve these roads to benefit both the government and the public at large. The level of economic development in any nation, particularly developing countries, could be seen from the level of its road infrastructure. For example, the road sector alone accounted for a GDP contribution of 9% in Ghana (NTPG, 2005).

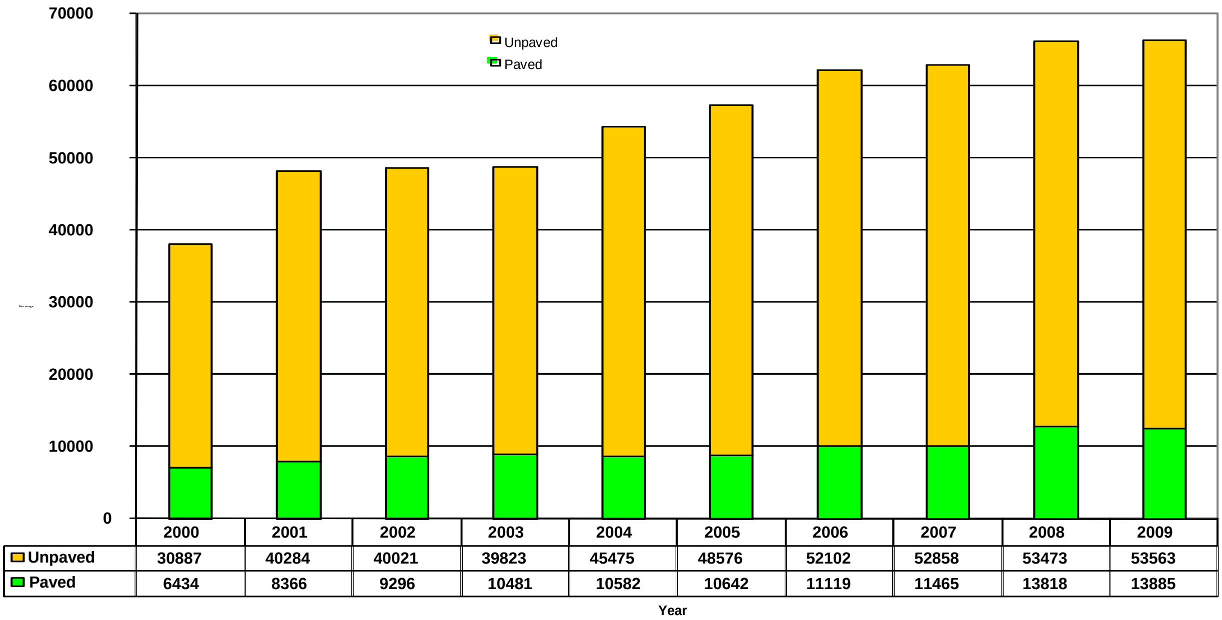



| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| Urban Roads | 2,200 | 3,365 | 4,064 | 5,013 | 4,796 | 5,575 | 9,764 | 9,764 | 12,400 | 12,400 |
| Feeder Roads | 23,999 | 32,597 | 32,597 | 32,595 | 38,561 | 40,862 | 40,671 | 42,010 | 42,194 | 42,209 |
| Trunk Roads | 11,122 | 12,688 | 12,656 | 12,696 | 12,700 | 12,781 | 12,786 | 12,549 | 12,697 | 12,839 |

**Figure 3.3: Network size by Road Class (***Source: Ministry of Roads and Highways –Ghana***)**

The total portfolio of roads stood at 67,448km as at the end of 2009. The network distribution by class as at 2009 was 18.38% for urban roads, 62.58% for feeder roads and 19.04% for trunk roads.

The surface type of roads in Ghana is mainly gravel and unpaved. Figure 3.4 presents the proportion of the surface type for the road network in Ghana. Just as it is in many other developing economies, availability of funds has inhibited the paving of the road network due high cost required for paved carriageway. Given the volume of the various road types, the demand for road projects for both new and upgrade schemes, far outweighs the funds available. To satisfy the greater majority of the communities with the limited funds, unpaved roads are mostly constructed. The paved roads in Ghana cover the trunk roads and urban roads although some of the feeder roads network is paved.




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| Unpaved | 30887 | 40284 | 40021 | 39823 | 45475 | 48576 | 52102 | 52858 | 53473 | 53563 |
| Paved | 6434 | 8366 | 9296 | 10481 | 10582 | 10642 | 11119 | 11465 | 13818 | 13885 |

**Figure 3.4: Surface Type of Road Network (***Source: Ministry of Roads and Highways, Ghana***)**

In Ghana, the construction sector employs a relatively large number of people. The activities in the construction sector directly affect other sectors of the economy. The government therefore, often uses the construction sector as a regulator for the economy of Ghana. If there is a low economic activity, the government increases spending on construction to create growth for the economy. On the other hand, if there are inflationary pressures or the economy is overheating because of high activity, the government reduces spending in the construction sector in an attempt to reduce money in circulation. Therefore, the importance of the construction sector to the government could not be overemphasised.

# 3.2 REVIEW OF THE ROAD SECTOR IN GHANA

In Ghana, the transport system serves as the nucleus for the socio-economic development of the nation. The road sector, which forms the backbone of the transport system in Ghana, is regulated by the Ministry of Roads and Highways. The main function of the Ministry is policy formulation. The Ministry has three (3) Agencies under its jurisdiction. These are:

i. Ghana Highways Authority (GHA);
ii. Department of Urban Roads (DUR); and
iii. Department of Feeder Roads. (DFR).

The Agencies are responsible for the development and maintenance of the roads and its related infrastructure in Ghana. The tables and figures including other relevant information used for the review were obtained from the Government database of the Ministry of Roads and Highways in Ghana. The subsequent sections examine the functions of the Ministry and its Agencies with particular emphasis on estimating practices in Ghana.

## 3.2.1 Ministry of Roads and Highways

Similar to all transport systems worldwide, the road system in Ghana is a national asset that contributes to the socio-economic development of the nation. In recognition of its economic importance, the Government of Ghana in 2009 created the Ministry of Roads and Highways from the combined Ministry of Transportation (GoG, 2009). This was aimed at ensuring efficiency in the administration of the road network in Ghana through a single Ministry with sole responsibility for the roads and the associated infrastructure. The rationale for the new establishment was to ensure that a Minister who can carry out the political programme of the government heads the new Ministry.

The Minister is appointed by the President of the Republic of Ghana, and is assisted by a deputy who is also appointed by the President. The technical team of the Ministry is headed by the Chief Director. The vision and mission statements that drive the activities of the Ministry are summarised in the subsequent sections.

### *3.2.1.1 Vision and Mission Statements*

The vision of the Ministry of Roads and Highways of Ghana is to make the road network in the country all weather roads that create easy accessibility in the country to facilitate quick economic activities (MRH, 2009).

The mission statement of the Ministry is to provide an integrated, well managed and sustainable transport infrastructure to meet national objectives. To achieve the vision and mission of the Ministry, policies have been formulated to facilitate the realisation of the objectives adopted for the sector, which is listed below.

i. Develop in-country capacity for Government institutions and the private sector manage the road network efficiently.
ii. Ensure sustainable funding of the sector programme.
iii. Make investment decisions by taking account of sound socio-economic and sustainable environment factors.
iv. Enhance operational efficiency of the road network to promote economic delivery of social services.
v. Integrate road network with other modes of transport, with a view to achieve greater efficiency for the use of the network.
vi. Develop comprehensive road safety programme.
vii. Mitigate negative environmental and social impact of the road and other transport related activities.

Like all other sectors of the economy of Ghana, the road sub-sector performs its functional responsibilities based upon the above policy guidelines.

### *3.2.1.2 Directorates of the Ministry*

In order to harmonise the activities within the Ministry towards achieving its goals and objectives, the responsibilities of officers in the Ministry have been categorised into units based upon their functional roles (GoG, 2009). Each unit is called a Directorate and headed by a Director. The technical head of the Ministry is the Chief Director, to whom all the other directors report. There are seven (7) directorates in the Ministry and these are:

i. Administration
ii. Procurement
iii. Policy and Planning
iv. Monitoring and Evaluation
v. Human Resource Development
vi. Research, and
vii. Finance

For the purposes of understanding estimating practices in Ghana, the study focused only on the activities of the Procurement Directorate, which has the direct responsibility for ensuring that good practices are incorporated in the estimating practices of the roads sector. The Procurement Directorate is responsible for all pre-contract activities in the Ministry and its Agencies (GoG, 2009). The Procurement Directorate reviews all the pre-contract activities, such as:

- preparation of Tender documents for goods and works;
- preparation of Request for Proposal documents for Consulting services;
- evaluation reports for works, goods, and services;
- evaluation designs; and
- preparation of project budget for use by the Central Government through the Ministry of Finance and Economic Planning in the preparation of the country's fiscal policies.

The reliability of the budget submitted to the Ministry of Finance and Economic Planning is dependent on the reliability of the cost estimates produced for the various proposed project activities in a given budgetary round. Cost estimates are produced in Ghana from the first principles. This, therefore, requires adequate calibre and number of experienced estimators for the realisation of a desired level of reliability. The available staff that meets the above requirements from each of the implementing Agencies and the resultant impact on reliability of cost estimates from the activities of these staff are discussed the subsequent sections of this chapter.

The organisational structure of the Ministry shows the relationship between the Procurement Directorate and other Directorates. The existence of the lateral relationship improves the interaction with the other directorates. In particular, supporting activities such as recruitment for the procurement directorate and training programmes that the directorates organises to facilitate the realisation of reliable project estimates receive fast attention once approved at directorate level. The responsibility of the procurement directorate among others is to ensure that estimating processes are uniform in all the Agencies under the Ministry. The procurement directorate is also responsible for all aspects pertaining project costs and estimating. Figure 3.5 shows the organisational structure of the Ministry of Roads and Highways in Ghana. The subsequent sections review each of the implementing Agencies under the Ministry in relation to how estimating activities are conducted.

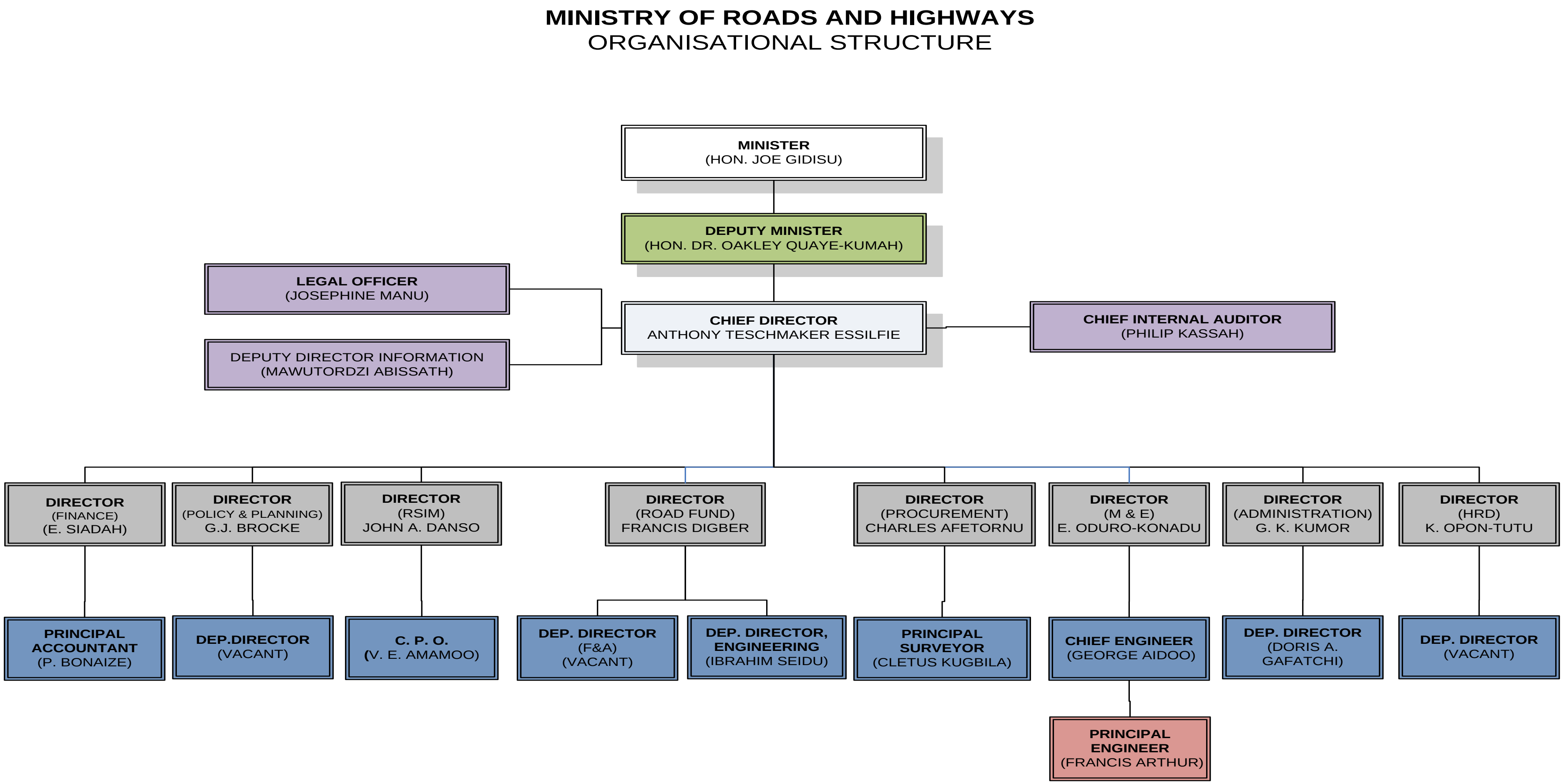



**Figure 3.5: Organisational Structure of Ministry of Roads and Highways (***Source: Ministry of Roads and Highways of Ghana***)**

## 3.2.2 Ghana Highway Authority

Ghana Highway Authority (GHA) was established in December 1974. The Ghana Highway Authority is charged with the responsibility for administration, development, and maintenance of trunk roads and related facilities in Ghana. GHA is the largest of all the agencies under the Ministry (MRH, 2009). The vision and mission statements of the Ghana Highway Authority are as follows.

### *3.2.2.1 Vision and Mission Statement*

The vision of Ghana Highway Authority is to ensure that Ghana has a smooth economic and reliable trunk road network compatible with the minimisation of road accidents (MRH, 2009). The mission statement is to provide a safe and reliable trunk road network at optimal cost, with the use of modern technology in road building and new income-generation to facilitate socio-economic development in Ghana.

Ghana Highway Authority has developed broad policy objectives to accelerate the realisation of the mission and vision statements. These are to:

i. maximise the benefits from existing and planned highway investments in order to network at its optimal mix, such that the total road transport cost (construction, maintenance, and operation) is at a minimum;
ii. achieve a high level of quality in the design, construction, and maintenance of roads and to pay attention to safety and environmental issues for the roads sector;
iii. train and develop adequate levels of manpower in order to keep them well informed of their roles, responsibilities and accountability, and to enable them make good decisions as well as become dedicated to the continuous improvement of the trunk road network in Ghana; and
iv. help expand local construction capacity to support highway development and maintenance.

### *3.2.2.2 Structure of Ghana Highway Authority*

The structure of Ghana Highways Authority (GHA) and its relationship with estimating practices is discussed in the subsequent section.

**Board of Directors**

Ghana Highway Authority is governed by a Board of Directors. The board is made up of ten (10) members, consisting of a chairperson, the chief executive (head of GHA), and eight (8) others (MRH, 2009).

**The Directorate**

The head of the Ghana Highway Authority is designated as Chief Executive, and is assisted by three (3) Deputy Chief Executives. These are Deputy Chief Executive (Administration), Deputy Chief Executive (Development), and Deputy Chief Executive (Maintenance) in accordance with their functional roles and responsibilities. The Chief Executive and the three (3) deputies are responsible for the operational activities of the GHA, and implement the strategic decisions of the board of directors.

**Departments**

The Ghana Highway Authority (GHA) has three (3) main departments. These are Administration, Development and Maintenance. These three departments together with the regional offices are responsible for the implementation of the policies and projects of GHA. The divisions in each of the three departments are listed in the next section, and the departments and divisions responsible for estimating practices in GHA are discussed in much more detail. Figure 3.6 shows the organisational structure of the Ghana Highway Authority (GHA).

**Administration Department**

The Administration department is comprised of seven (7) divisions. These are:

i. Human resource;
ii. Training and development;
iii. Finance;
iv. Legal;
v. Public affairs;
vi. Internal Audit; and
vii. Management Information System (MIS).

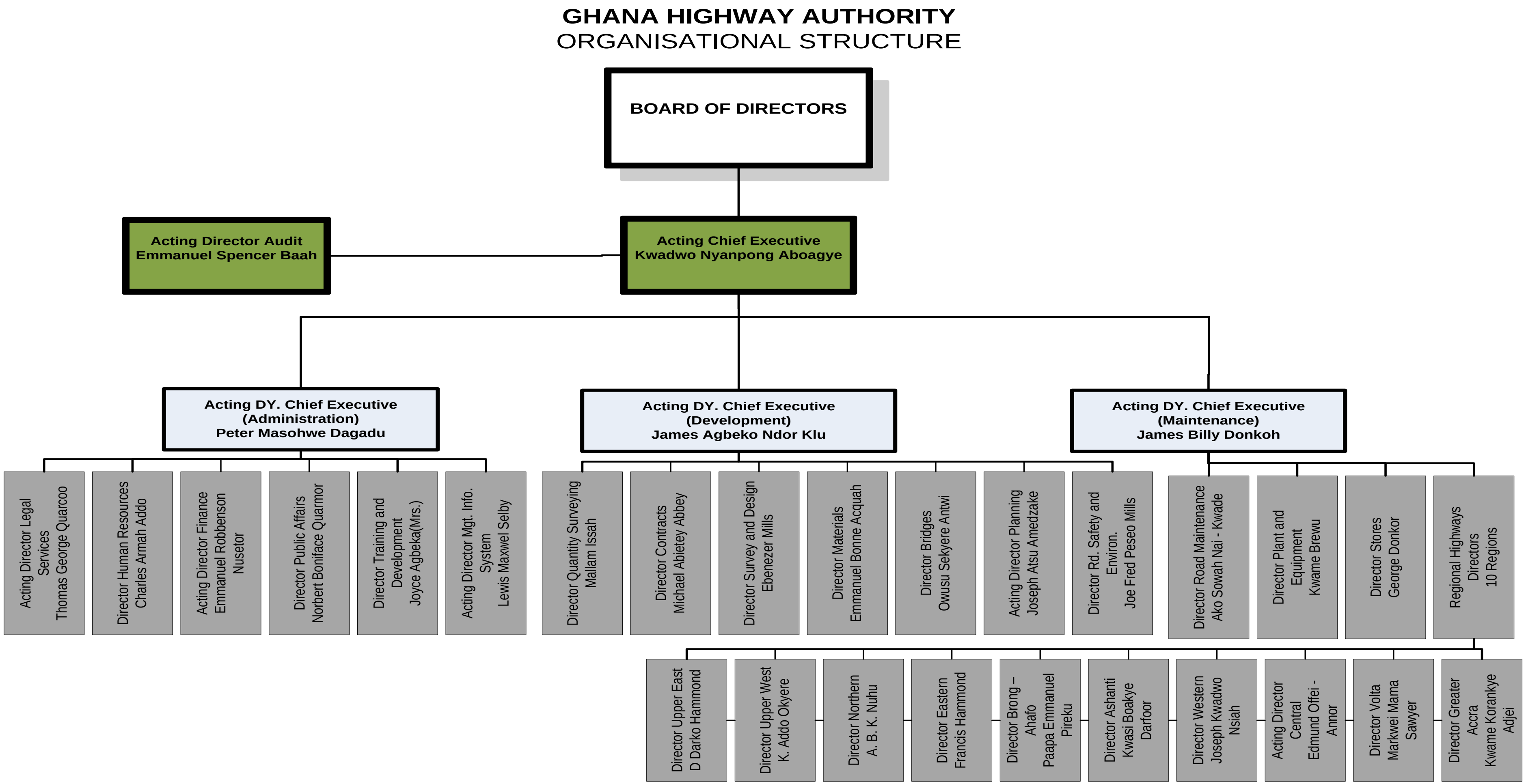



**Figure 3.6: Organisational Structure of Ghana Highways Authority** *(Source: Ghana Highways Authority, Ghana)*

***Human Resource (HR)***

The HR division is responsible for developing and recommending policies to address personnel planning, enlistment, promotions and replacement of staff. It is also responsible for maintaining a labour relations programme for achieving a stable working relationship between the Authority (Executive) and its employees. There is lateral relationship between this division and the division responsible for estimating. This is to ensure interaction between the two divisions to ensure that the appropriate types and calibre of staff are recruited for the estimating division.

***Training and Development Division***

The Training and Development Division is charged with the responsibility of identifying the training needs of staff, organising and supervising the development and implementation of skills programmes aimed at tackling the training needs of staff. This division liaises with the estimating division in order to put together training programmes to improve the calibre of estimating staff.

**Development Department**

The development department has six (6) divisions.

i. Design
ii. Materials
iii. Contracts
iv. Bridges
v. Road safety and environment

**Maintenance Department**

The maintenance department has the following three divisions.

i. Plant and Equipment
ii. Road maintenance
iii. Stores and Supplies

**Regional offices**

Ghana is organised into ten (10) geographical regions for effective political administration of the country. Ghana Highway Authority has offices in all the (10) geographical regions of Ghana and the head of the regional offices is designated as

Regional Highway Director. The Development and Maintenance departments together are responsible for all the pre- and post-contract activities in the Ghana Highway Authority. The pre-contract activities include the preparation of cost estimates for the designated road project and related costing required for approval of a proposed scheme. In the GHA, estimating is prepared from the first principles. The estimating practice in Ghana Highway Authority is the same as what pertains in the Ministry and the rest of the Agencies under the Ministry. Again, the staff strength of GHA in respect to experienced estimators, is very low. The details of the number of experienced estimators as against the number of projects for which cost estimates are prepared for is shown and discussed in the subsequent section of this chapter.

### 3.2.3 Department Of Feeder Roads

The Department of Feeder Roads (DFR) was created in 1981 as a separate agency from the Ghana Highway Authority (GHA) to administer the feeder roads network. Feeder roads comprise mainly rural roads in Ghana. The setting up of the DFR was to have a department whose essential focus is on the rural roads network to ensure effectiveness of, as well as improvement in the transportation of agricultural produce. The Department of Feeder Roads has a developed vision and mission to propel its strategic and operational activities.

#### *3.2.3.1 Vision and Mission of DFR*

The vision of DFR is to realise a decentralized feeder roads network ensuring that all rural communities are provided with road access to enhance the social and economic well-being of citizens (DFR, 2010). The mission of the Department is to ensure provision of adequate and accessible feeder roads at optimum cost. This is addressed by using competitive and effective planning, development, rehabilitation and maintenance to achieve efficient movement of people, goods and services, as well as promote socio-economic development of rural communities and the agricultural sector.

The DFR is guided by a set of key objectives in pursuance of its mission statement that can be summarised as follows.

- To provide improved access for the movement of people to facilitate the promotion of economic activities and road access to rural communities.
- To protect investment made on improved roads maintenance system.
- To provide employment opportunities for rural poor through the greater use of labour-based road construction technology.
- To use sound economic principles as decision criteria for investment programmes in the rehabilitation and construction activities of road schemes.
- To improve the institutional capacity of DFR to site its programmes.
- To engage expects to provide specialised technical services.
- To implement measures to mitigate the negative environmental schemes.
- To assist in the development of the technical capacities of the District Assemblies (DA's).
- To facilitate the decentralisation process and for the effective maintenance of feeder roads.
- To assist the District/Municipal assemblies in the prioritisation of roads for maintenance using the Road Prioritisation Methodology.
- To address the levels of poverty and gender issues in the respective districts.
- To assist in the expansion and enforcement of core labour standards.

The implementation of these objectives are best appreciated by providing an analysis of the strengths and weaknesses of DFR.

### *3.2.3.2 SWOT Analysis of DFR*

In delivering its objectives, the Department of Feeder Roads is affected by a number of factors, some of which produce a positive outcome while others present a negative consequence for the department. A SWOT analysis was performed on the DFR by a consultant to identify factors that contribute negatively to the achievement of its objectives, and also to strengthen those that DFR has performed relatively well. This was conducted against the background of numerous cost overruns experienced on most projects executed by the department (GoG, 2009). In one sense, the cost overruns are deemed as the result of unreliable project cost estimates among others. Figure 3.7 shows the organisational structure of the Department of Feeder Roads, and forms the basis of the results from the SWOT Analysis, as well as its reflection of reliability for project cost estimates. The key features from the SWOT are discussed below.

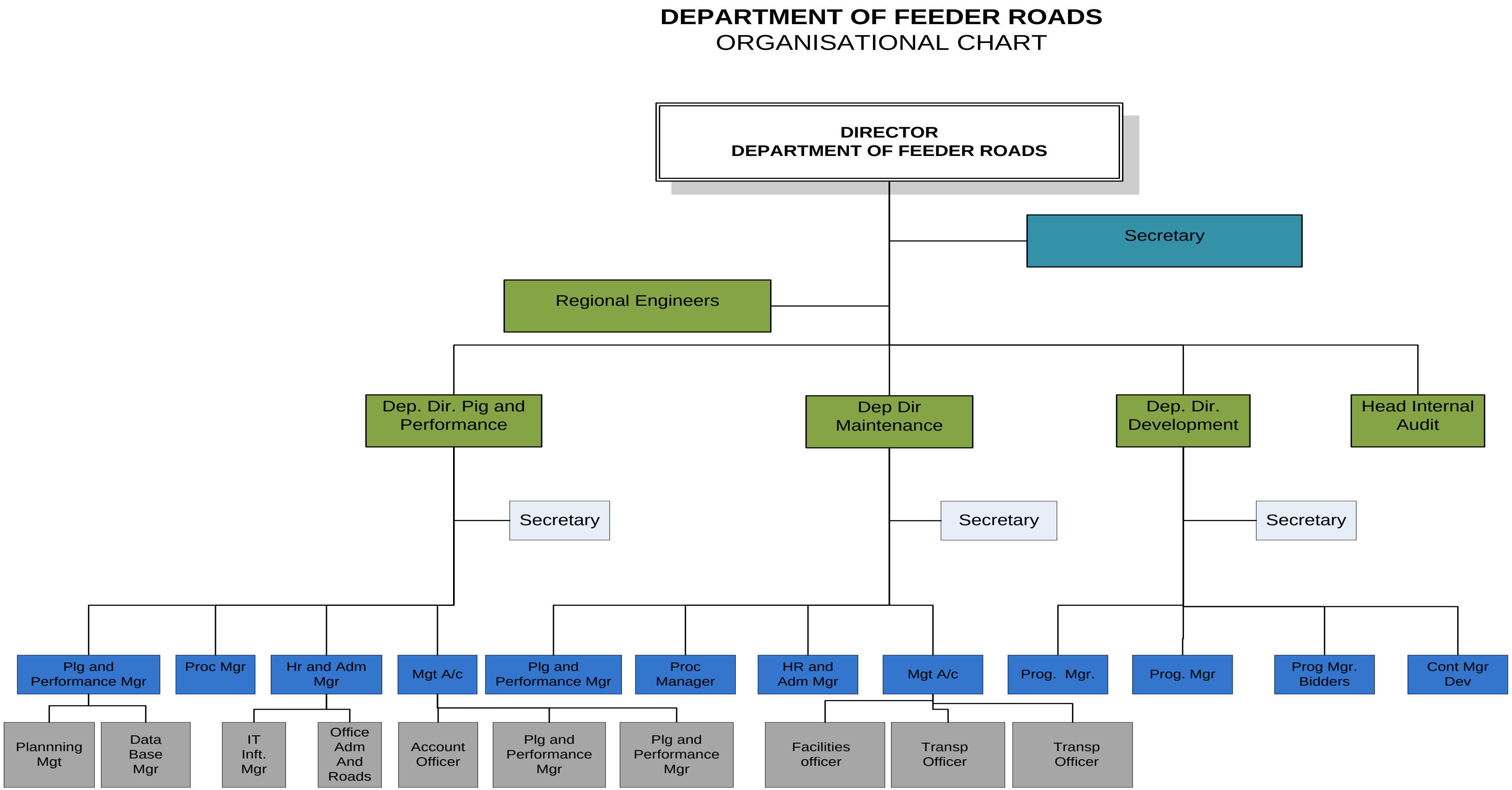



**Figure 3.7: Organisational Structure of Department of Feeder Roads (***Source: Department of Feeder Roads –Ghana***)**

The factors that account for the strength of the department were

i. Loyalty and commitment of management and staff.
ii. Ability to appropriate land for road construction.
iii. Donor attraction to rural development programmes.
iv. The ability to implement cost effective road construction and maintenance by appropriating key technologies and solutions.

The weaknesses identified in the findings were

i. Limited financial resources for achieving set targets.
ii. The provision of rural roads as social service which does not contribute revenue.
iii. Inadequate in-house capacity for contract supervision.
iv. Inadequate number and calibre of experienced estimators.
v. Under-motivated staff as a result of poor remuneration.
vi. Inadequate database for effective planning.
vii. Weak accounting systems resulting in inability to meet expenditure and report schedules.
viii. The rapid deterioration of gravel surface roads resulting in demand for funds not budgeted for.

The findings from the exercise identified some opportunities which if utilised would improve the overall performance of the department. These were

i. Availability of private sector consultancy firms for provision of supervision.
ii. Availability of Donor support for feeder roads rehabilitation.
iii. Increases in the road fund allocation to support feeder roads maintenance.

Notwithstanding the identified strengths and opportunities, the department also has some threats that required medium to long-term attention, which are outlined below.

i. Over-reliance on donor support
ii. Premature takeover of DFR district offices by the District Assemblies as a result of the national government decentralisation programme
iii. Inability to recruit due to the combined effect of control measures put in place by the government and poor staff remuneration

The estimating practice in the Department of Feeder Roads follows the same procedure in Ghana Highway Authority and that of the Ministry. The estimating unit of the Department of Feeder Roads is headed by a Chief Quantity Surveyor. The Chief Quantity Surveyor has very limited number of experienced estimating staff supporting the function of the unit. The Department of Feeder Roads executes, on average, five hundred and fifty (550) projects annually (DFR, 2008). This is against the backdrop of estimating from the first principles, which requires a considerable amount of time to programme each estimate, representing a high workload to staff ratio. The high workload to staff ratio in the Department of Feeder Roads is often the cause of stress on the limited experienced staff. It is frequently the root of negative and inadequacy in decision-making by the estimator. The effect of this high ratio on the behaviour characteristics of the individual estimator in decision-making and its consequential influence on reliability of project cost estimates.

### 3.2.4 Department of Urban Roads

The Department of Urban Roads (DUR) is responsible for the administration, development and maintenance of urban roads and related facilities (MRH, 2009). The vision and mission statements of DUR are presented in the subsequent section.

#### *3.2.4.1 Vision and Mission Statement*

The vision of the DUR reflects a commitment to the creation of decentralised road units in the Metropolitan assemblies for the provision and management of urban roads to support a quality transport system. The mission statement of Department of Urban Roads is to assist in building capacity in the Metropolitan and District Assemblies, to provide a quality road-transport system for the efficient and safe mobility of goods and people. To achieve its vision and mission, the following specific objectives were set up to enable effective working of the department (DUR, 2010).

i. To reduce the average travel time on the arterial roads in each city.
ii. To progressively reduce the walking and waiting time for public transport to communities in each city.

iii. To strengthen the capacity of the Metropolitan and District assemblies to manage the road operations of the transport system in each city.
iv. To develop and apply social, economic and environmental criteria in project selection.
v. To progressively improve the environmental conditions for all roads in the city.
vi. To collaborate with other institutions to reduce the number of traffic-related accidents resulting in deaths and serious injuries within the urban areas.
vii. To progressively improve the proportion of the road network in good condition especially in low income and newly developing communities.

### *3.2.4.2 SWOT Analysis for DUR*

In order to analyse the performance of the department with reference to its programmes, a consultant was engaged to perform a SWOT analysis of its operational and strategic circumstances (DUR, 2009). The salient elements from the exercise are discussed in the subsequent sections.

The factors accounting for the strength of the department were

i. A dedicated and youthful staff with desire to innovate.
ii. Ability to relate to the public and other stakeholders creating a good relationship between the department and its principal stakeholders.

The factors identified as weaknesses were

i. Replacement of vehicles and office facilities required for effective delivery of the programmes adopted by the department.
ii. Inadequate number and calibre of estimating staff.

The following are opportunities identified for the department. The rationale is that effective exploitation of the opportunities would lead to improvement in the performance of the department in general, and more specifically, the reliability of project cost estimates it produces.

i. There is the political goodwill from parliamentarians and assemblies to support the provision of transport infrastructure and services.

ii. There is capacity available, both locally and internationally to support the implementation of the programmes adopted by the department.

The following findings were the dominant threats that were seen as a diminution for the realisation of reliable project estimates.

i. Low salaries of employees.
ii. Uncontrolled land use practices within the cities.
iii. Inadequate enforcement of road traffic regulations.
iv. Inadequate quality delivery from some contractors.

The exercise also resulted in the proposal of strategies targeted at the effects of the weaknesses and threats indicated above. These are

i. DUR should undertake regular discussions with the Police, Utility Agencies, and Estate developers to ensure effective enforcement of regulations.
ii. DUR should implement training programmes to eliminate technical shortcomings for its supervisory staff.

Estimating in the Department of Urban Roads is conducted through the first principles method as is in Ghana Highway Authority and Department of Feeder Roads. In Department of Urban Roads, the insufficiency in the number of experienced estimators is even more pronounced as there is a relatively high number of youthful and inexperience staff.

Estimating practices in the Department of Urban Roads and the measures that put in place to mitigate the high impact of the inexperience youthful staff on the reliability desired for in cost estimates are discussed in the subsequent sections of this chapter. The Department of Urban Roads has a Head Office and operates in all the District and Municipal Assemblies in Ghana. Recruitment is however, conducted in the Head Office for the District and Municipal Assembly Offices. The Head Office has a Contract Manager who is responsible for all operational issues related to estimating in the Department. Workload to estimating staff ratio is also high as it is in the other Agencies of the Ministry of Roads and Highways. Figures 3.8 and 3.9 respectively present the organisational structure of the Head Office and the District and Municipal Assembly Offices.

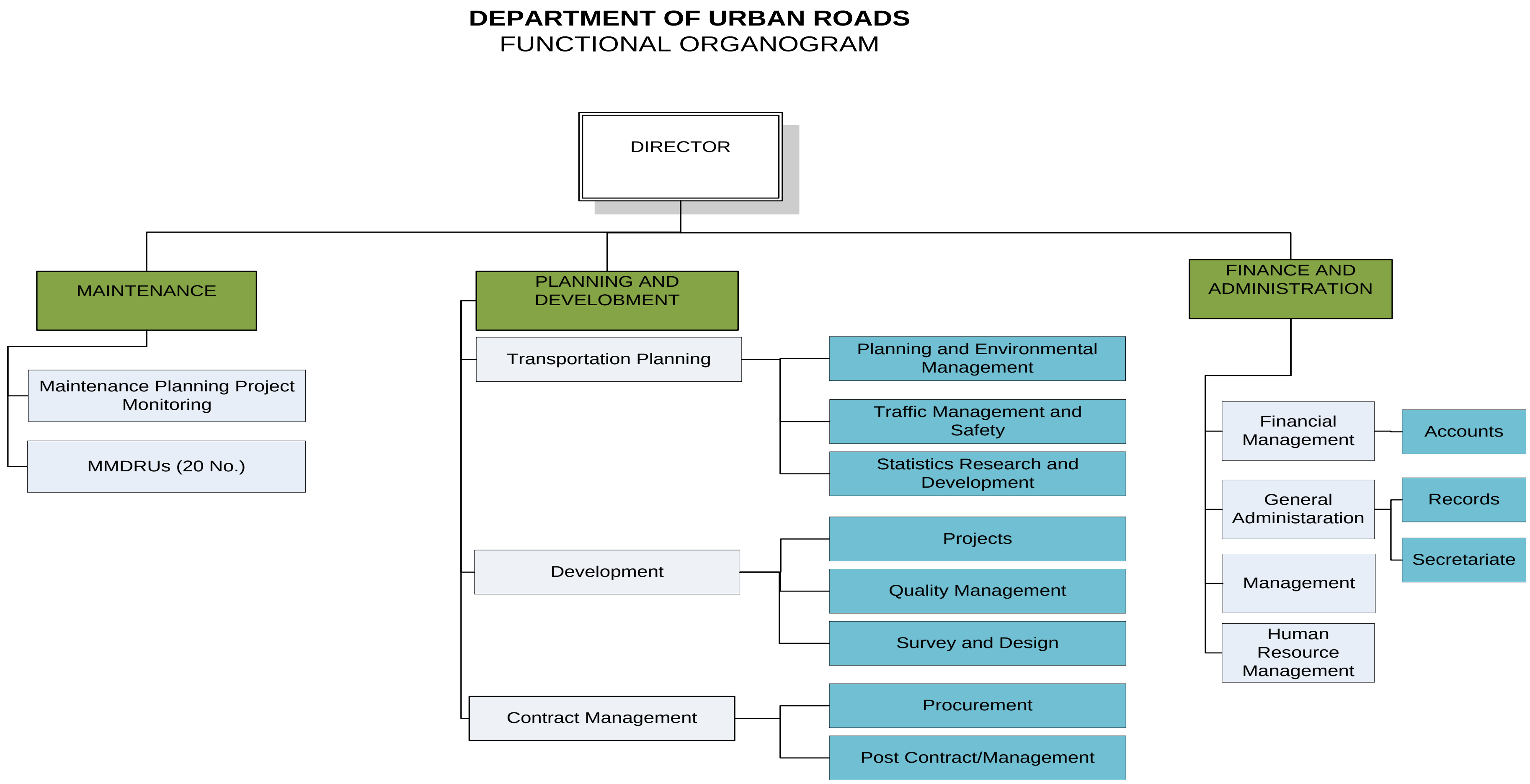



**Figure 3.8: Organisational Structure of DUR Head Office (***Source: Department of Urban Roads - DUR***)**

**DEPARTMENT OF URBAN ROADS**
FUNCTIONAL ORGANOGRAM FOR METROPOLITAN,
MUNICIPAL AND DISTRICT OFFICES

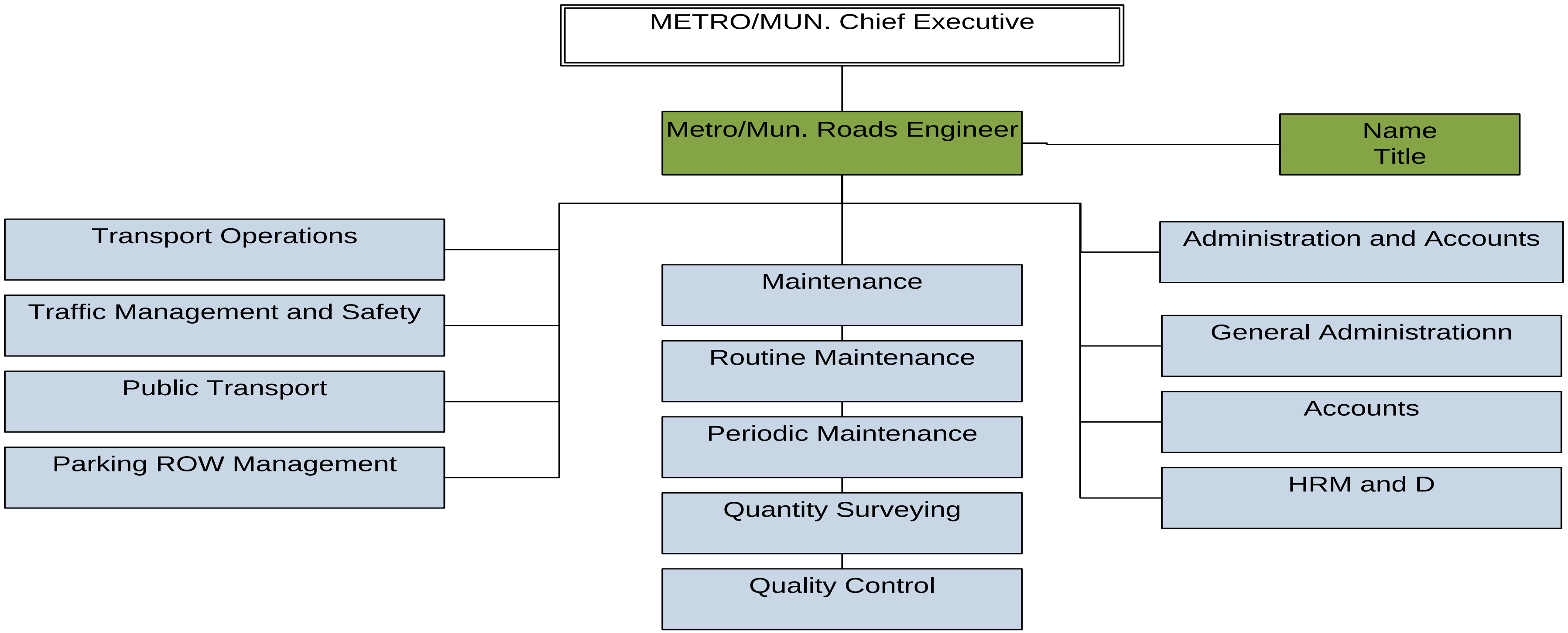



**Figure 3.9: Organisational Structure of District/Municipal DUR Office (***Source: Department of Feeder Roads-Ghana***)**

## 3.3 ESTIMATING IN ROAD SECTOR OF GHANA

The estimating procedures adopted in Ghana are standardised for all the implementing Agencies under the Ministry of Roads and Highways. The Ministry of Roads and Highways together with other Ministries that have substantial construction operations, such as Works and Housing, constitute the Government or public construction sector. The group of estimators in the public construction sector employ similar practices. The other group of estimators are the ones in the private construction sector, where practices may be similar but not standardised. Estimating procedures are similar in both building and road sectors of the Ghanaian economy. In the two sectors, estimating is done from first principles. In both cases, the inputs are labour, equipment and plant, and materials. The cost of labour depends on output standards and all-in labour cost. The cost of equipment depends on output rates and hourly cost of equipment and the cost of materials depend on quantity outputs and unit cost of the materials. Other considerations such as profit and overheads, and inherit risk, are also similar. Therefore, the conditions that emerge from any discussions of estimating procedures in the road sector could be applied in the building sector and other civil works.

Construction activity in Ghana for which estimating is required can be is categorised into road, building, and civil schemes. Bridges and related facilities are considered as part of the road schemes. Apart from sewerage works and airports there is little civil works as airport pavements are classified under road schemes. Roads therefore, form a major part of the economic contribution made by the construction sector in Ghana. The major contribution from roads accounts for the concentration of the study in the road sector.

### 3.3.1 Contribution of Estimating to National Economy

The government of Ghana shares the importance of efficient management of construction as a contributor to the national economic growth. The industry accounts for a significant proportion of employment in Ghana and therefore, has a sizeable influence on the macroeconomic performance of the country. The construction industry is responsible for large percentage of the Gross Domestic Product (GDP). For example, the road sector alone accounted for 9% of GDP in 2005 for the country (NTPG, 2005).

On a socio-economic level, construction activities, in the form of labour-based technology, are commonly used in the rural areas to improve the living standards of the communities, and thus, reduce the rate of rural urban migration. For such labour intensive methods to achieve the aspirations desired by the national government, the costing of schemes, need to be reliable and justifiable.

Reliable forecasting of cost of future events is vital for the realisation of reliable estimates on projects. Business executives in both private and public sectors of any economy depend heavily on these estimates in making their business decisions. Cost estimates therefore, form a key element in the planning and management of the project, and project staff expend considerable effort preparing them. The ability to produce cost estimates to a reasonable level of reliability and in a timely fashion to support the efficient planning of a project is influenced by a number of factors. Many researchers including Walker et al. (2010), Greenwood et al. (2008), Touran and Lopez (2006), Wong and Hui (2006), McCaffer and Edum-Fotwe (2005), Edwards and Bowen (2005), Tas and Yaman (2005); Williams (2003), Skitmore and Thomas (2002), all concur on the role estimating plays in planning and budgeting for any economy.

The importance of reliable project cost estimates to the national economy is not unique to Ghana but shared worldwide. For example in February, 2011, the Ministry of Defence (MOD) in the UK was criticized for not completing projects already initiated and causing financial loss to the state, since the objectives for a number of high profile projects could not be realised. In response, the inability to complete the projects was associated directly with unreliable budgets estimated by professionals involved in the delivery of MOD projects (The Telegraph, 2011).

In Ghana, road projects are funded directly by the government, or indirectly with monies from donors or both. Projects that are donor funded often require additional stringent accountability rules beyond what the national government adopts for locally funded schemes. The additional accountability rule has implications that pertain to the reliability of project costs as well as the running of the recipient economy. Since the donor sources of funding are critical to the promotion of most of the major projects undertaken by the country, it is self-evident that cost estimates of proposed projects have to be reliable in order to avoid damaging the national credibility.

The practice of estimating from first principles for the cost of road projects in Ghana is done by determining the direct cost and indirect cost on the work activity under consideration. The direct cost is obtain from the output standards of plant and machinery, all-in rates of labour, utilisation standards for materials and the prices of other inputs from the market. In addition, percentages are applied to the above list of direct cost items to account for indirect cost and profit. The procedures adopted in determining the direct and indirect cost in Ghana are discussed in much more detail within the subsequent sections. The discussion covers procedures adopted by the public or Government sector as well as some of the peculiarities that pertain to the private sector.

## 3.3.2 Estimating in Public or Government Sector

The public sectors bodies responsible for estimating the cost of construction projects comprise two dominant clusters. The first of the two clusters is responsible for architecturally oriented infrastructures such as building and civil engineering works excluding roads and related infrastructures, while the second addresses the road network (MRH, 2009). The former includes Architectural and Engineering Services Limited (AESL), and the Ministry of Natural Resources, Water Works and Housing and the latter is the Ministry of Roads and Highways. The procedures adopted in each of the categories are similar in that they all estimate cost of projects from the first principles. Therefore, the estimating practices in the Ministry of Roads and Highways could be use as the representative of the estimating practices in Ghana in the construction sector. Each of the cost elements are discussed in the subsequent section.

### *3.3.2.1 Direct Cost*

Direct cost refers to the cost of construction inputs that is incorporated fully and wholly into the activity of the finished work. These are costs associated with plant and machinery employed for the works, the materials incorporated into the works and labour used on the works. In some organisations, the supervision cost of the contractor is included into the labour cost whiles others include it in the cost of overheads of the project when building up the unit rate of the various work items in the project from the first principles. However, whichever method is adopted for the supervision cost, it is always included in the rate built-up for the preparation of the project cost estimate. In the public sector of which the Ministry of Roads and Highways has the oversight responsibility for the road sector, the supervision cost of the contractor is accounted for as part of the cost of overheads when deriving the unit rates from first principles.

The supervision cost to the client is also included in the rate build-up from first principles (MRH, 1987). This approach is adopted irrespective of whether the client employs an external consultant to execute the service or does it in-house through the staff in its various Agencies. This cost is however, included in the total cost of the facility be it road or any other infrastructure. The direct costs included in the unit rate build-up are obtained from a number of sources. These sources are discussed in detail in the subsequent section of this chapter for each cost component.

***Plant and Machinery Cost***

Equipment and tools are required to install the materials in road construction and for that matter in the whole of the construction industry in Ghana. The equipment usage relationship with the materials is often obtained from data provided by manufacturers and stored in cost libraries or databases. The usefulness of the database however, depends on its frequency of review and update. In the road sector of Ghana, the resource input for equipment utilisation is estimated on activity basis. In countries where the manufacture of plant and equipment for road construction is not local, the users of these machines and equipments depend on the specifications in the manufactures manual. The use of the output standards in the manual from the manufacturer in most cases does not give the true representation of the actual outputs of those equipments. This is because the geographical terrain upon which the study is conducted for establishing the utilisation rating of the machine differs from region to region. The output standards of any equipment and machinery will differ significantly in the tropics where temperatures are as high as 45 degrees Celsius to the places where temperatures fall below freezing point.

The equipment and machinery imported into many developing economies by the private contractors are often ones that have been previously used in the developed economies. The efficiency of these equipments reduces with age. Therefore, the output standards from the manufacturers manual for those used equipments and machinery do not reflect the real situation prevailing on the project site where the equipment and machinery are employed. No local data on utilisation is compiled that provides accurate and relevant utilisation information for the equipment and machinery. In the absence of a credible alternative, the output standards of the original equipment manufacturer are the most practitioners would apply in estimating cost for a project.

In 1975, there was a work-study initiative conducted in Ghana on the utilisation of basic equipments employed for road construction (MRH, 1987). The findings of that study have since been applied for estimating the cost of road projects in Ghana with no alteration to account for changes in work conditions and methods. The use of the rather dated information in recent times has had a negative impact on the reliability of project estimates. This is due to the fact that recent significant improvements in technology has produced greater efficiency for construction plant and equipments. It is therefore expected that the output standards of these plant and equipments will increase when compared with the output standards from the 1975 studies. Furthermore, advances achieved in fuel utilisation for plant equipment has led to the transformation of the utilisation rates for these machinery. The use of the newer high output standards in estimating the cost of road projects in Ghana should lead to the minimisation of project cost overruns. The situation is however, not as expected. Rather the cost at completion is still high when compared with the initial budget. This is an indication that the problem is beyond the reliability of the data used in the estimating.

Part of the reason why most contractors in developing economies own used equipments from the developed economies is due to the turnover of the local companies have, which could not sustain the acquisition of new pieces of equipment. Typically, these contractors find it difficult to obtain loans from the banks for their business. The difficulty arises from the demand for collateral from the banks which most of these local companies are unable to provide. Furthermore, the interest rates on business loans from the banks are relatively high at an average of thirty percent (The Ghanaian Journal, 2011). These factors inhibit the growth of small and medium size companies in developing economies such as Ghana and leaving them with limited capacity.

The use of output standards from either the manufacturers manual or the data from 1975 studies do not adequately represent the contemporary conditions of the equipments that are employed in the road sector of Ghana. The equipment existing in 1975 when the studies were conducted were either modified with the advancement in technology or taken out from production. The effect of the changes in circumstances for the use of these plants on the reliability of cost estimates therefore becomes significant. The differences contribute to unreliable project cost estimates in Ghana. Figure 3.10 shows the behaviour of the cost estimate as the result of the differences in the data as against the actual that the equipment produces at the project site.

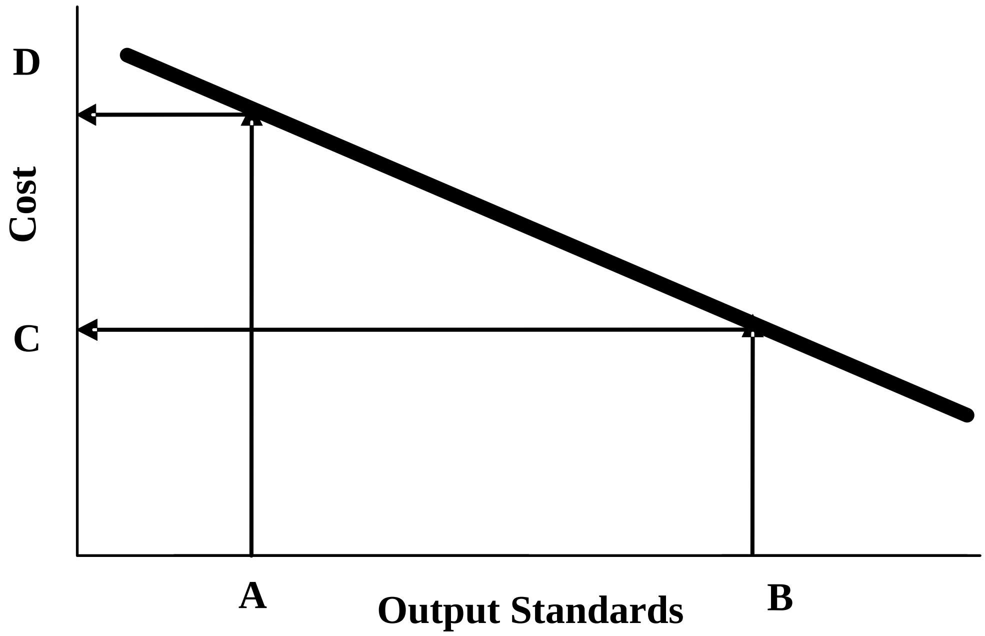



**Figure 3.10: Cost versus Output Standards in Road Sector of Ghana**

From Figure 3.10, output standard **B** produces cost estimate **C**, whiles output standard **A** produces cost estimate **D**, and illustrates the real situation in Ghana. Efficiency of the equipment improves with technological advancement. Logically therefore, cost estimates should be lower with the use of more efficient equipment than lesser efficient equipment. From figure 3.10 output standard **A** represents the data form 1975 studies and **B** represent data from the use of more efficient equipment and machinery due to the advances in technology. Output standard **A** produce cost estimate **D** which is higher than cost estimate **C** produce from output standard **B** assuming all other factors are the same. This is an indication that the cost estimates on road projects can be said to be on the higher side in Ghana. However, cost overruns are still experienced on most projects in Ghana due to unreliable project estimates.

The output data established by the public sector in 1975 is the only source of data in the road sector for calculating outputs of equipment and machinery. The private sector depends heavily on the same data in project cost estimating. In direct contrast to what pertains in the United Kingdom for example, the data on equipment and machinery are reviewed periodically. Such reviews ensure that the performance data reflects real and changing situation at any point in time. The current situation in the road sector in Ghana is however, undergoing a major review. Workshops have already been organised to address how to conduct a detailed work-study for the development of new output standards in the road sector (MRH, 1987). The initiative for the review plan was a result of the findings from the literature review of the research study that formed the foundation of this thesis. The key findings from the overall research study will therefore, feed into the review exercise to inform how the sector should address dependability of equipment and machinery output data in order to improve project cost reliability.

***Material Cost***

In general, material costs exclude the mark-up for handling by the contractor. To establish the basic costs of materials, estimators collate prices from a series of market surveys. Cost information is readily available and often reflects the true price situation prevailing in the open market at any given time. In addition, the utilisation standards for materials are computed for each work activity. The cost of the material component in any activity can therefore, be obtained with a reasonable degree of reliability. The limitation to the degree of reliability arises from arbitrary increases in open market prices of materials and is often the source of worry to all stakeholders in the construction industry. The problems of frequent increases in material prices are more pronounced in the developing economies than in developed economies due to instability of the currencies in developing economies. The effect of such increases can be seen in the use of fixed sum contracts. Any expected increases in prices of the materials for fixed sum contracts are incorporated in the unit rate build-up by project practitioners in both public and private sectors of the Ghanaian economy as done in the developed economies (MRH, 2010). Most processed materials for the construction industry are imported from developed economies. Therefore, the ability to predict to a high degree of precision any price increases for materials is beyond the control of the estimator. These prices are influenced by the fluctuation of the country’s currency with the major currencies such as the British Pounds Sterling and the United Sates Dollar where most of the materials are imported from. It is against this background that fixed sum type of contracts are considered not suitable in developing economies such as Ghana, even though most clients want to have the comfort of a fixed sum for construction projects.

The type of contract in common use within Ghana is ad-measurement or re-measurement contract with provision for fluctuation clauses (MRH, 1987). In the road sector of Ghana, this takes the form of Price Adjustment Formula provisions to enable the computation of Adjustment Factors on project. These are incorporated in the tender or contract documents in accordance with international best practices for re-measurement types of contract. The level to which contractors are compensated for increases in the input resources in projects is determined by the cost indices that are used in the Price Adjustment Formula (FIDIC, 1999). The cost indices for the road sector are produced by the Ministry of Roads and Highways, with inputs from other sectors of the Ghanaian economy. All stakeholders in the road sector depend on the cost indices published by Ministry of Roads and Highways for the management of their construction projects. The index applied for equipment is based upon the USA index for construction equipment (FIDIC, 1999). The USA index is transformed to suit the Ghanaian context and rendered in Cedis by using the interbank exchange rate. For the building sector, the indices are produce by Building and Road Research Institute of Ghana.

In Ghana, the quantity of material input in any work activity is obtained by aggregating the volumes of its constituent parts. Concrete for example has a number of input resources. In estimating, the quantity of cement in a cubic metre of specified concrete grade for example is obtained along with water and the different grades of aggregates. This involves computing the quantity and making allowances for wastage that arises from processing. Wastage in concrete occurs in two ways. The first form is the wastage that occurs during transportation of the input resources from the storage to the point of mixing. The second is the wastage that occurs when the mixed concrete is transported to the point of placement. The allowance made for the wastage depends on the concreting operation and varies from estimator to estimator. The estimator decision-making orientations can significantly affect the level of allowances that are adopted for these wastages. It is common to find that inaccuracies in the cost allocated for materials are attributed to the computational error but not to the behavioural characteristics of the individual estimator in decision making. The implied argument that is at the heart of such attribution is that the estimator exercises no personality influences on the output.

***Labour cost***

In developed economies, there are independent publications from recognised institutions on labour productivity. In Ghana, labour hours required for work activities in the road sector are derived from the studies conducted in 1975. The data is based on a national average hence the cost obtained from such data requires further adjustment to reflect actual conditions in a particular location.

The ten geographical regions in Ghana are broadly viewed as coming under either a southern or northern zone. In general, the income level of people in the northern zone is relatively lower, compared to their equivalent counterpart in the southern zone. Generally, people from the northern extraction are hard-working farmers. From the same study, it was established that the output for an activity from people in the northern zone are higher than those in the southern zone (MRH, 2010). It is against this background that an average data will not depict the real situation on the ground. As a first step to achieving better reliability, the compilation of the data should be performed separately for each of the zones.

In recent times, the technological advancement in the areas of health and construction methods have had a positive impact on the improvement of labour output standards compared with the results obtained in the 1975 studies for any activity. Most experienced estimators do adjust the 1975 data in order to take account for the changes in technological advances. However, the reliability of this adjustment is dependent on the decision-making orientation of the individual estimator. There is therefore, a very high subjective element in the resulting data from this form of transformation. It is only when new and updated output standards are developed from work-study that the subjective element would be minimised.

Again, it should be noted that, the development of new data on output standards for labour will not fully eliminate the influence of the behavioural characteristics of individual estimators in decision making. This is due to the fact that the use of the updated data itself would still be based on some assumptions of how work will proceed on site. As long as the assumptions are made in any estimating process, there is bound to be differences between the values obtained by two estimators. No two estimators can think and act in the same manner. Their behaviour characteristics in decision-making if un-moderated will continue to influence their actions and therefore, differences are bound to occur between any two estimators.

The construction industry in Ghana is regulated by Labour Act 652. The Act provides for all issues to be considered when building all-in rate for various categories of labour. Some of the compensation aspects in the Act include leave allowance, food allowance, tools allowance for tradesmen using their own tools, protective clothing allowance, social expenses such as deaths benefits, medical and transport allowance. The Act however, does not indicate the level of compensations that has to be included for each of the allowances when building all-in rates for labour. Individual estimators determine the level of compensation. The influence of the individual estimator could therefore, impact appreciably on the levels of compensation that is allowed in the all-in rate for labour. For example, the Act provides that allowance must be made to compensate for lost of time due to deaths and sickness. The Act does not spell out the levels of compensation but only the type of compensation. The individual estimator therefore, makes the decision as to the number of deaths to allow for in a year and how many people will fall sick and for how long in the year. Ideally, data from previous periods should guide the decision of the estimator. However, such previous data hardly exists. As such, decisions of this nature require some level of experience in the industry and in particular, the organisations that the estimate is being prepared for. In general, the allowances for the various assumptions are aggregated as a factor that is applied as a multiplier for the basic cost of labour. A factor of 3.70 is commonly used in practice. This factor is only a guide since each individual estimator’s assumptions determines the exact figure of the factor to apply to the basic wage.

***Subcontractor quotations***

In the road sector of Ghana, subcontract arrangements are either nominated or domestic subcontractors. For both cases of subcontract arrangement, the public sector estimator relies on the quotations from subcontractors in specialised works such as pilling and in relocation of services among others. In some instances, the estimators for contractors equally rely on such subcontractor quotations for items of work which they intend to sublet. In both cases, the quotations of the subcontractor contain labour, material, equipment and tools, indirect cost and profit to the subcontractor. The main contractor includes cost of its mark-up for attendance to the sub-contractor to establish the cost of the works involved.

### *Indirect Cost*

Indirect cost consists of cost of labour, material, equipment and tool items required to support the whole project. In preparing the engineer's estimate in the public sector, provisions are made for indirect cost to cover both the cost to the client and the contractor. The engineer's estimate is prepared as part of the project documentation and employed as a guide for evaluating tenders. The engineer's estimate is prepared by the estimating department of the client's outfit. In Ghana, the engineer's estimate is prepared by the procurement units in the respective Agencies under the Ministry of Roads and Highways for road related projects.

Indirect cost to the client consists of land acquisition cost, legal fees, administration costs, and design and supervision fees. In major projects, design and supervision fees are separated from the project estimate. In Ghana, indirect cost is either priced separately as a bill item or incorporated in the unit rates as a percentage. Usually, 15 percent is provided on the unit rates for such indirect cost. This figure is based on the 1975 studies, and is often not adequate to reflect recent improvements in efficiency levels for equipment and labour utilisation in most organisations. Again in determining the indirect cost, the estimator's decision-making orientation influence the judgement they exercise. This explains why indirect cost would differ from estimator to estimator for the same project.

### *Profit*

Allowance for profit is established as a percentage contribution to the unit rates of work activities in Ghana. In the public sector of Ghana, ten percent is usually adopted to cater for profit in the unit rate. The adopted percentage is based on the 1975 studies, which again presents a different context not particularly relevant to contemporary conditions in construction. In recent times however, most organisations tend to allow a percentage based on their position in the industry.

The profit level adopted is a reflection of the return on investment expected to maintain continued viability in construction business. Profit assessment is therefore influenced by the extent of risks inherent in the particular business operation. The different types of risks that impacts on profit levels in the construction sector within Ghana include working capital risk, contractual risk, technical risk and investment risk. The level of profit is dependent on the level of allowance made for these risks and is influenced by the estimator's behaviour in assessing risk. In practice, a 10% figure is allowed on the net cost of works as profit in Ghana, as most contractors are not in a position to evaluate an accurate percentage that reflects their specific context (MRH, 2010).

Contingency amounts are allowed in the project cost estimates to account for uncertainties. The basis of the contingency amount is often established as a rule of thumb and dependent on the experience of the estimator. The reliability of the contingency amount is also influenced by the individual estimator's decision-making orientation.

## 3.4 WORKLOAD TO STAFF RATIO IN GHANA

The estimating procedure in the road sector of Ghana often involves a reasonable number of experienced estimators. This is due to the fact that estimating is done from the 'first principles'. Estimating from the 'first principle' requires a great amount of time and adequate numbers and calibre of experienced estimating staff. However, the sector lacks adequate numbers of experienced estimators. Table 3.1 shows the number of experienced estimators and the average number of project estimates prepared annually in the various Agencies under the Ministry of Roads and Highways in Ghana.

**Table 3.1: Estimating load to Staff ratio in Road sector of Ghana**

| No. | Name of Agency | No. of Experienced Estimators | Average No. of Projects per year | Estimating load to staff ratio |
|---|---|---|---|---|
| 1 | Ghana Highway Authority | 9 | 180 | 20 |
| 2 | Department of Urban Roads | 6 | 300 | 50 |
| 3 | Department of Feeder Roads | 3 | 550 | 183.33 |
| | **Total** | **18** | **1030** | **57.2** |

(*Source: GHA, DUR, and DFR of Ghana*)

From Table 3.1, the average estimator is required to prepare cost estimates for 57.2 projects in a year. This implies that estimates are prepared on 4.8 projects in a month by each estimator in the road sector of Ghana. The implication of such a relatively high estimator workload is the effect on reliability of project estimates.

In previous studies, the influence of high workload on the decision-making orientations of estimators was explored. For example, Mei-Yung et al. (2005) investigated the factors that affect reliability of cost estimates and concluded that stress on estimators caused a negative effect on the reliability of cost estimates. Mei-Yung et al. (2005) identified some of the critical stressors as excessive workload, role conflict, job ambiguity, and work environment, among others, as having significant influences on the decision-making behaviour of the estimator. A stressful estimator is not analytical in performing its duties. The decisions that such an estimator makes are not based on detailed rational assessment of available information due to the high workload. This situation affects the estimator's ability in making sound and logical judgement and a sub-optimal position is adopted. Often such a situation arises because the estimator has very little time to analyse information thoroughly before making decisions in such a work environment.

From Table 3.1, it could be deduced that the behaviour of the estimator in the road sector of Ghana is greatly influenced by stressors identified by Mei-Yung et al (2005). Again this leads to consequences of unreliable project estimates such as projects being abandoned due to lack of funds to the detriment of the beneficial communities. If such projects are to be completed, then funds would have to be taken from other sectors of the economy, thus, disrupting a balance in the government's programmes.

## 3.5 INFLUENCE OF ATTITUDE ON COST ESTIMATE

A project estimate is a prediction of a future event or outcome. In other words, it is an informed assessment of the likely cost of the project. The word likely means there are a number of probable outcomes that could be derived depending on how the uncertainties that are inherent in the project are assessed. A decision maker must estimate the probable outcomes of those future events or actions based on information available at the time of the decision. The choices exercised by the estimator for such future decision situations may be subjective.  For example, evaluating the nature of control measures for future period or assumptions made in determining the wastage of mixed concrete during transportation.  In both examples, the rigour in the decision of the estimator to match their adopted solution to the operational environment of the works would have a direct effect on the estimate that is produced.  The level of subjectivity attenuates with experience, as the estimator develops a bounded rationality of the conditions under which the works will be performed.  Equally, the rigour is augmented with experience because of a better definition of the bounded rationality the estimator develops.  This position was emphasised by Adams and Swanson (1976) and Archilbald and Villoria (1967). Abernathy (1971) also confirmed from his investigations that estimates improve as the estimator gains experience, as the range of unknown variables employed in their decisions are reduced to a limited but essential ones.

The ability of the estimator in assessing risk influences the decisions the estimator makes in estimating.  Simply put, some estimators are risk prone and others are risk averse.  Their risk disposition is strongly related to the personality traits of the individual estimator.  As such, it can be argued that their personality trait would influence the behaviour characteristics in decision-making and risk perception of the estimators.  Since no two estimators have exactly the same personality trait, it can be expected that decisions made by different estimators would reflect significant differences.  Therefore, the effect of individual personality traits that could account for the differences in estimates produced by two estimators with the same data in the same work environment may be the cause of the lack of reliability in cost estimates. Figure 3.11 illustrates the concept of estimates produce by the two estimators for a project with the same information.

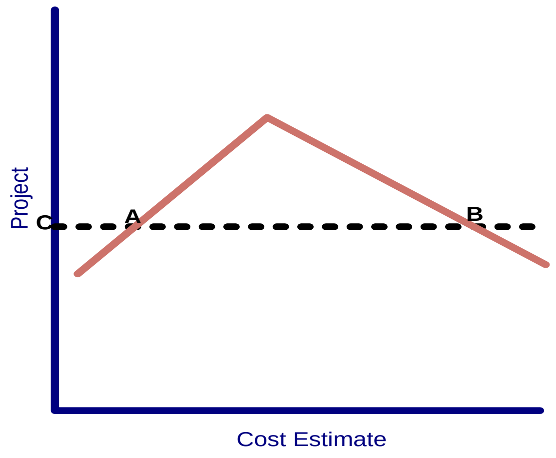



**Figure 3.11: Estimate of Two Estimators with Same Information**

Figure 3.11 is a typical graph showing how decisions on factors within the control of the estimator significantly affect the outcome of cost estimates. The situation depicted in Figure 3.11 is more prevalent in the construction industry and all other forecasting operations. Understanding the nature and extent of the disparity could pave the way for establishing adjustment factors to address cost estimating problems in Ghana. From Figure 3.11, one estimator produced an estimate A and the other produce an estimate B for the same project with the same amount of information. Both estimate A and B are equally likely to be the cost of the project. However, there is far greater chance that A would be exceeded because very little time would have been spent in analysing the requisite information before coming to a decision. Estimate B on the other hand, would have a greater chance of being an accurate estimation, due to the longer time employed in analysing information and making decisions. The estimator generating the estimate B displays a lack of preparedness to take risk, hence the longer time it takes to make project decisions by waiting for full information. The question here is which of the two estimates could be said to be a reliable estimate for project C. It is logical that the mean of the two estimates could be said to be best estimate for Project C. The boundary from A to B therefore, constitutes a range within which the estimate is deemed viable. The magnitude of the range can be attributed to the differences in decision-making orientations of individual estimators. For the construction industry in Ghana, defining these boundaries will assist in judging the degree of reliability that can be associated with project cost estimates produced by different estimators. However, there are questions that have to be answered on how this could be achieved. These include deciding on the following issues.

- Whose estimate should be used in defining the boundaries?
- What should be the qualifications and experience of the boundary estimators?
- How many projects should such boundary estimators have accomplished in their career, and on an annual workload?
- What should be the personality traits of such boundary estimators?

Setting boundaries in estimating has been the focus of many studies in recent times. However, only physical factors associated with the project have been utilized in all the research on setting boundaries (Touran and Lopez, 2006; Ahmed et al., 2007). Several tools have been employed in setting the boundaries, with the most commonly applied tool being the Monte Carlo simulation. Monte Carlo simulation has gained increased popularity in addressing uncertainty and risk in construction (Vose, 1996). Some of the studies that applied the Monte Carlo approach to address uncertainty and risk in construction management include Touran and Lopez (2006), Tung (2008), and Ahmed et al. (2007). Much of the application of the Monte Carlo technique utilizes the physical project parameters to address uncertainties and risk in relation to performance, but not endogenous factors that relate to the behavioural characteristics of the estimator.

## 3.6 PROCUREMENT REGULATIONS IN GHANA

The public procurement activities in Ghana are regulated by Public Procurement Act, 2003 (Act 663). The Act was constituted to harmonise public procurement and to ensure economical use of the limited national resources. In furtherance of the Act, a provision was enshrined for establishing a Public Procurement Authority with suitable administrative and institutional arrangements for public procurement and prescribed tendering procedures. The Public Procurement Act 663 applies to procurement of goods, works, and services financed wholly or in part from public funds except where the Minister of Finance and Economic Planning decides that it is in the national interest to use a different procurement procedure. The Act also provides for functions that pertain to procurement of goods works, and services such as description of requirements, contents of invitation for tender, procedures for preparation, selection and award of contract as well as all the phases in contract administration.

### 3.6.1 Public Procurement Authority of Ghana

The Public Procurement Authority in Ghana is responsible for all the administrative procedures required to ensure adherence to the provisions in the Act. The work of the Authority is regulated by a Board. Notably, the Act makes explicit provision for the involvement of women in public life as part of the commitment of the country to the Millennium Development Goals. The Board comprises people with adequate competence and experience in public procurement nominated by the public and private sectors and be composed of the following roles.

- Chairman
- Vice-Chairman
- Four persons from the public sector made up of the representatives of Attorney General, and three (3) other persons of whom one is to be a woman.
- Three (3) persons from the private sector at least one should be a woman.
- The Chief Executive of the Board who is also the Chief Executive of the Authority.

The term of office of the Board members is four years. The Act provides for the functions of the Board and include, but not limited to, general overseeing of the procurement procedures to ensure conformance to the provisions of the Act.

## 3.6.2 Adjudication Committees and Boards

To ensure decentralisation of authority and for prompt handling of the procurement activities, the Act provides for the establishment of Entity Tender Committees by all the various Entities associated with public procurement. An Entity is the institution undertaking the procurement. In the road sector of Ghana, the Ministry and each of the Agencies under its ambit, namely Ghana Highway Authority, Department of Feeder Roads and Department of Urban Roads each have their own Entity Tender Committees. The Act provides for the functions of the Entity Tender Committees as the adjudication body on all Evaluation Reports that emanate from a particular Entity to ensure proper adherence to the principles of procurement.

For the purposes of transparency, the members of the Entity Tender Committees are drawn from the procurement Entity, the public sector, the Attorney General's office, and parliament. For the Agencies under the Ministry, the Head of Agency is the Chairman whiles the Honourable Minister of Roads and Highways is the Chairman for the Ministry's Entity Tender Committee. The broad spectrum for the composition of the members making up the Entity Tender Committee provides it with a greater opportunity for achieving transparency, accountability, and fairness in discharging their responsibilities within the procurement guidelines.

The Act also made provision for Ministerial / Regional Tender Review Boards and a Central Tender Review Board. The functions of these bodies are similar to that of the Entity Tender committees. In addition these bodies give concurrent approvals to documents reviewed by the Entity Tender Committees which are above the thresholds of the Entity Tender Committees. The thresholds are explained in the subsequent section.

### 3.6.3 Threshold for Procurement Activities

The Act details thresholds for procurement activities for the various Entity Tender Committees based on the level of mandate held that Entity. All procurement activities beyond the thresholds are referred to the Ministerial or Regional Tender Review Board or the Central Tender Review Board for adjudication. Tables 3.2 and 3.3 show the various thresholds for the procurement of works, goods, and services under the Act. The currency in Tables 3.2 and 3.3 is the Ghanaian Cedi.

**Table 3.2: Threshold for Decentralized Procuring Entities**

| Authority | Goods (GHC) | Works (GHC) | Technical Services (GHC) | Consulting Services (GHC) |
|---|---|---|---|---|
| Head of Entity | Up to 50m | Up to 100m | Up to 50m | Up to GHC 50m |
| Entity Tender Committee | >50m – 250m | >100m-500m | >50-250m | >50m-100m |
| District Tender Review Board | >250m-1.0b | >500m02.0b | >250m-1.0b | >100m-500m |
| Ministerial and Regional Tender Review Board | >1.0b-8.0b | >2.0b-1.50b | >1.0b-8.0b | >500m-3.5b |
| Central Tender Review Board | Above 8.0b | Above 15.0b | Above 8.0b | Above 3.5b |

*(Source: Public Procurement Act of Ghana, Act 663)*

**Table 3.3 Threshold for other Procuring Entities**

| Authority | Goods(GHC) | Works(GHC) | Technical Services(GHC) | Consulting Services(GHC) |
|---|---|---|---|---|
| Head of Entity | Up to 50m | Up to 100m | Up to 50m | Up to 50m |
| Entity Tender Committee | >50m-1.0b | >100m-2.0b | >50m-1.0b | >50m-500m |
| Ministerial and Regional Tender Review Board | >1.0b-8.0b | >2.0b-15.0b | >1.0b-8.0b | >500m-3.5b |
| Central Tender Review Board | Above 8.0 | Above 15.0b | Above 80b | Above 3.5b |

*(Source: Public Procurement Act of Ghana, Act 663)*

### 3.6.4 Ministerial or Regional Tender Review Boards

For effective accountability and good governance, limitations have been placed on the amount of procurement activities for the Ministerial/ Regional Tender Review Boards and the Entity Tender Committees as indicated in Tables 3.2 and 3.3.

The composition of the Ministerial or Regional Review Tender Board is similar to that of the Entity Tender Committees. In the case of the Ministry of Roads and Highways, the Ministerial Review Board has membership made up of heads of the three Agencies under the Ministry, the technical head of the Ministry, the head of procurement unit of the Ministry as its secretary and representative of the private sector as spelt out in the Act. The Act also expressly provides for each Ministry to have its own Ministerial Tender Review Board.

In addition to the National structures, each of the ten geographical regions of Ghana has its own Regional Tender Review Boards. The composition is similar to that of the Ministerial Tender Review Boards with functions spelt out in the Act to promote fairness to all tendering companies. To ensure accountability and good governance, the Act provides for appointing the chair of both review boards from the public sector.

### 3.6.5 Central Tender Review Board

Projects above thresholds specified in Tables 3.2 and 3.3 are referred to the Central Tender Review Boards for adjudication. The composition of the Central Review Board is similar to the Ministerial or Regional in that members are drawn from various stakeholders in both public and private sectors of the country.

### 3.6.6 Procurement Methods

The Procurement Act 663 of Ghana also defines the procedure that has to be adopted in each category of procurement and the methods for ensuring the adherence to the principles of procurement and good governance.

The procedure is enshrined in the National Competitive Tendering and International Competitive Tendering methods of procurement, a provision in the Act that is similar to all International best practice. However, for other methods of procurement such as sole sourcing, restricted tendering, and price quotations among others, the Act provides for additional safeguards and measures to mitigate any potential abuse and corruption. The subsequent sections briefly discuss the provision in the Act for each of the above procurement methods other than Open Competitive Tendering. The exclusion of coverage for Open Competitive Tendering is because that method of procurement dominates the public sector procurement programme and has commonality with practices across construction worldwide.

#### *3.6.6.1 Sole Sourcing*

The sole sourcing method of procurement is provided in the Act for works, goods and services that are procured under conditions that reflect emergency. The Act provides for approval from the Public Procurement Authority prior to engaging in sole sourcing procurement to ensure that the public agents involved are not open to abuse and to minimise any potential corruption. The threshold for the various procurement methods are shown in Table 3.4 and shows that no limits are associated with the sole or single sourcing. This is because emergency demand for works and services are often difficult to estimate for, as the nature of operation would evolve in conformance with the notion of emergency. The principle enshrined in the Act is that the Public Procurement Authority would discharge its responsibility pertaining to sole sourcing with probity and adequate control.

**Table 3.4: Thresholds for Procurement Methods**

| Procurement Method/ Advertisement | Contract Value Threshold |
|---|---|
| (1) Pre-qualification<br>a. Goods<br>b. Works<br>c. Technical Services | <br>a. Above GH¢35 billion<br>b. Above GH¢70 billion<br>c. (not more than 10% of cost of works) |
| (2) International Competitive Tender<br>a. Goods<br>b. Works<br>c. Technical Services | <br>a. Above GH¢15.0 billion<br>b. Above GH¢20.0 billion<br>c. Above GH¢2.0 billion |
| (3) National Competitive Tender<br>a. Goods<br>b. Works<br>c. Technical Services | <br>a. More than GH¢ 200 million up to GH¢2.0 billion<br>b. More than GH¢500 million up to GH¢15 billion<br>c. More than GH¢200 million up to GH¢ 2.0 billion |
| (4) Restricted Tendering | Subject to Approval by PPA |
| (5) Price Quotation<br>a. Goods<br>b. Works<br>c. Technical services | <br>a. Up to GH¢200 million<br>b. Up to GH¢500 million<br>c. Up to GH¢200 million |
| (6) Single Source Procurement and Selection | Subject to Approval by PPA |
| (7) Advertisements for Expressions of Interest for Consulting Services in local newspapers | Above GH¢700 million |
| (8) Least-Cost Selection | Up to GH¢700 million |
| (9) Selection based on Consultant's Qualification | Up to GH¢ 350 million |
| (10) Single Source-Selection | Subject to Approval by PPA |

*(Source: Public Procurement Act of Ghana, Act 663)*

## *3.6.6.2 Restricted Tendering*

For reasons of economy and efficiency, a procurement Entity may engaged in Restricted Tendering subject to the approval of the Procurement Board. The criteria set by the Act for projects qualified under this method of tendering are as follows.

i. That the goods, works or services are available from a limited number of suppliers or contractors.

ii. That the cost of the goods, works, or services compared to the time and cost required to evaluate a large number of tenders is disproportionate.

In restricted tendering, it is required that the service providers are selected in a non-discriminatory manner in order to ensure effective competition. The Act provides for a minimum of 3 and maximum of 6 in number of service providers to form the pool from which the eventual provider will be selected in order to satisfy the rules governing the principles of procurement.

## 3.7 SUMMARY

The chapter has established the importance of the construction sector to the economy of Ghana, and discussed the context of construction in Ghana and reasons for selecting road sector for the study. Estimating in the Ministry of Roads and Highways and its Agencies were discussed to establish the common elements of the practice in Ghana. The weaknesses associated with the dominant method of estimating in Ghana in relation to reliability of project estimates were identified. In addition a detailed discussion is conducted on the characteristics of data utilized for estimating of project cost and its influence on the desired reliability. The review also identified factors including high workload, inadequate project information, limited number of experienced estimators, inflation, inadequate project data and other exogenous factors that influenced reliability of project estimates in Ghana.

The chapter also covered how different estimators in Ghana influence the reliability of project cost estimates. The nature of assumptions made by estimators are associated with the individual estimator's personal characteristic in assessing risk and thus, influence the reliability of project estimates. The chapter emphasised the decision-making stages in estimating practice in Ghana. The Public Procurement Act that regulates procurement activities in Ghana was addressed in considerable detail. The chapter focuses on the argument that the behaviour characteristics of estimators were may hold the key to achieving reliability in the estimating exercise. The next chapter gives attention to the principal endogenous factor, the personality trait and behavioural characteristics of estimators.

# CHAPTER 4

# ESTIMATOR ENDOGENOUS CHARACTERISTICS

## 4.0 OVERVIEW

This chapter addresses the principal endogenous factor, which is personality trait, and behavioural characteristics of estimators. It commences by reviewing the historical developments of generic personality traits of individuals and the instruments for psychometric testing. A range of testing instruments is presented to demonstrate the extent of commonality and differences that exits in charactering personality. The behaviour characteristic of estimators is also explored to establish how individual estimator decision-making orientation influences the reliability of their decision outcomes.

Furthermore, consideration is given to the impact of information sharing culture in the estimating environment on reliability of cost estimates on construction projects. The information sharing culture has a potential to influence the quality of information and basis on which the estimator's decision would be made. Other attributes of the estimator discussed in connection with information sharing as having a significant effect on the reliability of cost estimates include, ethics, integrity, experience, qualification and judgement. The rationale is that the attributes displayed by estimators are a reflection of individual personality trait.

## 4.1 HISTORICAL DEVELOPMENT

The concern of man in understanding and predicting the behaviour characteristics of others dates back to ancient time (Misumi, 1985). More specifically, many of the theories associated with trait were aimed at predicting the behaviour characteristics of human beings and developed in the nineteenth century (Misumi, 1985). Examples of such theories include the “genius” and “great man” ideas. The essence of the two concepts is reflected in the position adopted on personality archetypes. Essentially, the first adopts the position that some people have inborn ability to with reference to particular trait, while the second argues that others are born with ability to learn the trait under consideration. The first is innate and the second is acquired. Aaltio-Marjosola et al. (1998), agreeing with Misumi (1985) on the “great man” and “genius” theories argued that the two theories are symptomatic of the concepts of astrology and palmistry, methods used in the past to predict the behaviour of others.

According to Goodstein and Lanyon (1971), astrology is the method used to predict the behaviour of individuals through inferences based on the observation of heavenly bodies and fixed stars. “*Personality assessment for an individual was accomplished by noting the moment of birth and then getting the appropriate predictive information from one of a number of elaborate manuals of almanacs*” (Goodstein and Lanyon, 1971). Analogous to astrology is another technique of personality assessment known as biorhythms. The theory of biorhythms is that our day-to-day effectiveness is governed by our position on three cycles defined as physical, emotional, and mental. Goodstein and Lanyon (1971) argued that the three cycles are fixed based on the moment of our birth and are not modifiable. Previous philosophers such as Thommen (1973) agreed with Goodstein and Lanyon (1971) on the usefulness of biorhythms in predicting one’s potential effectiveness any given day.

Another historical method in personality assessment is palmistry. Goodstein and Lanyon (1971) define palmistry as the method for determining the personality characteristics of a person by interpretations of the various irregularities and folds of the hands. This method has existed in China as far back as 3000 BC. Goodstein and Lanyon (1971) suggested that importance should be given to the lines of the hand as well as the monticule or swellings between these lines in the palmistry method of personality assessment. Analogous to palmistry is the phrenology method of personality assessment. Phrenology relies on measuring the external shape of the human skull to determine personality archetype. Phrenology was developed by Franz Joseph Gall who was a German physician and anatomist (Goodstein and Lanyon, 1971). Gall’s basic assumption in the phrenology method is that a human brain was the locus of control over human behaviour, a view accepted uniformly by psychologists (Misumi, 1985).

The use of these methods, which reflect astrological notions, although still in practice today, are difficult to substantiate scientifically, and their classification is often the subject of much debate. Critics of these astrological methods argue that none of the underpinning assumptions have been scientifically tested, and the accuracies of their predictions are not supported by empirical investigations. For example, in palmistry readings, physical exercises by the subject can alter the monticule and other characteristics of the hand. The resultant effect has been significant differences in the interpretations of the same person's hands by different 'readers' (Goodstein and Lanyon, 1971). However, the uses of such non-scientific based psychological methods are still accepted by many people for predicting human behaviours.

Within construction, interest in the assessment and understanding of human nature has been an important aspect of management in the work place. Much of the emphasis for understanding human nature has concentrated on worker motivation, and how to enhance productivity (Olomolaiye et al., 1998). The rationale is that in order that managers and workers can work as one effective and productive unit, they both must know their role. The workers should know how to contribute to organisational objectives. Equally, the managers need a clear understanding of how to maximise productivity by supporting their workforce through the appropriate leadership. For example, in addition to knowing how human nature dictates a worker's actions, the manager has to be aware of the specific working environment, personalities, and motivational forces, which drive workers. Such psychological knowledge can then be used to judge which actions are essential to motivate the work force in order to obtain the highest possible levels of productivity. Much of the contribution made to construction through such motivational factors have drawn on the works of Maslow (1943) on individual needs, McGregor (1960) on Theory X and Y, Herzberg (1968) on hygiene factors, and more recently from Ouchi (1982) on Theory Z. In essence, these theories implicitly acknowledge the notion that no two human beings are the same. Each person is unique and this is reflected in each person's ability to perform work, for example, in a chosen profession. No two individuals with the same qualifications and experience in a chosen profession can perform in the same way. There is bound to be differences since each person is unique. In the context of the study, the notion that no two estimators are identical in their personality presents an important explanation as to why different estimators given the same resources and conditions generate different estimates. The essential message from the work of seminal contributions to the subject of psychology such as Haynes and Wilson (1979) is that the clue could lie in their personality trait. The subsequent sections of the chapter explore current theories and tools on personality to shed light on the influence of trait on behaviour as well as the tools to measure such traits. The review of the trait theories is divided into different sections, with the earlier sections addressing the philosophical works and the latter sections focusing on the tools for measuring personality.

## 4.2 PERSONALITY THEORIES

The systematic efforts to understand and predict the behaviour characteristics of another human being are commonly shared by all people. An attempt by a person to study the intentions of another person approaching them by looking straight into the eyes or observing their posture can be regarded as the early stages of personality assessment. Personality assessment is a field of study that draws on general psychology, which defines personality as "that branch of psychology which is concerned with providing a systematic account of the way in which individuals differ from one another" (Wiggins, 1979). The relevance of such differences to the study in this thesis derives from the position that it could help explain why some estimators produce reliable estimates and others do not. The rationale is that knowing those differences should facilitate the provision of the right support regime to enable individual estimators to produce more reliable estimates.

### 4.2.1 Seminal Personality Theories

Notable among the works that explain personality characteristics are the contributions of Allport (1937); Cattell (1950, 1965); and Eysenck (1961). The works of each of these psychologists forms the focus of the review in the subsequent sections.

### 4.2.2 Trait Uniqueness Theory

Gordon Allport was one of the most remarkable trait psychologists. Allport (1937) indicated that traits have existence, which he considered as real. Allport was the first to introduce the trait uniqueness theory. Based on Allport's theory, in estimating, each individual estimator makes decisions that are consistent and influenced by the uniqueness of the personality trait of that particular individual. It could be inferred from the Allport theory that differences in cost estimating of two different estimators could be due to the uniqueness of their personality trait given the same exogenous factors. Therefore, the reliability of cost estimates may be largely dependent on the personality traits of the estimators.

In line with the uniqueness theory it can equally be inferred that trait predispositions tend to integrate dissimilar stimuli and responses. In other words trait is "*a generalised and important neuropsychic system (peculiar to individual) with the capacity to render many stimuli functionally equivalent, and to initiate and guide consistent (equivalent) forms of adaptive and expressive behaviour*" (Allport, 1937). Allport was of the view that the disposition of some people influence the majority of their behaviour. Allport (1937) called this highly generalised disposition as **cardinal** traits. Allport differentiated between the cardinal trait and other forms of trait. For example, the cardinal trait could be inferred for a student who always wants to obtain excellent grades in all subjects as *goal achievement* since that appears to drive their life. Based on the Allport classification achievement therefore, becomes the cardinal trait in this example. The next trait after the cardinal is the **central** trait. While the central trait is also a reflection of a generalised disposition it is considered less pervasive. Allport (1937) called the third type of trait secondary disposition or "attitude". The secondary dispositions were considered to be more specific and narrowly defined traits. Figure 4.1 shows how the four trait categories come together to define how an individual responds with their friendliness trait in different contexts. It illustrates that each individual has different levels of the cardinal, central, and secondary dispositions. In general it shows that there are fairly broad consistencies in behaviour by uniting the responses to numerous stimuli.

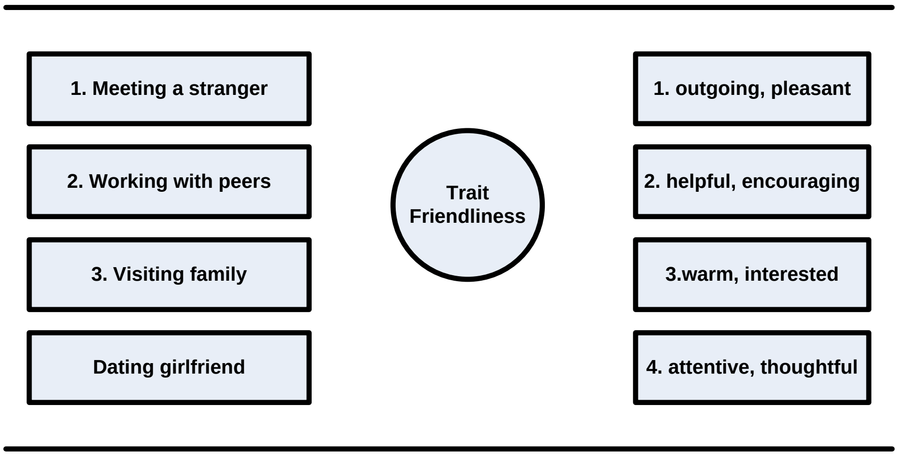



**Figure 4.1: Trait as the Unifier of Stimuli and Response (***Source: Mischel, 1986***)**

According to Allport (1937), traits never occur in any two people in exactly the same manner. He further argued that comparison between people could not be made on the basis or through the study of their traits. It is therefore, reasonable to conduct any comparisons based on the common dispositions that reflect the traits they exhibit.

Although Allport contributed immensely to the trait theory, he was critical of the trait theories of other earlier psychologists who preferred the use of statistical methods for analysing traits (Mischel, 1986).

### 4.2.3 Common, Unique, Surface and Source Traits

Raymond B. Cattell also provided one of the earlier theories on personality trait. Cattell (1950) concurred with Allport (1937) on the uniqueness of personality traits of each individual. In addition Cattell (1965) made a distinction between what he described as **common traits** and **unique traits**. Cattell (1965) proposed that all people possess common traits while unique traits are exclusive to each individual. He further suggested that the unique trait cannot be found in any other person, a view that is consistent with the theory of Allport (1937). Common traits identified by Cattell (1965) are normal behaviours of estimators in general and are influenced by one's development and upbringing. The unique trait theory of Allport (1937) combined with Cattell's extension with common traits would help explain why the personality trait of each individual estimator is of uttermost importance in improving the reliability of project estimates. The deduction that can be drawn from the personality theory of Allport (1937) and Cattell (1965) is that each estimator is unique due to inimitability of their individual personality traits. Therefore, the unique trait of individual estimators might be the influencing feature that determines their decision-making orientation.

Other forms of trait differentiated by Cattell (1965) were **surface** trait and **source** trait. Surface trait refers to readily apparent personality characteristics such as integrity, discipline. Source trait is a conception of the underlining foundation of the readily apparent personality characteristics. Cattell (1965) subsequently developed a procedure for analysing responses or scores from experiments, statistically positive correlations and mathematical techniques such as factor analysis. The analysis involved generating the correlation for a surface trait to establish a factor that accounts for the difference in variations in behaviour. Cattell's contribution on surface and source traits provides a strong justification for arguing that the influence on the behaviour of estimators in project cost estimating could be ascertained by deploying appropriate statistical analyses. Figure 4.2 shows the different inputs into Cattell's surface and source traits.

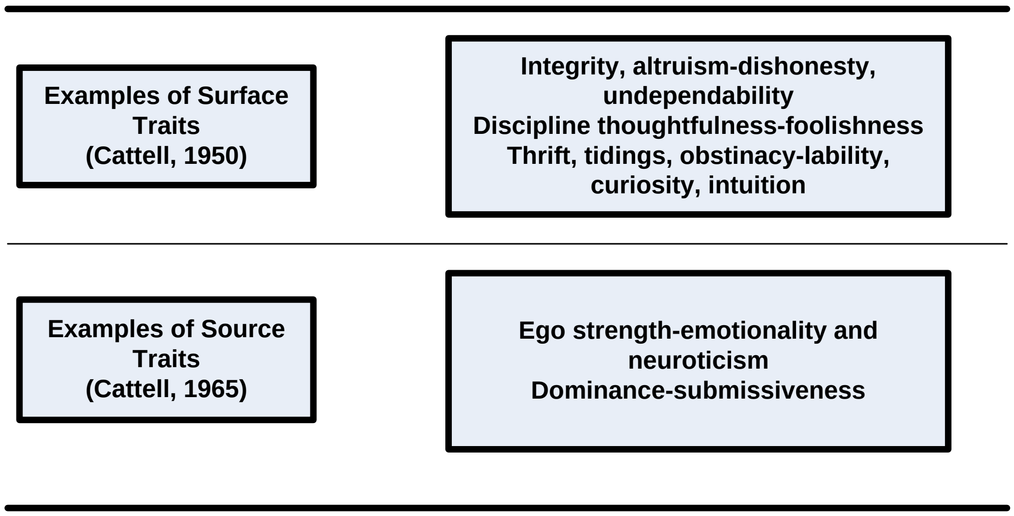



**Figure 4.2: Surface Traits and Source Traits (***Source: Mischel, 1986***)**

Figure 4.2 shows examples of surface traits, which are responses that correlate positively with each other, while the examples of specific source traits are sources of personality reactions that operate in specific situations.

## 4.2.4 Neuroticism

Eysenck (1961) is an English psychologist who introduced the notion of neuroticism and also investigated aspects of introversion and extraversion, which was originally introduced by Carl Jung (Mischel, 1986). The neuroticism trait describes a personality that reflects a stable, calm and reliable temperament, and is manifested by people who are moody, anxious and reckless alike. People showing characteristics of extraversion are people who generally like change, are optimistic and not always reliable. Eysenck (1961) also gave characteristics of introversion as diametrically opposed to extraversion. In estimating, decisions are made on many issues. The ability to make sound decisions is dependent on the individual estimator ability to assess each decision situation with a high degree of certainty. An estimator who reflects an introversion is likely to be conservative and risk averse, while one that has extraversion would be more risk prone.

## 4.2.5 Concepts of Personality

While there are common threads that can be associated with the notion of personality, the various contributors to the subject detail marginal differences that is worthy of consideration. For example, Allport (1937) in describing personality related it to an earlier antecedent, *persona,* which was the theatrical mask used in Greek drama. Allport (1937) established the principle that personality is what the person really is, and involves what is most typical and deeply characteristic of the individual. Hall and Lindzey (1978) also argued that it is impossible to apply one substantive definition of personality to all situations and contexts associated with people. Goodstein and Lanyon (1971) equally expressed the difficulty in developing a definition of personality in view of the diversity and contradictory elements involved. However, Goodstein and Lanyon (1971) suggested a definition for personality that could draw the diverse views together as follows – "*an abstraction for those enduring characteristics of the person which are significant for their interpersonal behaviour*" (Goodstein and Lanyon, 1971).

Some of the earlier contributors defined personality as "*a person's unique pattern of traits"* (Guilford, 1959) and *"the most adequate conceptualisation of a person's behaviour in all its detail*" (McClelland, 1951) among others. The common feature of these definitions is the importance they all attach to a persistent pattern in the responses of any person as a unique representation of that person.

The notion of trait as a reflection of the pattern of response suggests that the behaviour of human beings towards the forces operating in their situational environment is of great importance in personality perspective. These led to the view arrived by Mischel (1986) that "*the individual is influenced by many determinants and human behaviour reflects the continued interaction of many forces both in the person or environment or situation*" (Mischel, 1986).

## 4.2.6 Fundamental Assumptions on Trait

The trait theories of the earlier investigators have essential differences in their position on key philosophical stance. Mischel (1986) indicated that despite these differences, the theoretical assumptions and strategies in each of the theories are the same. Mischel (1986) named the assumptions and strategies as follows.

i. Traits are assumed to be general and fundamental dispositions that account for consistencies in behaviour.
ii. Some traits are considered to be relatively superior and specific, others that are more basic and widely generalised are assumed to produce consistencies in many situations.
iii. The predominant objective is the identification of the underlying broad dispositions. Emphasis is on the measurement of an individual’s position on one or more dimensions by means of objective instruments or tests administered under standard conditions.
iv. People’s tested or sampled behaviours (including what they say about themselves) are viewed as signs of their underlying traits.
v. To search for basic traits psychometric strategy is used that samples and compares large groups of subjects quantitatively under uniform conditions.

These assumptions underpinned many of the current trait principles that have informed several of the testing and assessment tools applied by psychometric classification.

## 4.2.7 The Trait Approach

Mischel (1986) suggested that the trait approach seeks to classify people with a particular trait in terms of everyday language, such as aggressive, friendly among others, in order to compare their psychological attributes. The trait approach is based on the assumption that individual’s behaviour is determined by the basic psychological qualities of the person. These qualities express themselves in many contexts. The trait approach appears to suggest that individuals differ consistently in their response to the same situation or stimulus. Mischel (1986) also accepted the notion that individuals react differently when confronted with the same issue assuming that all other conditions stayed the same. Figure 4.3 shows a graphical presentation of the differences in the response to the same stimulus of criticism from a teacher. The respondents represent different pupils and provide an example of consistence differences among people in their response to the same stimulus. Mischel (1986) consequently described trait as the consistent differences between the behaviour characteristics of two or more people, as aptly reflected by Guilford who suggested that "*trait is any distinguishable, relatively enduring way in which one individual varies from another*" (Guilford, 1959).

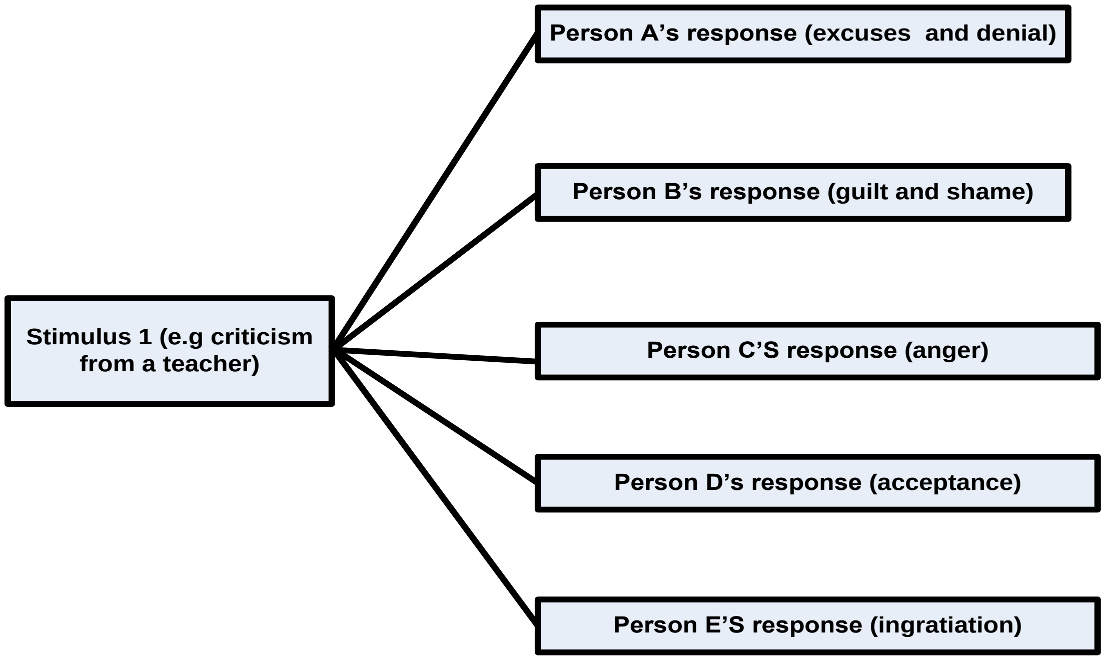



**Figure 4.3: Individual difference in Response to Stimulus (***Source: Mischel, 1986***)**

## 4.3 USE OF PERSONALITY ASSESSMENT

Goodstein and Lanyon (1971) are adherents of the views espoused by Cattell (1965) that emotional temperament is one of the most notable differences between one man and another. Emotional temperament shows how some people are quick and excitable, while others are slow and deliberate. This has been applied in the past and is still being used in some organisations for placement of employees in job categories.

Mactavish and Marie (1992) opined that oriental astrologers who devised the oldest system of typology classified character in terms of signs based on the element of water, air, earth, and fire. The system provides that persons born under the same sign are thought to share a similar nature and have comparable temperaments

(Mactavish and Marie, 1992). This underscores the reasons why some people behave in similar ways even if they have no biological relationship. This type of selection has been used in the olden days to select people for jobs in both private and public sectors. In China for example, such tests were used to select civil servants (Mischel, 1986). Many historians believed that this method of selection accounted for the stability of the Chinese Empire (Mischel, 1986). Many of the ancient countries used this method of selection in all their businesses including selection into government positions. In France for example, some organisations still use astrology and graphology to select top business executives (Cattell, 1965). According to Furnham (1992), even though empirical investigations have revealed that interviews have very little reliability, Americans are still using interviews in their selection. In America, personality text are used as a "*way to understand the relationship of individual differences to work-related behaviour*" (Furnham, 1992).

## 4.3.1 Personality and Team Effectiveness

There were numerous studies in the past on the relationship between personality and rated leader effectiveness. For example, Stogdill (1948), Howard and Bray (1987), and Bentz (1998) among others illustrated the link between personality and team performance, which incorporates the leadership factor. The importance of understanding the behaviour characteristics of individuals is evident by the number of authors that focus on the subject matter matter of personality. Cone and Hawkins (1977), Hersen and Bellack (1976), Haynes (1978), Ciminero et al. (1977), Haynes and Wilson (1979), and Goodstein and Lanyon (1971) among other authors gave the subject extensive treatment in their various publications. Their studies led to the conclusion drawn by Hogan (1994) that the criticism of personality tests in the 1970s and 1980s was no longer valid for the 21$^{st}$ century. In recent times Huitt and William (1992) have identified important differences in how problem solving is approach by people individually and collectively to illustrate the point of synergy from different personalities within a team.

While various studies continue to research aspects of personality and cognitive styles and their relationship to people and team performance, some social scientist have raised questions on the justification of the underlying concept implied by such analysis. One of such social scientist was Mohr (1982). Mohr (1982) argued that there is lack of reasonable and warranted stability in the results from such analysis. In particular, Mohr (1982) argued that different results were always obtained to similar questions in repeated administration of the experiment. Mohr (1982) also explained that interactions between the variables being measured was the main reason for the instability that characterised the results obtained from the same question. Mohr (1982) defined this instability as the dependence of the impact of one phenomenon on the presence or level of another phenomenon. The lack of clarity on the extent of the various instability levels therefore, rendered any causal assessment potentially spurious.

However, research by Mischel (1986) has shown that there is sufficient ground to supports the notion that personality assessment is the reliable and valid method in predicting individual behaviour characteristics especially in making decisions. If that basis is acknowledged as the general rule, then personality assessment could be employed to predict the individual estimator behaviour characteristics in decision-making. By combining the notion of the causation between personality and performance with the surface and source traits theories of Cattell (1965), it should be possible to define measurement frames that can facility assessment of estimator behaviour. Such a measurement could prove invaluable in establishing the influence of personality archetypes on the reliability that various estimators may attain in estimating the cost of a project.

## 4.4 PERSONALITY AND STRESS

This section addresses how different people cope with psychological challenges that face them in their everyday life. Some of the challenges are discussed and recommendations made from works of previous studies on coping with psychological challenges. The relevance of these challenges to the study derives from the work conditions of the estimators that formed the study sample as outlined in an earlier chapter. For the estimators the challenges take the form of anxiety and stress. Each of these factors will be addressed briefly below.

### 4.4.1 Anxiety and Stress

The theories of earlier psychologists define anxiety in many different ways. The definitions of some of the earlier psychologists are discussed. According to May (1950) "*Freudian formulations emphasise the breakthrough into consciousness of unacceptable impulses. Leading theories focus on association with painful or aversive stimulation, and phenomenological-existential theories stress the perception of a basic threat to the self or to the individual's very existence on personality*". Both pain and perception are very subjective reflections of human experience, thus making stress and anxiety subjective phenomena that will differ from one person to another in terms of their acceptable threshold. Mandler and Watson (1966) defined anxiety as the state of distress and helpless in which the organism has no alternatives whiles Malmo (1957) argued that anxiety is as a disease or over-arousal.

Experiences of anxiety are countless, and hence, it would be more appropriate to identify the causes and see how such a phenomenon could be measured rather than finding a universal definition for anxiety (Mischel, 1986). Individuals experience anxiety in different ways. Maher (1966) identified some basic elements in any individual that is experiencing anxiety as:

i. a conscious feeling of fear and danger;
ii. a pattern of psychological arousal and bodily distress that may include miscellaneous physical changes and complaints; and
iii. a disruption or disorganisation of effective problem-solving and cognitive control.

According to Maher (1966) anxiety should be avoided because of its aversive nature and recommends a quick escape from any threatening situation as a means to overcome the effects of anxiety. Strengthening of successful escape behaviours enables one to avoid similar future dangers (Mischel, 1986). However, in situations where the escape pattern is reinforced, an individual may continue to avoid similar situations in the future even if they are no longer present a threat. For most estimators, stress and anxiety that arises from the nature of work becomes essential to their performance as in very cases there would be no defined escape mechanisms in place. The same escape mechanism may not be effective for everyone, and their personality archetype needs to be taken into account to define the most appropriate mechanism suited to the particular individual estimators.

## 4.5 TOOLS FOR TESTING PERSONALITY

Personality assessment is the process of gathering information about an individual and organising the information with the aim of understanding the person. To understand the personality of an individual equally requires some amount of prediction into the future of the behaviour of that person (McDonald, 2008). The assessment is usually conducted through the administration of an appropriate test. The objectivity of a test increases when something enhances the uniformity of the testing conditions to which different subjects are exposed (Mischel, 1986). The objectivity of personality test is achieved when standardised test materials are used, clear instructions are given and uniform answer sheets are used with clear scoring procedures. A personality test that lacks objectivity stands the risk of bias and hence the results are not valid Mischel (1986). The various tools for personality testing are discussed in subsequent sections of this chapter to explore how each of the tools addresses the requirement of objectivity. Key lessons on achieving objectivity would then be employed to inform the development of the research instrument adopted for the study.

### 4.5.1 Self-Reports

This is the type of personality testing whereby the individual assesses him or herself and makes deductions from the results of the assessment. Self-reporting test come in many forms and widely used (Skeels, 1966). As much as ninety-eight percent (98%) of the studies assessing personality traits published in the *Journal of Research in Personality* in 2003 relied on self-reporting test (McDonald, 2008). A similar research by Kagan (2007) revealed that ninety-five (95%) of the studies reported in *Journal of Personality* in 2006 employed a self-reporting questionnaire. Since much of the submission is under the control, it is for subjects to ‘fudge’ the results if they have been through the process once before. Various types of self-reporting test are discussed in the subsequent sections.

## 4.5.2 Intelligence Testing

The use of intelligence tests are widely recognised as a good discriminator of intellectual superiority and hence an indicator of mental performance. A French physician named Alfred Binet developed the first of the tests in 1890's (Kirby and Linda, 1997). The test is a practical way of studying mental processes and is utilized for mental ability testing by many companies. Building on the work of Binet, David Wechsler later developed Intelligence Quotient (IQ) test, which involves assessing an individual's mental standing or IQ in relation to other people under the same conditions (Skeels, 1966). The conditions could be same age, same practical experience among others. According to Skeels (1966), IQ results are similar for identical twins even if they are brought up in different environments. Honzik (1972) later provided the following explanation for the similarity measures of identical twins by arguing that it is the interaction between the genes and environment that accounted for the similarities in the IQ's of such twins (Honzik, 1972). The gene and environment proposal of Honzik (1972) has opened a new avenue for looking at individual performance in the work place.

## 4.5.3 Minnesota Multiphasic Personality Inventory

The Minnesota Multiphasic Personality Inventory (MMPI) is a self-reporting test that adopts a scale with 550 printed statements (Mischel, 1986). The statements are from a wide range of topics on personality that differ widely on attitudes, emotional reactions and psychiatric symptoms among others (Mischel, 1986). In taking the MMPI test, the individual has a limited number of ways in which the questions making the instrument can be answered. The choices could be "true" or "false" or "undecided". The others could be "yes" "no", "strongly agree", or "don't know".

The motivation in deploying the MMPI instrument is the standardised nature of the questionnaire and the objective attribute of the scoring procedure, thus, making reproduction and replication of the test easy to achieve. The disadvantage of MMPI type of psychometric test is the unwillingness of people to reveal themselves accurately, especially if they believe that their answers would be used to make important decisions about them. However, such information on the estimator's personality trait could be important in enabling a better understanding of the differences in estimates produced by two estimators with the same conditions and information.

## 4.5.4 The California F Scale

The California *F* Scale is a self-reporting test that assesses authoritarian attitudes. The scores on the *F* Scale are presented as high or low. For example, the results from the *F* Scale test on Kofi when compared with other students on authoritarianism could be represented as follows: Kofi's *F* Scale is high compared to the other students. "*The meaning of high or low on the measurement scale will depend on the network of associations that have been found for the test in research*" (Mischel, 1986).

Titus and Hollander (1957) studied the relationship between the *F* Scale with questionnaire and non-questionnaire measures and revealed that correlation of the *F* Scale is strong when questionnaire measures are applied but weak with the non-questionnaire option. The work of Titus and Hollander (1957) appear to suggest that any effort to understand the influence that trait can have on reliability of estimators in costing projects would yield a more effective assessment if a questionnaire option is adopted.

## 4.5.5 The Q-Sort Technique

Another tool that originated from California is the California Q-sort, also referred to as the Q-technique. The technique involves the use of a large number of cards with printed coded statements such as "I am an impulsive person" or I am "likable", that is used for self-description (Block, 1961). The printed cards are self-arranged in order of perceived match to the personality of the individual and deductions are made from each arrangement accordingly.

The descriptors employed for the Q-sort testing are drawn from a variety of sources. They include material drawn from particular theory on personality (Stephenson, 1953), therapeutic protocols (Butler and Haigh, 1954) and personality inventories (Block, 1961). According to Mischel (1986), the Q-sort presents one of the most effective methods that could be employed to describe the characteristics that associate with successful performance in a given task. Administering such an instrument would demand more resource support that would be inappropriate in a Ghanaian context. For example mapping various descriptors on to various traits that reflect the context of the study environment would entail a full research study in its own right. The absence of a ready instrument that is configurable rendered the Q-sort tool unsuitable for the purposes of this study.

### 4.5.6 Informant Report

The informant reporting method involves obtaining information on a person from another person in order to achieve a more complete description of the trait of the person under observation (McDonald, 2008). Although personality is perceived to be an attribute internal to the individual, and therefore, best judge by that individual, others may get to know people based on the overt behaviours and actions of the subject. Informant reporting methods include judgement by peer observers, and confidential report on others such as character references. Informant reporting methods are built on the notion that people can offer a unique perspective on another person's personality (Hogan, 1998). In an estimating environment, the use of informant reporting could spark an air of suspicion among staff, as the work environment is bound to reflect power political dynamics. The use of staff evaluation at present presents its own difficulties of favouritism and accusations of bias directed at superiors. Adding the element of peer informant or perhaps junior informant reporting would only aggravate any difficult situation that may exist.

### 4.5.7 Comparative Evaluation of the Reports

Both self-reporting and informant reporting tools have their merits and demerits when employed to assess personality. Table 4.1 shows the advantages and disadvantages of the self-reporting and informant methods of personality measure. The use of any particular tool would be determined by the type of study that is required and other related issues such as the level of accuracy for the assessment.

The reliability of either of the reporting formats is dependent on appropriate management of the risks factors identified in Table 4.1. Of particular interest, is the risk of reporting bias, which is common in both formats. In this research, risks identified in Table 4.1 among others in the self reporting format used for the investigation were mitigated. The mitigation measures used in the research have been presented in the subsequent sections.

**Table 4.1: Advantages and Disadvantages of Reporting Formats**

| Method | Advantages | Disadvantages |
|---|---|---|
| Self-Report | -Practical and efficient<br>-Convenient and easy to administer<br>-Inexpensive<br>-Direct insight into unique personal information<br>-Individual motivation to respond<br>-Can control most response biases<br>-Many readily available psychometrically-tested inventories<br>-Most commonly used method. | -Potential issues with credibility of response (due to response biases):<br>• Socially desirable responding<br>• Acquiescent Responding<br>• Extreme Responding<br>-Assumes that respondents have self knowledge and do not have distorted self-perceptions<br>-Issues with non-context-specific language use of questions<br>-Cultural limitations |
| Informant Reports | -Can provide objective information about target<br>-Potential to be practical, inexpensive and convenient (e.g. internet)<br>-Multiple rates and aggregation of data can lead to reliability of results<br>-Others can provide insight on behaviour, especially across-situations<br>-No socially desirable response | -Less efficient and more effort required to obtain third-party data than simply ask the target<br>-Similar response bias to self-Reports (e.g. Acquiescent and Extreme Responding)<br>-Issues with choosing informants-possibility of biases based on relationship or research aims<br>-Others cannot access certain personal information about target<br>-Difficulty to assess situations-specific behaviour. |

*(Source: McDonald (2008)*

## 4.5.8 Myers-Briggs

The “Myers Briggs Type Indicator” is one of the most popular tools available that assist organisations in understanding the personality characteristics and behaviours of their employees. The review of the “Myers Briggs Type Indicator” in this thesis is organized into a number of sections. The first section examines the historical development, the second examines the tool itself and the third section discusses its application and uses.

### *4.5.8.1 Historical Development*

In 1917, Katharine Cook Briggs began the research into behaviour characteristics of people. She developed a framework that was described as the four-type framework. The framework was made up of social, thoughtful, executive, and spontaneous categories of behaviours. Around the same time the theory of Jung, which was aimed at understanding the behaviour characteristics of people was proposed in a publication that translated his original German edition (Jung, 1971).

Katharine Cook Briggs and her daughter Isabel Briggs Myers subsequently developed and tested several questions after studying Jung’s theory that was aimed at assisting people in identifying their own Jungian type preferences (Kirby and Linda, 1997). The Briggs-Myers Type Indicator was created in 1942 and the hand book published in 1944. The name of the indicator underwent different changes until in 1956 when the present name “Myers -Briggs Type Indicator” was established (Tupes and Christal, 1961).

### *4.5.8.2 Myers -Briggs Type Indicator*

The Myers Briggs Type Indicator tool is commonly abbreviated as MBTI. The primary purpose of the Myers Briggs Type Indicator was to make Jung’s theory understandable and useful to the life of everyday people. The MBTI has four dichotomies for classifying the personality of subjects, which are represented by the letters E-I; S-N; T-F; and J-P. These are presented in Table 4.2 and show that individuals often combine varying degrees of a trait dichotomy.

**Table 4.2: The Four Dichotomies**

| **PERSONALITY DICHOTOMIES** | |
|---|---|
| **E**xtraversion | **I**ntroversion |
| **S**ensing | i**N**tuition |
| **T**hinking | **F**eeling |
| **J**udging | **P**erceiving |

(*Source: Myers et al., 1998)*

**E**xtraversion and **I**ntroversion are referred to as attitudes of a person. People with a leaning towards extremes of Extraversion tend to draw energy from their action and are more spontaneous. They tend to act first before pausing to reflect and then act again whiles people that manifest extremes of Introversion tend to reflect before acting and then reflect again. In a sense, it could be summed as extraverts are action oriented whiles introverts are thought oriented.

The two centre dichotomies represented by S-N and T-F describe functions of **S**ensing, i**N**tuition, **T**hinking, and **F**eeling that reflect basic preferences for **P**erception and **J**udgement (Myers et al., 1998). The Judging functions are Feeling and Thinking whiles the perceiving function are Sensing and iNtuition. Each person uses one of these four functions more dominantly and proficiently than the other three. However, all four functions are used at different times depending on the circumstance. “*Sensing (S) seeks the fullest possible experience of what is immediate real, INtuition (N) seeks the further reaches of the possible and imaginative, Thinking (T)* *seeks rational order and accord with the non-personal logic of cause and effect, and Feeling (F) seeks rational order in accord with the creation and maintenance of harmony among important subjective values*" (Myers et al., 1998).

According to Myers et al. (1998), E-I and J-P, the other two dichotomies reflect the orientations of energy or attitudes. In the Extraverted (E) attitude, individuals rely on the environment for stimulation and guidance. These types of people are action oriented, social and open to new and different experiences. In the Introverted (I) attitude, individuals rely on concepts, ideas and inner experiences. People under this category are more private and prefer to think with contemplative detachment before taking action. Judges (J) are those individuals who habitually use judging when interacting with the outer world and are likely to come to conclusions and achieve closure quickly. People who habitually use perception when interacting with the outer world and are quick in gathering information before coming to closure are people with Perception (P) type personality (Myers et al., 1998).

The eight preferences above can be exhibited in varying degrees by each individual. The identification of the character of any individual is therefore, dependent on the predominant types they display. The objective of MBTI tool is to determine and identify in each individual which of the four basic preferences are predominant in the individual in the mist of the other preferences that are all competing together. The identification of the basic four preferences does not mean that individual does not exhibit the other preferences. The dominant preferences are the focus of the application of MBTI. The behaviour of an individual in terms of how that individual perceives any situation and the decision taken for a course of action, is influenced by these functions and orientations. The basic four preferences that MBTI uses to classify a person could result in an arrangement of different personality types. There are four permutations from the four basic preferences from MBTI resulting in sixteen different personality types.

For a better understanding of the interpretations of the sixteen different types of personality, Isabel Myers designed a table was captioned as the "type table". Table 4.3 presents the Myers type table, and provides details of the different permutations that can be achieved with the use of the tool. Isabel Myers employed the type table to highlight and classify similarities and differences in the types, and also to show the frequencies of types in a group of people that have common characteristics. The common characteristics could be their role at the workplace, such as estimating, or any other activity that the group of people share.  Examples in construction include engineers, architects or other professional specialisations or skills involved in the delivery of the project.

**Table 4.3: Personality Type Table**

| | | | |
|---|---|---|---|
| **ISTJ** | **ISFJ** | **INFJ** | **INTJ** |
| **ISTP** | **ISFP** | **INFP** | **INTP** |
| **ESTP** | **ESFP** | **ENFP** | **ENTP** |
| **ESTJ** | **ESFJ** | **ENFJ** | **ENTJ** |

***(Source: Myers et al., 1998)***

The accuracy of the application of MBTI has been the subject of contention in the past.  For example, McCauley and Mary (1994) presented evidence from their study that suggested that the tool could achieve an accuracy of 75% correct classification of type, later researchers such as Hammer and Allen (1996) reported that the accuracy as 85%.  McRae and Costa (1988), Carlson (1985) and McCauley and Mary (1994) among others have all investigated the application of Myers-Briggs Type Indicator for classifying personality and were of the view that the tool helped to explain an individual's personality preferences not only to employees but to the individual themselves.  McCauley and Mary (1994) also revealed that most individuals who were measured by the instrument agreed with the majority of the elements of their type description.

Despite the confirmation of the accuracy and validity of Myers-Briggs Type Indicator in predicting human behaviour archetypes, some researchers such as Gardner and Martinko (1996) were of the view that the instrument does not produce consistent and valid results in measuring personality.  Gardner and Martinko (1996) undertook a systematic study of the application of MBTI in measuring managerial attributes, effectiveness and behaviours and expressed concern on the conceptual foundations and psychometric properties of MBTI.  Some past critics such as Gross (1962) even took a very extreme stance by advocating for the abolition of psychometric testing including personality assessing devices because of the level of misclassification. Gross (1962) was of the view that psychological tests were generally inaccurate and more significantly, immoral since the testing invaded the privacy of the respondent. While some critics argue for abolishing use of psychological tests including personality assessment devices, others are of the view that the deficiencies such tools should to be addressed (Goodstein and Lanyon, 1971).  Such an improvement could enhance their accuracy and make them more useful for assessing personality types. However, some of the controversies related to the problem of misclassification makes the use of the MBTI tool the preserve of the expert rather than a tool that could be self-administered by estimators. The important limitation of self-administration rendered the use of the MBTI tool unsuitable for the testing required to support the experiment required for the investigation in the research on which this thesis is based. Since the nature of the study in this thesis is exploring correlations between classified personality types and other performance variables, any misclassification could potentially generate spurious correlates.

### 4.5.9 The Big Five Personality Test

Tupes and Christal (1961) postulated that five personality traits are sufficient to describe adequately an individual's behaviour characteristics. Other researchers of personality traits such as McCrae and Costa (1999) and McDonald (2008) arrived in a similar position on the subject and agreed with the notion expressed by Tupes and Christal (1961).

The Big Five Personality test takes advantage of the notion of the adequacy of five archetypes, and is rooted in the concept that the differences in our personality are associated and coded in the language we speak which has evolved over several generations (Tupes and Christal, 1961). McCrae and Costa (1999) revealed that the basic foundation of the five-factor theory of personality is that people can convey a vast amount of information about themselves through the expressions of thoughts, feelings and actions. Therefore, any well-designed and self-reporting personality questionnaire could be used to express the five traits of Extraversion, Agreeableness, Conscientiousness, Neuroticism and Openness (McDonald, 2008) The name "Big Five" is derived from the number of traits that are dominant and unique to the individual. Tupes and Christal (1961) explain each of these traits as follows.

a. **Openness:** this refers to the extent to which an individual is accessible to new ideas, creative experiences and different values.
b. **Conscientiousness:** this refers to the extent to which an individual is organised, strategic and forward planning.

c. **Extraversion:** this describes the level to which an individual is inclined to experience positive emotions and the extent to which that individual is attracted to social, stimulating experiences.
d. **Agreeableness:** this refers to the extent an individual shows concern for the feelings of others, as well as, how that individual easily makes friends with others.
e. **Neuroticism:** it describes the extent to which an individual reacts to perceived threats and nerve-racking situations.

Table 4.4 shows the labels that are used in describing the trait and their full meaning. To use the Big Five test, the embodiment letter in the trait is used in describing the trait instead of the full name.

**Table 4.4: Labels used in describing Traits**

| | | |
|---|---|---|
| **E**xtraversion:<br>Orientated towards the outer world of people, events and external activities. Lively, active, needing social contact and external stimulations. | Versus | Introversion:<br>Orientated toward their own inner world thoughts and perceptions. Quiet, retiring, **not** requiring much social contact or external stimulation. |
| High a**N**xiety:<br>Tense, nervous, sensitive. Prone to mood swings and challenged by emotionally gruelling situations. | Versus | low aNxiety:<br>Calm, stable, phlegmatic. Resilient, and able to cope with emotionally demanding situations. |
| **O**penness (to experience):<br>Influence more by ideas, feelings and sensations than tangible evidence and hard facts. Open to new possibilities and subjective experiences. | Versus | Pragmatism:<br>Influenced more by hard facts and tangible evidence than subjective experiences. **Not** open to new ideas, and insensitive to subtleties and possibilities. |
| **A**greeableness:<br>Agreeable, tolerant, helpful and obliging. **Not** stubborn, cynical or opinionated. Happy to compromise. | Versus | Independence:<br>Self-determined with regard to their own thoughts and actions. Independent minded, Intractable, strong-willed and confrontational. |
| high self-**C**ontrol:<br>Diligent, persevering, moralistic. Detail-conscious, dutiful and strongly influenced by social norms and expectations. | Versus | low self-Control:<br>Lacking self-restraint, spontaneous and flexible. Not attentive to details. Not strongly influenced by social norms and expectations. |

*(Source: Tupes and Christal, 1961)*

Each individual is described by a profile of five scores. These profiles are grouped by cluster analysis into relatively homogeneous clusters. Each cluster represents a personality type, and the average profile of the cluster members describes a personality prototype (Tupes and Christal, 1961).

The tool provided that assessment of typeness is not the measure of similarity between an individual profile and a prototype profile.  However, the assessment of typeness is a measure of the deviation from the mean profile in the sample of a particular personality (Tupes and Christal, 1961).  Since the typeness of an individual profile is not a measure of similarity with a prototypical profile, it cannot be calculated with a similarity coefficient such as Euclidean distance from a fixed mean profile.

The Big Five Test is generally accepted as the personality test that produces the most stable results (Afetornu et al., 2009).  According to Tupes and Christal (1961), the result obtained for an individual that undergoes this test is likely to be the same when the test is performed on the same individual some years later.  The stability of the results from the Big Five Test made it the most preferred test among all the personality tests.  The stability factor served as a strong justification for adopting the Big Five tool as the basis for developing an appropriate measurement instrument to investigate personality profile of estimators.

## 4.6 ESTIMATOR TRAITS

Cost estimates form a key element in the planning and management of the project, and project staff expends considerable effort preparing them.  The reliability of the estimates produced is therefore vital for the planning and budgeting of any development.  The reliability is determined by a number of factors.  These include physical or exogenous factors that relate to the project and its management.  These physical factors are referred to as external factors.  The other factors that are related to the behavioural characteristics of the individual estimator in decision making orientations are the internal factors.  These internal factors relate to the behavioural characteristics of estimators and their orientations in assessing risk.  The individual estimator’s orientations in assessing risk are themselves influenced by the personality traits of the individual estimator.  These internal factors are controlled by the individual estimator’s personality traits.  The study focused on the influence these internal factors have on the individual estimator’s behaviour characteristics and the effect of that it has the reliability of project estimates.  The internal factors that influenced reliability of project estimates are discussed in the subsequent sections.

## 4.6.1 Effect of Personality Traits in Estimating

The ability to produce cost estimates to a reasonable level of reliability and in a timely fashion to support the efficient planning of a project is influenced by a number of factors. These include the skill levels and numbers of estimators, national, industry and project related factors. For example, Harris et al. (2006) considered many of the factors that influence estimating reliability and associated availability of information with greater reliability. Other writers on the subject including, Touran and Lopez (2006), Skitmore and Thomas (2002), Tas and Yaman (2005), Williams (2003), Wong and Hui (2006), and Edwards and Bowen (1998; 2005) among others, concur with the role information plays in establishing reliable estimates and subscribe to the 'information school of thought'. The implication from the greater information school of thought is that all other external factors being equal, two estimators will arrive at the same project cost. While the general concept asserted by the information school of thought is predominantly true, it ignores the influences of internal factors such as the behaviour and decision orientations of estimators in their operational environment.

The difference in the estimates produced by two estimators with the same information and under the same work environment may be accounted for by the influence of these internal factors in assessing risk and making decisions with incomplete data. The disparity that arises from different decisions made by estimators implies that the estimate, and for that matter, the forecast of any event will have an upper limit and the lower limit.

Estimators play important roles in the management of projects and business activities of construction organizations. Their actions can have a direct impact on the success of the projects they are involved in, and consequently, the prospects of the companies they work for. It is in this vein that the decision-making characteristic of estimators during the estimating exercise is crucial for effective management of construction business activities.

To understand who an estimator is, and how their actions and inactions affect the desired level of reliability in estimating, the subsequent sections briefly explore the background and role of the estimator.

### 4.6.2 Background on Estimators

Estimators are construction professionals that have graduated from estimating programmes the various colleges, universities, and other higher educational institutes that offer estimating programmes. Some professionals become estimators through the route of 'on-the-job' training after considerable years of experience. However, people in this category upgrade their qualifications through further programmes in estimating modules offered by higher educational institutes.

Estimators are individuals or group of people that predict cost of future events of projects before it is implemented (Archilbald and Villoria, 1967). In doing so, estimators compile and analyse data on all factors that can influence cost, such as materials, labour, equipment, duration, location, special machinery requirements among others. Often the type and size of the project determines the scope of duties that an estimator is required to perform. The ability of the estimator to predict the future cost of materials, labour and other inputs has a direct influence on the reliability of the estimate they produce. The availability of the requisite information in the right amounts and on a just-in-time basis can assist the estimator to make an effective decision given the prevalent conditions at the time of the decision.

In construction, it is the norm for organisations to employ people with a formal and relevant educational qualification or/and training to undertake estimating. However, there are cases where estimators progress through experience. In this regard, the importance of the estimator's experience for establishing an estimate could not be overemphasised. Archilbald and Villoria (1967) described the reliance on such experience for estimating as a numerical guess by the estimator based on experience.

The work activities of an estimator include obtaining information from relevant sources, determining the time, costs, and resources needed to perform a work activity, and identifying the underlying reasons or facts of information by reducing each item into its separate constituent parts. Other roles include processing, documenting, updating information and making decisions and solving problems. The ability of the estimator to perform adequately in these activities is dependent, largely, on the personal orientation of the estimator in decision-making and the quality of information available.

### 4.6.3 Decisions in Operational Environment

A decision maker subjectively assesses the probable outcomes of a choice in terms of future events and exercises a decisions based on that assessment. The estimating effort involves similar subjectiveness as estimators evaluate their choices based on their locus of control within a future period. The estimating process is an attempt to minimise the degree of subjectiveness associated with the production of the estimate. It does that by relying on the use of a structured operation system and deploying quantitative techniques for optimisation. In both cases, the reliability of the estimator's decision in the operational environment has an effect on the estimate that is produced. This position was emphasised by Adams and Swanson (1976) and Archilbald and Villoria (1967). Archilbald and Villoria (1967) in particular, also explored the factors that influence estimator behaviour during the process and concluded that motivation, amount of effort the estimator is willing to expend in the search for reliability, job-related conditions in the operational environment, personal characteristics of the estimator, and the manner in which information is processed determines the reliability of estimates. These factors could be categorised into external or exogenous and internal or endogenous to the estimator. The internal factors, which relate to the estimators personal decision-making orientation forms the focus of this research study.

### 4.6.4. Estimator Judgment

The ability of the estimator to make sound judgments of future events determined by their skills set, reputation (Abernathy, 1971). In making the judgement and decisions, estimators are influenced consciously by the exogenous factors and subconsciously by the endogenous ones. The estimators' ability to combine logic, common sense, experience, judgement and skills in making informed decisions about information on events drives the reliability of the outcome estimates. Much of the judgements that the estimators make are based on assumptions that reflect their personal values and beliefs, some of which are real and others perceived. As estimators gain experience, their perception-based assumptions are converted to real ones as the ability of the estimator in exercising sound judgement improves. This observation supported by Abernathy (1971), who conducted a number of investigations into the reliability of estimates for different levels of experience held by the estimator. The Abernathy (1971) studies revealed that estimates improve as the estimator gains experience. Afetornu et al. (2009) explored data in a different research context and suggested that the reliability of estimates is directly proportional to the level of capability of the estimator.  According to Afetornu et al. (2009), the relationship between estimating reliability and the experience of the estimator is best captured by the relationship in Eqn 4.1.  If I=accurate estimate, and A= decision-making orientation of the estimator, then:

$$I \alpha A \qquad \text{Eqn. 4.1}$$

Equation 4.1 shows that as the estimator makes quality decisions, the reliability of the estimate increases.  Decision-making orientation is a personal characteristic of an individual.  For example, estimators that are risk prone, make early decisions on information whiles those that are risk averse take a long time to analyse the event before making decisions.  The differing decision times that arise from the orientation of the estimator is presented graphically in figure 4.4.  From the theory on tools for testing personality, risk prone and risk averse estimators could be classified as Extraverts and Introverts.  According to Myers et al. (1998) people with a preference of Extraversion draw energy from action.  Such extravert estimators will exercise key decision at time $T_1$, while their introvert counterparts will do so at time $T_2$.  While the decision at time $T_2$ will produce a reasonable change in accuracy, the extra time involved makes the process of estimating rather inefficient.  The question that arises is the time $T_c$ when the optimum accuracy is achieved and what personality types reflect that optimum time.  To answer that question the personality orientations of estimators has to be established.

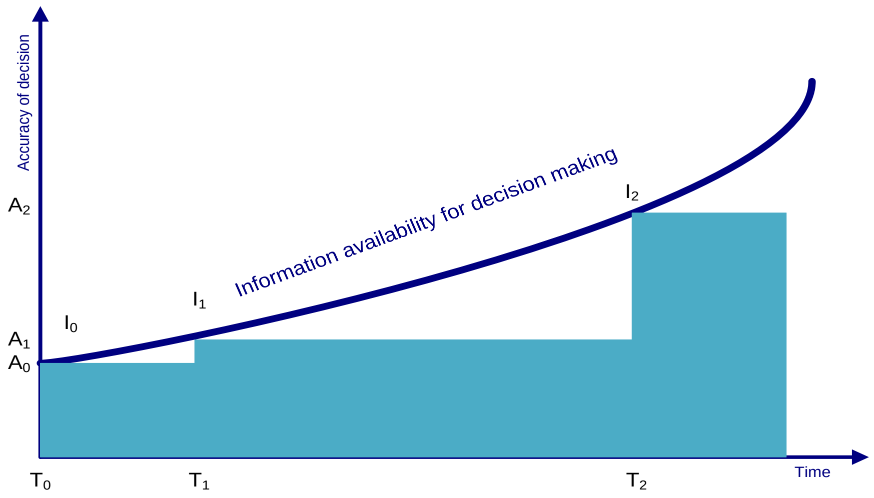



**Figure 4.4: Time that Estimators make decision. (***Source: Afetornu et al., 2009***)**

Where $T_{1} =$ Time that risk prone estimator makes decision,

$T_{2} =$ Time that risk averse estimator makes decision,

$T_{c} =$ The realistic time for estimator makes decision, and

From Figure 4.4, risk prone estimator has an accuracy of $A_1$ and the risk averse estimator, an accuracy of $A_2$. The relevance of the decision taken by the estimators, at the time of their decision is often not apparent. This is fully appreciated, only after they have been implemented and the results are known. In all cases the aspirations of the estimator is to exercise the most accurate or reliable decision option ($A_c$) compatible with an optimum ($T_c$). Knowing their personality archetypes will enable the problem of which estimators conform to the optimum ($T_c$) to be established.

## 4.6.5 Information Sharing Culture

The aspiration of the estimator is to produce project cost estimates that are reliable. The ability of the estimator to exhibit this aspiration is dependent on the information sharing culture within the project stakeholder organisations, as well as the behaviour characteristics of the individual estimator in exercising estimating decisions. There are several reasons that have been put forward to account for the existence of unshared information in project environment (Barrick and Mount, 1991). There is equally, evidence to support the notion that the larger the core of shared information, the earlier the realisation of the optimum estimate. Goldberg (1990), for instance, explored the accuracy of decision-making with respect to the level of information sharing in the work environment and concluded that the tendency to have a greater or smaller proportion of shared information is driven by the psychometric archetypes of the individual estimator.

In this regard, a number of factors influence the psychometric leanings of the estimator. These factors are categorised as external and internal, and correspond to the exogenous and endogenous categorisations adopted for this study. The factors that are related to the work environment, such as the culture of information sharing, constitute the external factors whiles those that are related to the conduct and personal characteristics of the estimator are the internal factors. The main focus of the research is to study the influence of these internal factors on the reliability of the estimate produce by individual estimators since these internal factors are related to the estimator's conduct.

A number of studies into staff behaviour in the work environment have also shown that productivity and satisfaction are directly related to the fit between the demand the job makes and the personal characteristics of the individual. Vianem et al. (1998) argued that individuals whose personality fit the organization culture often display a greater level of commitment than those whose personality do not fit the organizational culture. The relationship between environment and the individual's orientations in the job environment has been proven to be vital in the how an organization achieves its goals. Furnham (1992) studied the relationship between the work environment and satisfaction of the employee and concluded that "*the greater the match between the individual's needs and the environment attributes, the greater will be the potential for the individual's satisfaction and believed performance*" (Furnham, 1992).

## 4.7 ATTRIBUTES OF THE ESTIMATOR

The psychological attributes of the individual estimator are related to the personality traits of that estimator. The influence of each of these attributes on the estimator differs for each individual estimator. The personal attributes of the estimator influences the decisions that they make. For example, attributes such as trust, ethics, integrity, judgement, experience and environment are considered to have significant influences on the estimator's decisions (Afetornu et al., 2009). The influences of a selection of the above attributes on the decision-making orientation of the estimator are discussed in the subsequent sections.

### 4.7.1 Trust

Afetornu et al. (2009) argued in a contribution on the nature of the estimator's work environment that, the trust inclination of estimators becomes an important attribute that has a significant impact on the reliability of estimates. They showed that in an organization where there is a lack of trust between superiors and subordinates, estimators do exhibit high levels of transparency and diligence in performing their work. However, such transparency also means that estimators would work to rule rather that exercise any originality or take risks and is associated with a high level of transaction cost. All the same, it would appear that in work environments where there is limited trust estimates produced are more reliable as estimators strive to compensate for the lack of trust. Trust is an attitude, which can only be shown by people rather than the organisation. Uzzi (1997) and Dyer and Chu (2003) suggest that the level of trust the estimator has in their organisation has an effect on transaction costs associated with the project. Zaheer et al. (1998) explored the impact of trust on the organisation and concluded that although the notion of trust among individuals in an organisation is commonly used, it appears to be obvious that individuals do not exhibit trust. Barney (1986); Dyer and Chu (2003); Macaulay (1963); Egglestone et al. (2000) among others agreed with the notion that trust between individuals lowers transaction cost.

### 4.7.3 Ethics and Integrity

Estimating is professional discipline with very high standards of conduct. Estimators are required to exhibit personal professional discipline in all aspects of their work by exercising high level of ethical conduct and moral judgment in preparing project estimates (Kang, 2007). Pressures from superiors in the work environment sometimes affect the ethical conduct of estimators. However, it is understood that part of the estimators' professional role is the ability to withstand such pressures. The reliability of estimates is affected in those situations where the estimator is not able to resist such pressures, and is subsequently reflected in the decisions of the estimator. Kang (2007) has explored the ethical behaviour of project stakeholders including estimators in depth. Similar to trust, issues of ethics decompose into organizational and personal dimensions.

Integrity can be defined as consistency of actions, values, methods, measures and principles adopted by each individual (Kang, 2007). Integrity is also associated with various aspects of a person's life. In most instances, we speak of aspect such as professional and intellectual integrity among others. In general, the quality of the person’s character however, is the most important philosophical representation of their integrity. A person's character portrays how the person behaves in the performance of their duties. Their inherent characters in making decisions in cost estimating processes often directly influence estimators.

### 4.7.4 Judgment

Rush and Roy (2001) ascertained that quantitative knowledge is the elements of known cost and product structures which form the basis of cost estimating. According to their research, these are measurable whiles qualitative knowledge is the assumptions and *judgements* that cost estimators make during the process of estimating. The estimator makes the judgements based on their experience and information on past projects in order to arrive at an informed decision for a new project. Only experienced estimators understand much of the reasoning and logic behind their assumptions in estimating.

### 4.7.5 Experience and Work Environment

Rush and Roy (2001), Thompson et al. (1994), Abernathy (1971), Kahn and Robert (1964), and McClelland (1951) have indicated a significant relationship between experience, work environment and the desired reliability for project estimates. They identified the experience of the individual estimator and the conditions of the work environment as factors that influence significantly the reliability of project estimates. Thompson et al. (1994) showed how the influence of experience affects the skills and judgement of people. The conclusion of Thompson et al. (1994) agreed with Abernathy (1971) who revealed that estimates improve as estimators gain experience. The view of Thompson (1994) substantiates why expert judgement is used extensively during generation of cost estimates. Cost estimators constantly apply a combination of personal characters such as logic, skills, experience, commonsense and judgement in estimating (Rush and Roy, 2001). The conditions of the work environment also have an influence on the estimators' behaviour in estimating. In some organisations, the ratio of projects to experienced estimators is very high. In such situations, the high workload on the estimator affects the reliability of the decisions that the estimator makes.

#### *4.7.5.1 Pressures from Superiors on Estimator*

Pressures from superiors on estimators can have a negative impact on the freedom to exercise independent judgement on the part of the estimator. The reliability of the estimate is seriously undermined if such pressures are not well managed by the estimator. In the case of the study environment, there are pressures also exerted by politicians in their anxiety to satisfy voter demands. Construction of roads is one of the main campaign strategies for the dominant political parties. In view of this, pressures are more pronounced in election years. In situations like this, the estimator being an employee of the source of pressures is normally placed in a state of uncertainty in exercising their judgement for fear of being victimised should the judgement turn out not to be in favour to the source of pressure. The issue is how the estimator can feel protected under such a situation to make informed and independent decisions, which might not reflect the choice of the pressure sources.

## 4.8 SUMMARY

The theories of earlier psychologists on personality and its bearing on the study were discussed in this chapter and presented personality traits as well as their application to investigate the behaviour characteristics of estimators in decision-making. The various tools for testing personality and their advantages and disadvantages were discussed. While most of the tools agree on what to measure for establishing personality trait, their reliance on expert evaluation to classify subjects make such tools less relevant to the study that underpins this thesis. The Big Five tool was adjudged as having features that overcome the limitations of the other tools currently available, and was adopted for the study.

The ability to produce cost estimates to a reasonable level of reliability and in a timely fashion to support the efficient planning of a project is influenced by a number of factors. The chapter summarised these factors as the levels and numbers of estimators an organisation has, national, industry and project related factors, motivation, amount of effort the estimator is willing to expend in the search of accuracy, job-related conditions in the operational environment, characteristics of estimator himself, and the manner in which information is processed among others.

The chapter also revealed that the factors that are related to the experience and work environment also contribute significantly to the reliability of estimates. The review has identified pressures from superiors on the estimators and the influence of such pressures on the decision-making orientations of the estimator. The reliability of cost estimates is therefore, dependent on factors some of which the estimator has control over. The influence of these factors is to be studied and deductions made for the achievement of reliable project estimates.

Awareness of these trait assessment tools paved the way for the development of a suitable personality assessment instrument that was employed for the study. The detail of the instrument and research methods adopted in the investigations of the influence of individual estimator's personality traits on project cost reliability is given attention in the subsequent chapter.

# CHAPTER 5

# RESEARCH METHODOLOGY

## 5.0 OVERVIEW

This chapter opens with a brief discussion of the historical developments on research methods and the relevance of the different philosophical positions on research to the overall study. The chapter subsequently addresses the principal methods of investigation commonly applied within construction management research. More specifically, the two generic research methods, namely quantitative and qualitative, form the focus of the discussion on the methods. It also presents how the theories developed by the earlier researchers informed the researcher in the selection of the methods for the study. Quantitative research method was the predominant approach adopted in the study and the chapter provides an explanation for adopting that particular method. In addition, the research concept and how the concept is applied in addressing the reliability of project cost estimates are covered. This has been achieved by considering how the subject matter of the research relates to the factors that account for reliability of cost estimates from the perspective of personality traits of the estimator. The chapter also presents a discussion of the characteristics of the data sample used in the research and its relevance to the study, as well as the instrument used in eliciting the data.

## 5.1 RESEARCH PHILOSOPHY

"Philosophy" is derived from the Greek word, which translates as "the love of wisdom" (Bryman, 2004). Ruona (2000) argues that philosophy involves thinking about an issue, trying out to deduce reasons for and against that issue in question and thinking about how the concept works. Paul (1993) and Honderich (1995) have expressed other views on the subject, and suggest that philosophy offers a platform for in-depth thinking. This, they argue, results in an increase in the capacity of thinking and can provide a balance between what we think and actually do. In that respect, the study involved in this research has offered ample opportunity for such "thinking". Neuman described research as "*a systematic and organised effort to investigate a problem that requires a solution*" (Neuman, 2006). Bryman (2004) has suggested that there are two important philosophical considerations associated with construction management research. These are epistemological and ontological considerations and form the focus of subsequent sub-sections of this main section.

## 5.1.1 Epistemology

From a philosophical stance, epistemological considerations are concerned with the method through which knowledge is acquired. In other words epistemology addresses "how we know" (Bryman, 2004). In construction management research "how we know" can be categorised into positivist and interpretivist approaches.

### *5.1.1.1 Positivism*

The positivist approaches draw their inspiration from the natural sciences and are underpinned by the notion that the world order conforms to laws of causes and effects. The reliance on such laws implies the use of quantification and aggregation to interpret phenomena. Fitzgerald and Howcroft (1998), among others emphasised the fact that simplified and fundamental approaches reflected by quantification, can be used to tackle complex issues. Bryman (2004) in concurring with the views expressed by Fitzgerald and Howcroft (1998) indicated that a good research must be objective, and any measurement from the study must conform to the criterion of repeatability. Naturally, such a position in research would exclude many investigations that do not rely on replication and quantification to make a sense of the world. From a positivist perspective, how we know new facts is through quantification and aggregation.

### *5.1.1.2 Interpretivism*

The interpretivist perspective places a greater emphasis on the realism of the study context. The essential argument of the interpretivist philosophy stems from the nature of the phenomena under consideration in a study. For example, in investigating how individuals respond to pain, it is very difficult to argue that all subjects feel the same category of pain the same way. Simply banding different levels of pain to categorize respondents would not present a sufficiently robust way of representing individual pain. Interpretivism would therefore suggest that the context of pain for each individual subject would have to be evaluated on its own, as any aggregation could prove meaningless and spurious.

It is important to note that, while these two positions on research dominate the construction scene, a number of critics have argued for and against each of the two options. For example, Seymour et al. (1997) criticised the predominance of positivism in construction research. According to Seymour et al. (1997) the closeness of the researcher to the data source in the built environment is vital for a meaningful outcome to be derived from the research work. Seymour et al. (1997) therefore criticised advocated for more interpretivist approaches to be applied to research in the built environment. However, the view of other contributors counter advocacy of Seymour et al. (1997) by arguing that the use of only one perspective is inadequate, and that both perspectives are essential for developing a holistic 'picture' of the world around us (Green, 1998).

## 5.1.2 Ontological Consideration

Fitzgerald and Howcroft (1998) defined ontology as the logical investigation of the diverse manner in which different types of things are thought to exist. They further identified the two categories of ontology considerations as realist and relativist. These are briefly explored in the subsequent sections.

### *5.1.2.1 Realist Position*

Researchers with a realist position consider the external world to be made up of hard and tangible structures and therefore, are characterised by an objective creation of the mind. According to Breakwell et al. (2006), researchers with a realist perspective see theories as a useful way of predicting what will happen in future. They however, do not make any open claim as to the said theory by describing any real life issue.

#### 5.1.2.2 Relativist Position

The relativist position views the external world as consisting of multiple existences of actuality as subjective construction of the mind. The relativist position is of the view that personal and social factors cannot be excluded from science. The relativist position therefore, considers the fact that any theory only describes objective reality. According to Breakwell et al. (2006), the acceptance of any theory is socially reached through consensus among the scientific community as to what to believe.

Table 5.1 shows the summary of philosophical considerations of the two perspectives and their sub-categories as projected by the contributions of Fitzgerald and Howcroft (1998) and Bryman (2004).

**Table 5.1: Summary of philosophical considerations**

| **Ontological considerations** | |
|---|---|
| ***Realist***<br>External world comprise pre-existing hard and tangible structures<br>Structures exist depending on the individual ability to acquire knowledge. | ***Relativist***<br>Existence of multiple as subjective construction of the mind<br>Perception of reality is directed by varying socially transmitted terms. |
| **Epistemological consideration** | |
| ***Positivist***<br>Application of natural science methods to the study of social reality and beyond<br>World conforms to causation laws and complex issues can be digested through reductionism | ***Interpretivist***<br>Absence of universal truth and emphasis on realism of contact<br>Understanding and interpretation come from researcher's own frame of reference. |

*(Sources: Fitzgerald and Howcroft, 1998); Bryman, 2004)*

Table 5.1 presents the two considerations in a simplified format that highlights the differences and the conditions under which they could be selected for a particular type of research.

### 5.1.3 Cognition and Neuroscience

The dominant philosophies that inform studies in personality are often derived from the science of cognition. According to Lindsay and Norman (1977) and Neisser (1967), cognition focuses on the level of information processing that is a reflection of mental activity.

Easton and Emery (2005) define cognitive neuroscience as the understanding of the neural mechanism of cognitive processes such as thought, perception, and language. Cognitive neuroscience is therefore, concerned with the understanding of the functioning of the brain itself and can be considered similar to biological psychology. Biological psychology is defined as "*the study of the brain and how it causes or relates to behaviour*" (Wickens, 2005). In essence therefore, social cognitive neuroscience is the study of neural mechanisms of social cognition and social interaction in human and animals.

### 5.1.5 Philosophical Stance of the Research

The reliability of project cost estimates is a perennial problem in both developed and developing economies. Data availability and accuracy alone does not ensure the reliability of estimates. The driving force behind estimating process is the estimator. The research therefore, was directed at understanding the influence of individual estimator's personality traits on the reliability of estimates.

In addressing this problem, a number of theoretical considerations were explored. The first of these consideration is the prime question: *do personality traits of individual estimators differ and if they do, to what extent does that difference influence the reliability of project cost estimates?*

The theory on cognitive neuroscience was adopted to facilitate a deeper understanding of the cognition characteristics displayed by individuals and how that influences attribute differences. Cognitive neuroscience also strengthens the position of this study regarding the adoption of the psychological theories developed by Allport (1937), Cattell (1965) and Eysenck (1961) on uniqueness of the personality traits of every individual. These theories clearly suggest that differences exist in the behavioural characteristics of individual estimator in decision-making. Moreover, it supports the assertion that these differences might have an influence on the reliability of estimates produced by each individual estimator in a different way. The research concept was therefore, formulated with these theories as its foundation.

The research method was designed for simplicity and at the same time to emphasize an understanding of the causes of the problems identified with respect to reliability of project estimates. The theory of positivist epistemological consideration was adopted as the basis for the collection of data from the study source.

## 5.2. TYPES OF RESEARCH METHODS

This section addresses three principal aspects of research methods that dominate the doctoral studies in construction management. It commences with a look at the environment for the research study and goes on to address the qualitative and quantitative options applied by a significant number of researchers. The relevance of providing such coverage derives from the point that the methods for undertaking research in general have varied and developed considerably over the years. McQueen and Knussen (2002) identified the variations and developments over the years in the aims of the type of research, the philosophies behind them, and the practices and procedures used by various researchers.

### 5.2.1 Study Environment

The study environment gives rise to variables that incorporate both generic and context specific characteristics. The context specific aspect of the variables have an effect on the data recorded and therefore could influence the results of the research. The contextual influences of the study environment include such factors as inflation, the organisation itself, and the geographical location among others. It is therefore, useful that adequate measures are put forward to account for the influence of the environment on any research work. The study environment could influence the research in many ways. For example, in many developing economies, the lack of digital databases make paper based data systems very inefficient to manage. Archives of records are hardly employed to inform future developments because of the effort involved in accessing such data. Any study that requires the use of such archives would require adequate time for the retrieval of the relevant documents, often relocated for lack of storage, and sometimes distorted by the loss of some of the records held. The environment is a key factor towards the realisation of good research findings in this context and contributes to the accuracy in the recordings that are obtainable from the investigations of the data of the dependent and independent variables in the research work.

### 5.2.2 Qualitative Method

Qualitative methods are investigative tools that are employed for research to address the 'why', and typically, not the 'how' of phenomena by analysing unstructured information. Its use relies on elicitation instruments such as interview transcripts, open-ended survey responses, emails, notes, official reports, feedback forms, photos and videos (Bryman, 1989). The use of qualitative investigation does not rely on statistics and quantitative representation, which are the domain of quantitative researchers. Typically, qualitative tools enable the investigator to gain insight into the attitudes, behaviours, value systems, concerns, motivations, aspirations, culture or lifestyles of a subject or a group of people. When appropriately used, it can inform business decisions, policy formation, as well as communication and research in an organisation, a community or society.

Common techniques deployed under this method of study include the use of focus groups, in-depth interviews, content analysis, ethnography, evaluation and semiotics. While such formal approaches dominate the qualitative investigations, research in that field also involves analysis of unstructured information. The collection and analysis of such unstructured information can often involve meticulous and painstaking effort that can be time consuming. It is often a daunting prospect when confronted with large volumes of archival materials, and finding accurate themes and extracting meaning for phenomena can prove a difficult undertaking. Qualitative method avoids the notion whereby the researcher has to be the source of what is relevant and important in that field of study thus the study could be undertaken without prior information (Bryman, 1989).

In applying qualitative methods, data is collected without preconceived models and this orientation tends to support an illustrative mode of reporting (Frechtling and Sharp, 1997). According to Breakwell et al. (2006), qualitative analysis tends to be less explicit about the process of interpretation. An example of such limited interpretation includes data obtained in an unstructured opinion survey. The subjective nature of the responses makes it difficult to derive a consensus view across the survey sample. The subjective nature of this method prompted Bryman (1989) declare that the characteristics of qualitative data are unwieldy, unstructured, rich, complex, detailed, and with a concern for in-depth understanding of systems, processes and change. The in-depth understanding is not achieved by relying on quantification or aggregation to develop a representation, but is based on the assumption that there are multiple experiences and perspectives each of which is valid in their own right (Breakwell et al., 2006).

The features of qualitative research outline above do not match the characteristics of the study upon which this thesis is based, as the object is to establish potential causation.

### 5.2.3 Quantitative Method

Quantitative research involves the gathering of factual data that is represented in numerical format in order to study particular characteristics of interest about a phenomenon. The phenomena could range from a description of the behaviour of a source, characterising some other physical property of the source, or the relationship between a number of sources being studied. Often, in the use of quantitative tools it is important to establish relationships between how measured phenomena compare with existing theories. According to Fellow and Liu (2002), the application of quantitative methods in construction is driven by data that is collected by the use of scientific techniques and evaluated using aggregation. There are several scientific methods for collecting data when applying quantitative method of research, and these can range from simple numerical count to the use of multivariate analysis. The use of quantitative research options is driven by prior concerns from either literature reviews or from existing theories in the particular field of study (Bryman, 1989). The reliability of the quantitative method is dependent the level of limitation associated with the management of the sample employed; including non-response limitations, data elicitation errors and data processing errors (Bryman and Bell, 2007).

The method used for this research is discussed in much more detail in the subsequent sections of this chapter. The nature of the predominant investigation conducted in this study involved establishing causation between estimator attitude and reliability of project estimates. The derivation of such causation calls for the use of appropriate testing using numerical values to represent the principal variables being examined. While estimating reliability can be defined by using measured real number deviations, the estimator attitudes can take various forms of measurement depending on the type of characteristic under scrutiny. The use of numerical values to establish the characteristics of the behaviour between two variables essentially reflects a quantitative approach.

### 5.2.4 Triangulation

For some specific types of investigations, the use of a single research orientation is inadequate to achieve construct and internal validity. The adoption of triangulation involves an investigation where different approaches, such as qualitative and quantitative methods, are used in the same study to overcome the construct limitations presented by only one technique (Maanen, 1983). The weakness in each method is counter-balanced by the other method, thus, providing a means for cross checking that the construct for the study is apt. The growing use of triangulation in construction research has grown over the past two decades as researcher in the discipline recognise the limitation of the use of qualitative options for deriving inferences that can be generalised for their investigation. In the light of the growing reliance on triangulation within the discipline, it is important to point out that Maanen (1983) has indicated that the technique is not be suitable for some types of studies. Easterby-Smith et al. (2002) identified four distinct categories of triangulation that are in common use within human-based research. These are theoretical triangulation, investigator triangulation, data triangulation and methodological triangulation. Easterby-Smith et al. (2002) described each of the categories as follows.

***Theoretical***: This involves using models from other discipline to explain the situations in another discipline.
***Investigator****:* the collection of data on the same situation by different people and the results compared.
***Data****:* this involves collection of data from different sources or from different timeframe.
***Methodological****:* this involves data collection using both quantitative and qualitative methods. It could equally involve the use of two different methods from either the qualitative or the quantitative persuasion.

The use of the triangulation technique for research has been criticised by some investigators. Notable among them is Yin (2003) who argued that the use of multiple sources for collecting data makes any study conducted by triangulation very expensive. The research conducted for this thesis did not adopt any of the triangulation techniques as the construct of the investigation did not demand the use of multiple techniques for establishing whether estimator attributes have a causal relationship with the reliability of project cost estimates.

### 5.2.6 Choice of Research Method

Several forces drive the selection of an appropriate research method. Remenyi et al. (1998) suggest that availability of resources needed for the research, and the specific problem that the research addresses form part of the main forces that drive the selection of a research method. Peters and Howard (2001) identified key principles that should be observed in the selection as ensuring a systematic approach to the research, achieving rigour in the investigations and analysis involved, and good focus on the research topic.

The choice of a research method is important especially for ensuring that the all relevant variables connected to the study are identified, and their interaction and the extent of impact their exercise on the quality of the results are sufficiently defined.

In deciding on the method to be employed for the investigation, emphasis was laid on the fit of the adopted method to the type of investigation required as well as the thoroughness and comprehensiveness in representing the variables being studied. In particular, it became apparent at the early stages of the study that the method of investigation adopted is dependent on the subject matter of the research. The adoption of an inappropriate method could lead to the establishment of results and findings that could prove rather spurious for the study. The factors that impact significantly on the findings of the research were given necessary considerations prior to selecting the method. These included factors that were affected directly or indirectly by the nature of the study and would form the essential variables for the investigation, as well as the external and internal environment context for the research work.

Brewerton and Lynne (2001) commented on the current practice of adopting a research method for a particular study at the early stage of the research and argued that such a position often implicated a substantial tuning or at best a fine-tuning of the adopted approach. The essence of the fine-tuning is to ensure that the investigation does not become akin to a student laboratory exercise, whereby investigations are conducted, often with known outcomes, but only replicated for the purposes of learning existing or known facts.

## 5.3 RESEARCH CONCEPT

The method of estimating project cost within the construction industry in Ghana does not produce the results that matches with the speed and reliability demanded by the government and other stakeholders. While obvious exogenous factors can contribute to any improvement in satisfying the concerns of the stakeholders, the quality and contribution of the key individual at the heart of the production of that estimate could hold the key achieving the desired level of reliability. The fundamental concept within the argument that drives the investigation of this research is a potential causation of reliability in estimates by estimator personality archetypes. To establish the causation a number of key supporting investigations were conducted to complement the research. These complementary and supplementary details along with of cardinal proposition together form the research concept. Figure 5.1 shows the research concept for investigating the influence of estimator personality trait on the reliability of project cost estimate.

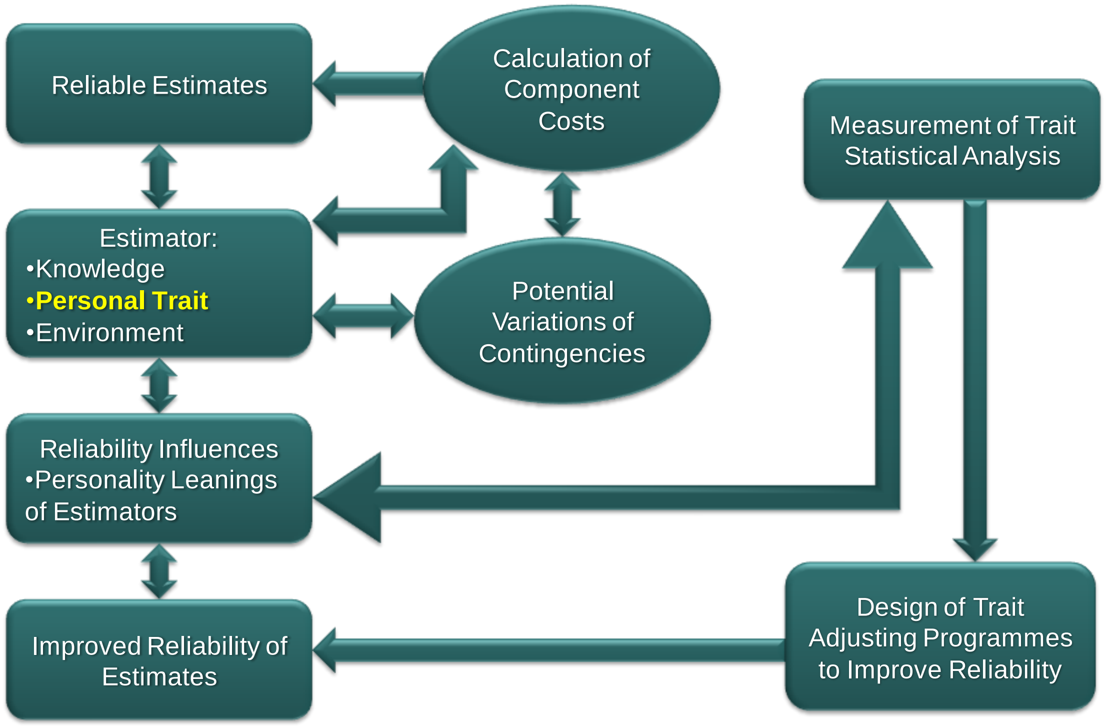



**Figure 5.1: Research Concept**

The essential problem identified with construction costing in Ghana is the unreliability of project estimates. To understand the problem requires a good knowledge of construction processes and how project estimates are generated. In construction, estimates are generated from the computation of cost components of materials, plant and equipment and labour. Contingency is then determined and applied to the cost components to produce the project cost components.

The term contingency in construction is the additional sum set as a limit to the computed cost components of labour, materials and equipment to compensate for project-related issues that the estimator could not have foreseen. In other words, the estimator allows for an amount in the estimate as contingency to cater for risks associated with the execution of the construction project. In another sense, the contingency is a reflection of the confidence that the estimator, and for that matter their organisation, has in their ability to produce a reliable estimate. The amount fixed for the contingency has no scientific basis and is often based on a 'rule of thumb' or on the estimators experience in projects of similar nature to the one on hand (McCaffer, 1976). The more experience the estimator has in delivering similar projects, the higher their confidence in estimating, and the lower the allowance that they need to make for contingency and vice versa. In both cases, the amount allowed for contingency is largely dependent on the ability of the individual estimator in assessing and making informed judgements on what the outturn cost of the project is likely to be. This judgement of the estimator is in itself influenced by the individual behaviour characteristics and decision-making orientation of the estimator.

A number of additional factors also influence the determination of the contingency. These include the following:

- the knowledge of the estimator in the field of estimating;
- the general experience of the estimator in the field of estimating;
- the environment of estimating; and,
- the risk orientations of the estimator.

The combined effect of these factors will reflect different permutation outcomes for different estimators, as their general and specific knowledge and experience will differ from one individual to another.

The rationale of the research concept is that achieving estimating reliability is driven by three dominant characteristics, the knowledge and information that the estimator has at the time of the costing, the environment in which the estimate is calculated, and the personality trait of the estimator. However, the contribution that each of these characteristics makes is not established, so the extent to which each characteristic has to be improved to bring about a desired level of reliability is not obvious. Thus far, research has indicated that the effective improvement in the exogenous aspects of those characteristics, namely, the environment and available information, lead to commensurate improvement in estimate quality. The extent of the marginal improvement in the quality of the estimate for a unit improvement in each of the exogenous factors is however, not yet established. Potentially, the current situation could imply inefficient application of improvement effort applied to the exogenous factors. Establishing the solution to the potential problem of inefficient application of exogenous factors essentially requires the collection and analysis of the relevant data. Of greater significance to the reliability difficulty however, is the endogenous problem of estimator behaviour in decision-making. Thus far, no construct exist that addresses how personality archetype of estimators relate to their estimating reliability. Establishing the construct of that relationship should pave the way for developing the foundations of the type of data to collect in order to address the marginal effect of the endogenous estimator trait on reliability of the estimates they produce.

The nature of investigation called for developing two principal tools of elicitation to establish the construct of the form of causation that exists between estimator personality trait and reliability of estimates. The first tool relates to the measurement of estimator personality attribute, and the second tool addresses the measurement of reliability for construction project cost estimates. The details for each of the tools are addressed subsequently.

### 5.3.1 Data Collection Technique

Breakwell et al. (2006) argue that data for this type of research can be obtained from target sources either by a direct or indirect means of elicitation. The direct elicitation approaches include self-reporting mechanisms such as interviewing, self-completion questionnaire, observing and revealing ones behaviour through either performance of tasks or a role play in any activity. The indirect elicitation options involve observation by the researcher of the respondent behaviour. The indirect approach could also involve observation of archival records and witnesses.

For the purpose of this research, the direct elicitation method was adopted for obtaining the data of the study. Different techniques for elicitation of data in the direct method were outlined in the earlier section. The study however, adopted the self-completion of questionnaire method to elicit the principal data for personality measurement in consonance with similar approaches in fields of study such as psychology.

The validity of any data collected is dependent upon the controls that the researcher exerts on the respondents. In collecting the data, the researcher achieved these controls by mitigating the risks commonly associated with the design of questionnaires. It includes ensuring that respondents do not form a pattern of response by providing an instrument in such a manner that its intentions are masked to the respondents. In this research, the researcher made presentations on the subject matter to provide the participants with relevant information on the purpose of the exercise prior to the commencement of answering the questionnaire.

#### *5.3.1.1 Type of Data Collected*

The data for the research were obtained from two separate workshops organised by the researcher for one sample and through questionnaires sent out to the other sample. Estimators for the two workshops were drawn from the Agencies under the Ministry of Roads and Highways in Ghana. The Agencies were Ghana Highway Authority, Department of Urban Roads and Department of Feeder Roads. Two categories of data were collected from each of the workshops. These were data from the responses to the questionnaire and cost estimates prepared by each individual estimator on the same design drawings with the same project information.

The design of the questionnaire for the research, the reasons of selecting estimators from the road sector for the study and the organisation of the workshops for the elicitation of data will be discussed further in the succeeding sections.

### 5.3.2 Data Analysis Techniques

Data analysis is concerned with how data are systematically interpreted in a logical sequence for the validity and reliability of the conclusions that are drawn. Data collected for the research were personality traits data and cost estimates data. The personality traits of the individual estimators were determined from the data using the personality instrument developed for the study. Statistical analysis was used in determining the influence of personality and some demographic data such as experience and qualification on reliability of project estimates.

According to Tupes and Christal (1961), five personality traits are sufficient for adequately describing the individual's behavioural characteristics. The Big Five Personality test is one of such instruments. The name "Big Five" is derived from the number of traits that are dominant and unique to the individual. The "Big Five" informed the researcher in the design of the personality instrument used for the study. The traits that were used in the design of the research personality instrument were Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism among others. Brief explanation of each trait by Tupes and Christal (1961) is as follows.

f. **Openness:** this refers to the extent to which individual is accessible to new ideas, creative experiences and different values.
g. **Conscientiousness:** this refers to the extent to which an individual is organised, strategic and forward planning.
h. **Extroversion:** this describes the level to which an individual is inclined to experience positive emotions and the extent to which the individual is attracted to social, stimulating experiences.
i. **Agreeableness:** this refers to the extent the individual is concern about the feelings of others and how easily the individual makes friends with others.
j. **Neuroticism:** it describes the extent to which the individual reacts to perceived threats and nerve-racking situations.

These profiles are grouped by analysis into relatively homogeneous clusters. Each cluster represents a personality type, and the average profile of the cluster members describes a personality prototype. Continuous measure of a typeness is not the measure of similarity between an individual profile and the prototype profile but rather continuous measure of typeness is the measure of the deviation from the mean profile in the sample from the deviation of a personality (Tupes and Christal, 1961). Thus, type of an individual profile is not a measure of similarity with the prototypical profile.

***Defining prototypical personality profiles***

The parameters that characterise individual profiles with regard to personality depend to some extent on how the prototypical profiles are defined. Asendorpf (2006) identified three main approaches for defining the prototypical profiles as follows.

**a. Empirical Definitions**

In empirical definitions, personality types are derived through cluster analysis. The resultant cluster centres define the prototypical profiles (Asendorpf, 2006). This method has the advantage of defining the resulting profiles such that the profiles simultaneously maximise differences between the types and minimise the mean individual distance from the best-fitting type. The method however, has a disadvantage of showing only moderate similarity across different studies because the resultant profiles depend on the specifics of the assessment instrument and the sample of individuals.

**b. A priori raw-score definitions**

In this method, the prototypical profiles are defined independent on the specifics of the study in terms of profiles of raw scores (Asendorpf, 2006). The advantages and disadvantages in the empirical method are the same as for this method.

**c. A priori z-score definitions**

This definition attempts to minimise the disadvantages in the empirical and priori-raw-score approaches and make it possible to use identical prototypical profiles for different assessment instruments.

## 5.4 DESIGN OF ELICITATION INSTRUMENT

The personality trait of estimators is a consistent and enduring predisposition in the way they behave not only in their personal life but also in the work environment. This can be established by employing an appropriate measurement instrument. The adopted instrument as developed by adopting the categorisations of the Big Five traits originally developed by Tupes and Christal (1961).

The developed elicitation instrument can be found in Appendix B, and is divided into two sections. Section A addresses the background details of the respondent and is aimed at eliciting data such as years of experience, educational and technical qualification, technical experience in estimating, as well as current career position. The review established that the details elicited in Section A of the instrument have an influence on the attainment of reliability in cost estimating. The data elicited from this section will enable the testing of the hypothesis of such influence.

Section B is aimed at eliciting the personality characteristics of the respondent estimator. It employs ten sets of questions that define the positive and negative reflections of the five principal categorisations adopted for the study. Each category was addressed with two sets of questions. This ensured systematic classification of the extent to which the respondent reflected a particular trait. One set of questions addressed for example Extraversion, and the second set will cover the opposite pole of Introversion. The rationale is that individuals have varying degrees of a particular trait, and the sum of their trait effects is what reflects as their personality archetype as illustrated by Figure 5.2. For example, questions addressing the Extraversion trait were structured to address a trait scale of Extraversion at one end to Introversion at the other end of the scale. The other four dominant traits received similar attention and a set of two questions were developed to address each dominant archetype. Each set of questions consisted of five separate questions that explored the degree to which the respondent reflected that archetype. The last activity in the design of the instrument involved re-ordering the sets of questions to mask any obvious patterns to ensure effective engagement during the response. Piloting of the resulting instrument with five estimators showed it was efficiently designed and efficacious for the type of data required for the study.

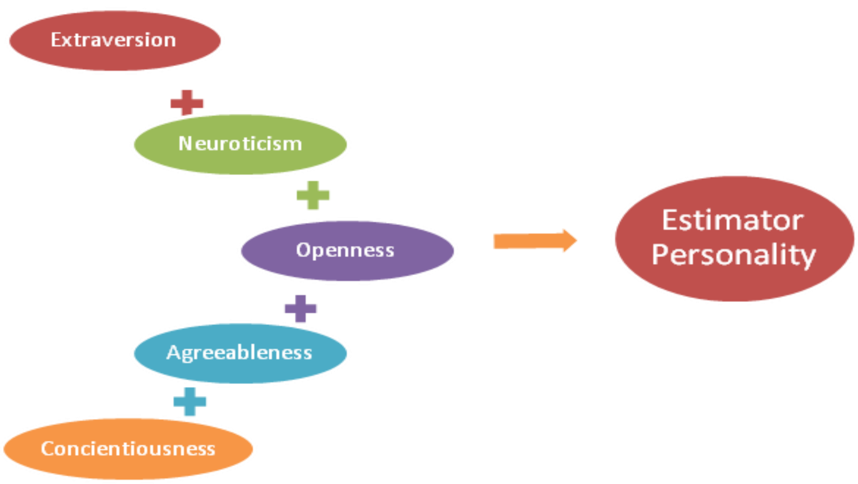



**Figure 5.2 Contributor traits to estimator personality**

The second tool deployed for the study involved the elicitation of estimating reliability for the respondent and is presented in Appendix D. This was achieved by designing an exercise that required estimators to addressed a technical task and then evaluating their performance by applying the principles of quality control charts. The banding adopted for the control charts are addressed in the relevant sections under the analysis of the data.

## 5.4.1 Questionnaire Design

The method used in the gathering of data was by a self-reporting instrument. There are different types of self-reporting instruments for conducting personality test. The research however, adopted the questionnaire option for the self-reporting exercise to design a bespoke instrument. The questionnaire drew on several personality testing instruments with the "Big-Five" instrument as the dominant contributor. The designed instrument was based on the notion that the differences in our personality are associated and coded in the language we speak. The adopted classifications for the designed instrument were **Openness**, **Conscientiousness**, **Extroversion**, **Agreeableness**, and **Neuroticism**.

While the classification was based on the configuration of the Big Five personality test, its detailed composition drew on other instruments as well as other extraneous factors prevailing in the study environment. The resultant instrument was trialled for stability of classification and clarity of terminology and general content. As such, the result obtained from an individual that undergoes the test is likely to be the same when the test is performed on the same individual some years later on if their circumstance has not altered. The questionnaire for the research was designed to be simple, user friendly, low cost of application and versatility. The questionnaire for the study was designed to enable ease of completion. The measures that were adopted to mitigate the risks identified in the design of the questionnaire are discussed in the subsequent section.

## 5.4.2 Wording of Questionnaire

The questions in the instrument were designed to be simple and straight forward, and every effort was made to avoid ambiguities. The wordings were crafted to mitigate following risks identified by Breakwell et al. (2006), Oppenheim (1992) and Sudman and Bradburn (1992) among others in questionnaire design. Some of these risks are addressed below on how the study responded to them.

**Vagueness and ambiguity**

This risk is occurs when the investigator is vague in phrasing the questions. In such circumstances, the respondents try to guess what the questions mean and respond based on that assumption. Each respondent may guess differently in accordance with theories of the uniqueness of individual personality trait proposed by Allport (1937), Cattell (1965) and Eysenck (1961). The inability of the respondents to arrive at the same guesses creates hidden ambiguity in any data from such questionnaire instruments. The mitigation measures employed for this study were to phrase questions for this research in clear language, and simple sentences that facilitates a common understanding by all the estimators. The effort to achieve clarity in the questions was complemented by the presence of the researcher at the elicitation workshop to provide explanations and clarifications for any that the responding estimators needed.

**Technical terminology**

This risk emanates from the use of questions that are phrased with technical language beyond the understanding of the respondent. What constitutes technical in this case could come from the use of technological terms, or context-related terms that is understood elsewhere but which is not commonly used in the study environment. The mitigation measures employed for this risk in the design of the questionnaire was that the questions were phrased in estimating terminologies that reflected day-to-day concepts in use for cost estimating within the profession in Ghana. The study drew on the expertise of relevant professional associations to confirm the efficacy of all terms in aiding a common meaning of the affected questions.

**Hypothetical questions**

Hypothetical questions are questions that propose scenarios to which the responded has to react, such as "*what would you do if …* ". Such questions should be formed such that the scenarios appear reasonable and realistic to the respondents. The questions of the research were presented in a form that enabled estimators to rank themselves on a scale of five categories from specific questions that matched the work context of estimators in Ghana.

**Leading questions**

Leading questions such as “do you agree that the government’s policies on construction industry development are unfair?”, for example subtly urges the respondent to agree with you. This was avoided in the questionnaire for the research. The questions in questionnaire were designed for the respondents to rank themselves on a scale of five without an indication of how they should respond.

**Double-barrelled questions**

These questions involve multiple premises. To avoid ambiguity, the questions in the questionnaire for the research were specific questions with a basic requirement for a definitive response and not multiple answers. The avoidance of such double-barrelled question matches well the decision requirements of most estimators, who are used to providing definitive decisions on issues in estimating.

**Social desirability**

Social-desirability is concern on the part of respondents regarding their desire to present their responses in a more positive manner. The reliability of the data in such instance could not be guaranteed due to potential bias in the response patterns provided by estimators who reflect such an orientation. Krosnick and Schuman (1988) argued that people are more prepared to agree on something than to disagree with the same thing. Such an effect is often accentuated by the presence of status-defining responses or request for sensitive information in the instrument. In this research, socially sensitive demographic data (for example income level) that were considered as confidential to the respondents were not included in the questionnaire.

## 5.4.3 Background and Demographic Data

Some respondents consider demographic data such as age for example as confidential. If the confidentiality requirement is not adhered to in the questionnaire, respondents end up giving answers which do provide a true reflection of their attitudes and thereby generate spurious inferences. In this research, questions on demographic were limited to years of experience, and educational qualifications, as such information is already available from other non-confidential sources. In general, the estimators in Ghana did not view questions about their experience as confidential and intrusive. However, information about their age was seen as intrusive and so that detail was excluded and substituted by their years of specific and general experience related to estimating.

## 5.4.4 Intentions, Expectations and Aspirations

According to Breakwell et al. (2006), many social psychology theories are concerned with accounting for intentions, expectations and aspirations. This are easily accessed through questionnaire. This important point makes the use and structure of the questionnaire for data elicitation essential for achieving good responses. The questions for the research were specified without referring to the intentions, expectations and aspirations of estimators. Equally, other pertinent factors that relate to the structure of the instrument were addressed and are considered briefly in the sections below.

### *5.4.4.1 Questionnaire Layout*

Many factors have to be considered in designing the layout of a good of questionnaire. They include how attractive the questionnaire instrument is. Some layouts lend themselves to ease of completion of the instrument and some other rather hinder engagement by the respondent. For the purpose of the study, the questionnaire was properly structured and presented in a format that could potentially attract quality and high response rate.

### *5.4.4.2 Respondent Motivation*

The good elicitation instrument also has to address respondent motivations in questionnaire design. The more pronounced ones are confidentiality of responses, and encouragement of individuals that their responses are of value to the overall study. The administration of the instrument was preceded by a presentation prior to the commencement of answering the questions. The purpose was to alleviate fears among the estimators and also to assure them that their responses would be treated with the highest confidentiality. In order to allow the estimators the choice of participating in the feedback, the last part of the questionnaire required estimators to state either “yes” or “no” to such participation in the feedback exercise. Also, the introductory letters for the questionnaire thanked the estimators for their time in attending the workshop and answering the questionnaire. Food and travelling allowance were also provided to motivate the participants at the workshop for more reliable responses.

### *5.4.4.3 Question Order*

In this research, demographic questions were included at the first part of the questionnaire to allow the estimators enough time to attend to more important questions. This way, the instrument built up the engagement of the respondent by progressing from information that is more familiar to the estimator, to ones that are less familiar, and thereby giving them confidence to respond fully.

## 5.4.5 Response Formats

Breakwell et al. (2006) listed three main types of questionnaire formats as categorical, multiple and rating scales. The format used in any questionnaire design is dependent on the aim of the research. Each of the types is discussed briefly.

### *5.4.5.1 Categorical Response*

In categorical response format only two alternatives are provided for the respondent to choose only one of the alternatives. This format was not adopted as the dominant approach for eliciting the essential research data for the study due to its limitation on the number of alternatives. It only featured in follow-on administrative aspect associated with their completion of the instrument.

### *5.4.5.2 Multiple Response*

This format is similar to categorical response format but in this case the respondent could choose from a multiple of options as their response. This format was adopted for the first section of the instrument, to facilitate consistency in their responses and also ensure that the data provided can be addressed with appropriate statistical tools.

### *5.4.5.3 Rating Scales*

The research adopted rating scale in the design of the questionnaire for the key aspects of establishing trait orientation for the respondent estimators. The statements on the questionnaire were designed with a scale of five and the respondents made their choice appropriately. Sample form of the letter to the estimators on the questionnaire is provided in Appendix A and the responses to the questionnaires are provided in Appendices B and C for the observed and control groups respectively.

## 5.5 SUMMARY

The chapter has demonstrated the importance of a good foundation for data elicitation. It achieved that by outlining the historical developments of research philosophy. Two main schools of thoughts in social research were identified as epistemological and ontological considerations. Epistemological considerations is concerned with the method through which knowledge is acquired whiles ontological considerations concerns with the logical investigations of the divers manner in which different types of things are thought to exist.

The chapter also explored the two main methods of research, which were identified in the review as quantitative and qualitative. The chapter presented the characteristics of each method and the techniques used in elicitation of data under each method. The chapter explained the reasons of adopting the quantitative method for the research.

It further, provided details of the design of the two elicitation instruments that were employed to collect data along with the mitigation effort directed at potential risks for studies of this nature. The next chapter presents how the data from the study was treated, the analytical techniques employed as well as the precautions applied to maintain internal and construct validity.

# CHAPTER 6

# ANALYTICAL FRAMEWORK OF THE STUDY

## 6.0 OVERVIEW

The chapter addresses the basics for using analysis of variance (ANOVA) and other tools employed for managing and analysing the data obtained from the study. In particular, the use of graphical representation of the data held considerable value to the researcher as argued by (Tukey, 1977). Other investigators such as Cohen et al. (2003) concurred on the role that data display through graphic visualisation could play in conveying the findings from an investigation. The chapter also presents various sampling methods and the advantages and disadvantages of each. Different types of variables namely ordinal, nominal and interval/ratio addressed and the choice of the most suitable option justified. The chapter further presents various forms of variable distributions and the circumstances under which each is applied.

In addition, the two types of hypothesis testing commonly applied to investigate phenomena in construction management namely one-tailed and two-tailed test are discussed. The chapter also addresses different types of transformations to prepare data for analysis, as well as data treatment for a one-way ANOVA testing.

## 6.1 DATA AND SAMPLE CONSIDERATIONS

This section discussed the population, sample from the population and the different methods for sampling from the population to support a research study. The section also presents different types of data required for the analysis in this study. This section also explains the reasons of adopting the particular sampling method and type of variable for the research.

### 6.1.1Population and Sample size

The word population has different meaning depending on the purpose for which it is being used. In research work within construction management the term population is used broadly to reflect immeasurable membership of sources from which respondents could be drawn. The characteristics of population and sample size are discussed in the subsequent section.

#### *6.1.1.1Population*

In everyday life, the word population is mostly understood as being connected to geographical, political or ethnicity for a collection of people. For instance, the geographical collection of animals, plants or any object is can constitute a population. In statistics, the term population refers to a discrete group of units employed for analysis. The term is used in a more restricted sense as the set of measurements of some attributes associated with the collection (Dowdy et al., 2004). For example, a population could be the collection of heights of engineers in a country. In this case, the variable of interest is the derived set of heights of engineers in the country. The population varies in size due to the nature of the discrete group of people being considered. If the size of the population is small, it is easy to contact all the people in the population. This is however, not the case in most instances. In almost all cases, the size of the discrete group is so large that it is practically impossible to conduct research for the whole group due to insufficient time and resources that are usually available for any research. This therefore calls for sampling the discrete group.

#### *6.1.1.2 Sample*

A sample is a portion of the population and the data obtained from the measurements on the sample is the sample data. The purpose of the sample is to get a representation of the population that will enable inferences to be drawn without analysing every single member of the population. In this regard, the sample enables the conduct of investigation about the population with considerable efficiency. For the representation to be adequate, the size of the sample as well as the method by which the sample is drawn has to meet certain requirements. In general, the size of the sample could vary depending on the size of the population and there are statistical methods for determining what the sample size should be to produce the limits of validity desired from a study. For example, if the size of the population is denoted by **N** and the sample by **n**, then the **n** items chosen from **N** becomes the reference for understanding the characteristics of the population.

While several sub-categories of sampling could be defined, in practice it can be argued that there are three main methods of sampling in common use within construction management research for selecting **n**. These are random sampling, systematic sampling and stratified sampling and are briefly discussed below along with their advantages and disadvantages.

**Random Sampling**

Random sampling in statistics refers to the adoption of a random approach to selecting the membership of the sample. Each member in the population is deemed as having the same chance of being included in the sample. Bryman and Cramer (2009) the reliance on a random sample is the most common basis for composing the sample for a study, although in very many cases the conditions of randomness is not adequately achieved. However, where such randomness is achieved, this sampling option eliminates the possibility of bias in the selection procedure and the sample generated gives a true representative of the population.

Although the use of the random sampling has the above advantage of being unbiased, the attainment of randomness for the investigation on hand is not essential for establish the causation implied in the research. In particular, respondent availability for the exercises made is quite inappropriate to rely solely on a random approach for composing the membership of the study sample.

**Systematic Sampling**

This technique of selecting the membership for samples is similar to simple random sampling. In systematic sampling however, the random selection is done systematically from a sampling frame. For example, if items are to be selected from a group of 200 items and the selection was based on every sixth item, then if the start is one, then the next selected item will be the item at sixth position and the next will be at twelve position, and so on, thus, ensuring a systematic selection. The technique potential has the disadvantage of selecting members to be included in the sample that do not represent the population due to the inherent ordering made by the frame of sampling. In using this technique for the selection of a sample, the care has to be exercised to ensure that no inherent ordering of the sample frame exists otherwise the sample will not be a true representative of the population.

This technique was adopted for the research and was combined with stratified sampling. The risk of inherent ordering was eliminated by selecting respondents with the systematic criterion of years of experience.

**Stratified Sampling**

In stratified sampling, the population is divided into strata or groups. The sampling is then done on the strata or group by using simple random or systematic sampling technique. This technique of sampling can be applied in other areas beyond simple academic research. For example, in the field explorations that use the stratified concept for sampling, there is an improvement in reliability of the outcomes from the investigations (Dowdy et al., 2004). Bryman and Cramer (2009) agreed with this view put forward by Dowdy et al. (2004) on reliability of the stratified sampling technique and argued that stratified sampling gives extra precision to that of random and systematic sampling methods. Dowdy et al. (2004), Bryman and Cramer (2009) and Christensen (1996) went on to suggest that the make-up of strata should be in the same proportion as the proportion in the population.

In this research, stratified sampling technique was used in sampling data. The estimators in the population of estimators were divided into two groups and samples obtained from these groups through systematic sampling technique that was outlined in the previous subsection.

**Sampling Problems**

The size of a sample is most often the issue that draws a lot of attention when conducting investigations. This is because in general, the bigger the size of the sample for the same population, the higher the accuracy of the inferences that are drawn about the population from the sample characteristics. However, a limitation on the increase in the size of the sample has to do with the time and resources available for the research work, and raises the question about the economic size to adopt for the study. Equally, it is common to find differences in the characteristics between the sample and the population from which the sample is derived. The difference, commonly referred to as the sampling error, reduces as the sample size increases. The increase in the level of efficiency with which the sample characterises the population stagnates as the sample size increases beyond the economically accepted level (Bryman and Cramer, 2009).

Another problem that tends to plague the use of questionnaire instrument for eliciting data is the potential for low return or response rate. In many instances the difficulty that low response rate presents is external validity for the study. It is important for the error that could arise from such response rate is addressed by devising appropriate techniques to mitigate any low rates of response. For example, if it is commonly accepted in construction management research that a 30% response rate has to be achieved for any questionnaire survey. The expected response rate has to be taken into consideration in deciding the number of the questionnaire to administer. Assume for instance that the study requires a sample size (**n**) of 60 and experience from past studies show that 30% of questionnaire sent out are not returned giving it a response rate (**r**) of 70%, then the total number to be administered should be **x**, whereby **x** is defined as 60 ÷ (100 – 30) or **n** ÷ **r**. In other words the sample size divided by the expected response rate should be adopted. The lesser the response rate, the larger the number to be administered. This implies the researcher has to send out 86 questionnaires in order to have the desired sample size. The subsequent section presents how the response rate was for the questionnaire sent out to estimators in the second group, which was the baseline group of the investigation.

For the purpose of the research, estimators working in the roads subsector within Ghana constituted the population for the study. It is practically impossible to study all estimators due to time and the resources available for the research. Thus, the data on all estimators were sampled for ease of the research. Two samples were formed with the first representing an observed group and the second a control or baseline group. Based on the information available from the public sector, the sample size for the observed group was 61 and that of the baseline group was 35 in the research. The size of the sample in the research agreed with Mbugua et al. (2000) who suggested that a minimum of 30 respondents is adequate for a sample size in any research work in the construction industry. This is because a sample size of 30 satisfies the minimum sample size for the use of parametric analysis for conducting the investigation.

### 6.1.2Types of Variable

Statistical test always presume certain kinds and types of variables. It is therefore important to understand and recognise the different types of data in determining the type of test to be performed in any statistical analysis. Ability to recognise the different forms of variables is one of the most important features in statistical operations (Bryman and Cramer, 2009). For the purpose of the study, the distinction developed by Steven (1946) has been used. Steven (1946) distinguished between the different forms of variables as comprising nominal, ordinal and inter/ratio scales. These are discussed below.

#### *6.1.2.1 Nominal Variable*

Nominal variables are suitable for simple and qualitative classification. It facilitates measurement only in terms of whether the individual members in a sample belong to some distinctively different categories. Nominal variables do not lend themselves to quantification or ranking order those categories employed for classification of the members in a sample. For example, two individuals may differ in terms of variable A (where variable A represents eye colour). It is impossible to say which one "has more" of the quality represented by the variable. Typical examples of nominal variables are gender, race, or colour. The use of this type of variable involves assigning respondents to a particular category. The variable cannot be rank ordered and so no value comparison can be performed between respondents.

The study is aimed at identifying the influence of individual estimator’s attitude on reliability of project estimates and entails comparing the various individual estimators. The study requires variables that can be rank ordered to represent the extent of reliability. It also relies on personality classification which reflects nominal classification.

#### *6.1.2.2 Ordinal Variable*

Ordinal variables allow rank ordering of the members making up a sample in terms of which has less and which has more of the quality represented by the variable, but still not by "how much more". A typical example of an ordinal variable is the socioeconomic status of construction staff. For example, we know that upper-middle is higher than middle but we cannot say that it is, for example, 18% higher. Also, this very distinction between nominal, ordinal, and interval scales itself represents a good example of an ordinal variable. For example, we can say that nominal measurement provides less information than ordinal measurement, but we cannot say by "how much less" or how this difference compares to the difference between ordinal and interval scales. The fact that ordinal variables can be rank ordered facilitates the comparison of responses on a particular subject matter of the research. It is also noteworthy that although ordinal variables lend themselves to ranking, there are other types of information that could not be deduced from this type of variable. For example, when respondents are categorised by skill level, a scale could be constructed for the various skills such as highly skilled, fairly skilled and moderately skilled. Such a scale would reflect ordinal characteristics. However, the level of difference between a respondent categorised as fairly skilled and highly skilled cannot be said to be the same. In this type of variable, it can only be deduced that the highly skilled person is higher on the scale than the moderately skilled person. The level of difference in skill could not be deduced simply from this variable. Therefore, highly skilled person cannot be said to have twice or three times as much skill as the respondent with moderately skilled person.

The study involved different comparison of individual estimators in the categories described in the personality instrument designed for the study. The research instrument for personality testing was scaled for each of the traits namely, Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism traits.

#### *6.1.2.3 Interval and Ratio Variables*

The interval and ratio variables have a lot of arithmetic qualities. The arithmetic attribute makes the interval and ratio variables widely useable and allows for wider statistical testing and analytical procedures for these types of variables (Bryman and Cramer, 2009). The technique used by most statistical test presumes that the variable is has interval characteristics and explains why most the typical statistical procedures, such as correlation and regression analysis, are applied to interval and ratio variables.

Interval variables do not only allow rank ordering the sample, but also to quantify and compare the sizes of differences between members making up the sample. For example, temperature, as measured in degrees Fahrenheit or Celsius, constitutes an interval scale. It can be said that a temperature of 40 degrees is higher than a temperature of 30 degrees, and that an increase from 20 to 40 degrees is twice as much as an increase from 30 to 40 degrees.

Ratio variables are very similar to interval variables but in addition to all the properties of interval variables, they feature an identifiable absolute zero point, thus, allow for statements such as $\mathbf{n_i}$ is two times more than $\mathbf{n_2}$. Typical examples of ratio scales are measures of time or space. For example, as the Kelvin temperature scale is a ratio scale, not only can we say that a temperature of 200 degrees is higher than one of 100 degrees, we can correctly state that it is twice as high. Interval scales do not have the ratio property. Most statistical data analysis procedures do not distinguish between the interval and ratio properties of the measurement scales. Figure 6.1 shows factors to be considered in deciding the nature of variable to adopt for any investigation that relies on quantification.

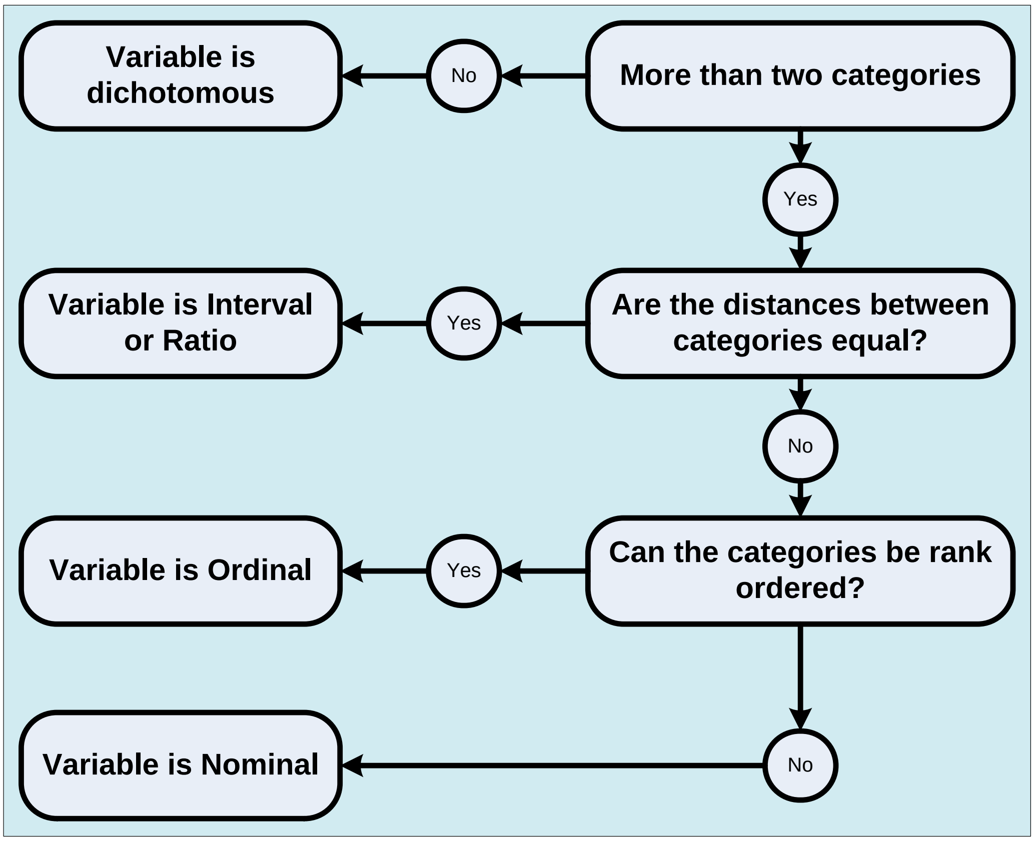



**Figure 6.1: Deciding the Nature of Variable** ***(****Source: Byrman and Cramer, 2009****)***

## 6.2 ONE-WAY ANALYSIS OF VARIANCE

Analysis of variance is used in testing the hypothesis about differences between two or more variables. There are a number of terminologies, which have to be understood before the application of ANOVA to any collected data. The subsequent sections explained some of the terminologies and how each relates to the analysis of variance technique. Analysis of Variance involves comparing several random samples drawn from a population. Samples are obtained from observing experimental units with different treatment applied to them (Christensen, 1996). The experiments are performed by investigators in all fields for the purpose of discovering something about a particular system or process.

Assumptions are usually made on samples for informed decisions to be deduced on them. In one-way analysis of variance it is assumed that the sample sizes are all independent of each other and the population is normally distributed with the same variance (Christensen, 1996).

## 6.2.1 Theory on Hypothesis Testing

The hypothesis testing involves the procedure for checking the validity of a statement or claim. The statement or claim made is known as the null hypothesis. The testing, therefore, is to ascertain the validity of the null hypothesis. The null hypothesis is a statement or claim made about a population parameter and can be tested if the relevant data is available. It should be noted that the inconsistency of the data to a null hypothesis might suggest that the hypothesis is false. Data which is consistent with the null hypothesis does not necessary establish that the null hypothesis is true and should be accepted. This is due to the fact that other factors could also have generated the data.

### *6.2.1.1 One Way ANOVA: Hypothesis Testing*

Three hypotheses that address qualification of the estimator, experience of the estimator, and personality of the estimator were tested in the study. Each is briefly discussed below.

***QUALIFICATION***

The Null Hypothesis tested was “there is no systematic difference in reliability across various qualification variables”: $\mathbf{H_0 : Mx = My = Mz}$ where $H_0$ is the Null Hypothesis. The Alternate Hypothesis was “there is systematic difference in reliability across various qualification variables"**: $H_1$: Mx≠ My; Mx≠ Mz; My≠ Mz** where $H_1$ is the Alternate Hypothesis

Mx, My, Mz are means of variables X, Y and Z respectively. X = HND or equivalent, Y = BSc. or equivalent and Z = MSc. or equivalent qualifications.

***EXPERIENCE***

The Null Hypothesis tested was "there is no systematic difference in reliability across various experience variables": **$H_0$ : Ma = Mb =Mc = Md** where $H_0$ is the Null Hypothesis. The Alternate Hypothesis was "there is systematic difference in reliability across various experience variables": **$H_1$: Ma≠ Mb; Ma≠ Mc; Ma≠ Md**; **Mb≠ Mc; Mb≠ Md; Mc≠ Md** where $H_1$ is the Alternate Hypothesis.

Ma, Mb, Mc and Md are means of variables A, B, C and D respectively. A=0-2 years; B=3-4 years; C=5-6 years and D=7-10 years of experience.

***PERSONALITY ARCHETYPE***

The Null Hypothesis tested was "there is no systematic difference in reliability across various traits variables": **$H_0$ : Me = Mc =Mo = Ma = Mn** where $H_0$ is Null Hypothesis. The Alternate Hypothesis was "there is systematic difference in reliability across various traits variables": **$H_1$: Me≠ Mc; Me≠ Mo; Me≠ Ma**; **Me≠ Mn; Mc≠ Mo; Mc≠ Ma; Mc≠ Mn**; **Mo≠ Ma; Mo≠ Mn; Ma≠ Mn** where $H_1$ is the Alternate Hypothesis.

Me, Mc, Mo. Ma, Mn are means of variables Extraversion, Conscientiousness, Openness, Agreeableness and Neuroticism respectively.

The level of significance (**α)** used is each of these hypotheses tests was 5%, at single tailed.

## 6.2.3 Analysis of Variance Models

This section presents the underling analysis of variance model and the corresponding assumptions. Two main types of models namely fixed and random effects are covered in this section.

### 6.2.3.1 Fixed Effects Model (FEM)

In fixed-effects model (FEM), the experimenter narrows down the possible treatments to several in which he has special interest. This is done at the later stages of the experimentation. Dowdy et al. (2004) explained the fixed-effects model with an experiment using six chemicals. In applying the fixed-effects model, the six chemicals would have been tested for melting, economical feasibility and availability. The problem then is which of the six chemicals could best withstand the effects of corrosion. The final choice in this case was made on the basis of corrosiveness. In fixed-effects model, the experimenter repeats the same treatment while keeping all other effects constant. The attribute of the model to use the same treatment in repetitive experiment is the basis of its name fixed-effects model.

### 6.2.3.2 Random Effect Model

This model is also known as the component of variance model. This differs from the fixed-effects model in the area of the treatment such as repetitive experiments for example. In random-effects model, it is assumed that the treatments are from a random sample for all of the treatments that are being tested. For example, in an experiment to ascertain the effectiveness of ten mathematics lecturers in teaching their students, the lecturer is the treatment group and the scores of their students is the variable of interest. Random-effects model will show if there exist significant variability among all the treatment groups.

## 6.2.4Assumptions for ANOVA

The ANOVA procedure is reliable only if certain assumptions are met. Thus, the more the experiment deviates from the assumptions the less reliable the deductions from the experiments would be.

In ANOVA, it is generally assumed that the treatment groups are normally distributed with same variance, and the experimental units are selected at random and assigned at random to the treatment group. Each of these assumptions is discussed.

### 6.2.4.1 Normality

The skewness and bimodality from a histogram is used to determine normality of the treatment group. Normality is also tested when the cumulative percentages are plotted. Normality of the data results in a straight line when data is plotted. The limitations to these two tests were that they only applied to large number of observations. For small sample sizes, the treatment group must be symmetric and unimodal in order to satisfy normality conditions. Sometimes however, ANOVA leads to valid deductions where in some cases the observations depart from normality. In general, the conditions for normality in large observations should be established if there are doubts about normality.

### 6.2.4.2 Equality of Variance

One important assumption in ANOVA is that all the treatment groups have the same variance. Hartley (1950) developed the $F_{max}$ test for testing homogeneity of variance. The use of the test developed by Hartley (1950) was dependent on the assumption that all the treatment groups are the same size and comparison of the largest sample variance with the smallest sample variance.

$$F_{max} = \text{largest treatment variance /smallest treatment variance} \qquad \text{Eq. 6.1}$$

The result from the formula is compared with the table computed by Hartley (1950) and deduction made as to the null hypothesis of the homogeneity of variance.

## 6.2.5 Transformations

In most cases, investigators are confronted with the situation in which the variances are not homogeneous and lack normality. The issue then arises as to how analysis of variance could be performed on the treatment groups. This is due to the fact that lack of homogeneity and normality do not satisfy the assumptions that underpinned the use of ANOVA in data analysis. Transformation is the process of converting data into a form which ANOVA can accept the and lead to valid testing. When data is transformed each observed value is replaced with another in accordance to the form of transformation. However, care must be taken not to change the order of the observed data with that of the transformed data. The validity of the conclusions from the transformed data is dependent on the consistency of the transformed data with the observed data throughout the analyses.

There are various forms of transformation. The choice is dependent on the nature of the data. ANOVA was designed for continuous data and hence it is not suitable for discrete data. The problem is how to select the form of transformation that best fits the observed data. This problem was addressed by Dowdy et al. (2004), who indicated that the nature of the data together with a plot of sample averages against sample variance will assist the investigator in deciding the form of transformation that best fits the data.

Some of the forms of transformation were:

- The Log Transformation
- Exponential Transformation
- Square Root Transformation among others.

The validity of ANOVA is dependent on the data meeting the assumptions such as normality, homogeneity and independent nature of the data is present. In this research data was tested for normality using frequency statistics. The results indicated that the distribution approximates to normality and thus data in the research was not transformed for the analysis.

## 6.3 SUMMARY

In this chapter different forms of data elicitation were discussed. The chapter also discussed different methods of sampling from the population as random, systematic and stratified sampling. The advantages and disadvantages of each method were discussed. The chapter justified why the data for the research was sampled using stratified sampling technique followed by systematic sampling.

Different types of variables were also discussed together with their characteristics. The interval variable was adopted for the study. The chapter revealed that the sample size is dependent on number of factors. The chapter mentioned these factors as the resources available, the time within which the findings were needed and the purpose of the study.

The chapter also addressed the three hypotheses tested for the research as influence of qualification, experience and personality archetypes on reliability of project estimates. The technique of analysis of variance (ANOVA) was used in the statistical analysis of the data. The chapter revealed that transformation is performed on data that do not conform to the assumptions for ANOVA. The chapter concluded that data for the research conformed to normality. The next section discussed the procedures used in data gathering, its management and analysis.

# CHAPTER .7

# DATA ELICITATION AND ANALYSES

## 7.0 OVERVIEW

In this chapter, the parameters that were considered in the gathering of the data are discussed. The conditions under which the data were gathered and the type of data gathered for the study are also discussed. Data were obtained from the road sector of Ghana. The spread of the Ministry and its Agencies responsible for road infrastructure in Ghana and their relevance to the characteristics of the data gathered are discussed in this chapter. The chapter also discusses the geographical and political administrative regions of Ghana and its relevance to the accuracy of the data for the study. The chapter presents the design of the instrument of collection data for the research. Questionnaire was used in the data elicitation. The chapter presents the factors that were considered in the design of the questionnaire and the mitigation measures that were used to address risks that impact negatively on the method of data elicitation.

Workshops were organised for the data elicitation. The chapter discusses the procedures adopted at each workshop for the realisation of reliable response from the participants. The methods used in the management of data for the study were discussed in the chapter. The chapter discusses the personality instrument that was designed for personality archetype test and the statistical techniques used for the statistical analyses.

## 7.1 DATA GATHERING

The reliability of research work or for that matter any investigation is dependent on the accuracy of the data gathered. Researchers and investigators therefore attached outmost importance to data gathering. In this study, data were collected through questionnaire and written documents. The subsequent sections discussed the procedures adopted in the gathering of data for the study.

### 7.1.1 Focus Group

The target group for this research was identified in line with the objective of the research. The main problem identified is unreliability in project estimate and how the estimator's attitude influences the desired reliability of project estimate. The literature review has identified many factors as the causes of unreliability in project estimates in terms of the physical aspect of the project. The influence of attitude of each individual estimator on the project cost reliability will vary from individual estimator to individual estimator due to the uniqueness of each person's personality traits. The theories of Allport (1937), Cattell (1965) and Eysenck (1961) among others on personality traits was employed as the basis for the selection of estimators to be included in the focus group for the study. The question that is implied in the study on personality is the characteristics of the role the estimator plays and the trait attributes that contribute positively to that role. This question is reflected in "who the estimator is in the construction delivery process" and is addressed in Chapter 2.

### 7.1.2 Source of Data

The data employed for the study was obtained from estimators within the Ministry of Roads and Highways, the Agencies under the Ministry and other road estimators in Ghana. The Ministry of Roads and Highways has its offices located in Accra, the capital city of Ghana. The Agencies of the Ministry namely Ghana Highway Authority, Department of Urban Roads and Department of Feeder Roads have their head offices in the capital city and regional offices in all the ten geographical regions of Ghana. The three Agencies and the Ministry work in concert with each other for setting performance standards and practices in the roads sector. Together, they would exploit the results from the investigation involved in this research study.

The road sector alone accounts for nine percent (9%) of GDP for Ghana (NTPG, 2005). So any improvements instigated by the results of this study could potentially have a significant impact on the sector and the whole national economy of Ghana.

Estimating procedures are the same in other sectors of the Ghanaian economy as explained in the previous chapters. Therefore, any improvements that are established because of this study could equally benefit the other areas of construction in the country and further afield. In addition, the results drawn from the data on the road sector estimators could be applied to other (non-construction) public and private sectors of the economy and for that matter in other parts of the world. Therefore, the reliability of the estimate produce from the estimators in the road sector could potentially have a significant impact of the success of road development programmes and beyond.

### 7.1.3 Selection of Estimators

Estimators who were the respondents for the study were selected from the road sector of Ghana. Sampling for the study was through stratified sampling approach and involved establishing two categories or strata of estimators. The first strata of estimators were those estimators with less than ten years experience in the field of estimating. This stratum was sample A or the main study sample. The second stratum was made up of those estimators with ten or more years of experience in the field of estimating. This stratum was sample B or control group. Estimators categorised into sample B were considered to have an appreciable level of practice and therefore, sufficient reliability in estimating. That assumption is based on the notion that technical experience is assumed to commensurate with the number of years in the field of operation. The estimators were thereafter selected for each sample using a systematic sampling technique. Samples A and B are discussed in the subsequent section.

#### *7.1.3.1 Sample A Estimators (Main Study Group)*

The selection this group of estimators was done to reflect the geographical spread of Ghana. The Heads of the three Agencies under the Ministry namely, Ghana Highway Authority, Department of Urban Roads and Department of Feeder Roads were contacted to nominate officers for this category. This was done to ensure that the researcher had no influence on the selection process, and that the selection is consistent with a value judgement on the qualification of estimators not set by the investigator. Each of the Agency heads nominated officers across all the ten geographical regions of Ghana. Each region is unique in its topography and vegetation. In Ghana, a person could be identified with its region based on the behaviour of that particular person. The resultant sample therefore, accounts for the different location contexts that could characterise estimator influences. In that sense the sample was a true representation of the population **of** estimators in Ghana. A sample size of sixty-one was obtained for this group.

#### *7.1.3.2 Sample B Estimators (Control)*

This group of estimators were employed as the base line for the study. In general, senior executives in the public sector are expected to have accumulated approximately ten years and that criterion was taken as the basis for allocating estimators into this category. All the estimators selected for this group had experience of ten or more years of both specific and generic estimating experience in the roads sector. The level of experience they would have gained over the years will range from managing different classes of road projects as well as projects that are categorised from small to very large. Their experience in delivering a variety of schemes would have given them awareness of the extent to which their estimating assumptions matches project outturn costs. The argument is that, such awareness is supposed to moderate the nature, type and scale of assumptions exercised by these experienced estimators. That argument is implicit in the established principle of an estimator gaining experience as they progress through their career. The control sample formed the base line for the study.

Sample size B was derived from estimators who had accumulated ten years or more experience in estimating practice as the first hard gate. Care was taken not to include estimators with ten or more years of experience whose technical and functional experience did not match the level of senior executives in estimating. The estimators in this sample were primarily drawn from the three Agencies under the Ministry of Roads and Highways. In addition, other estimators from the private and public sectors of the wider construction industry in all the ten regions were included in this group to limit the effect of ‘local action’ in estimating.

The method of sampling for this stratum of estimators was systematic sampling. This was done by sending out a preliminary questionnaire to many estimators that satisfied the characteristics of the baseline group. A sample size of thirty-five was obtained for sample B.

## 7.1.4 Organisation of Workshop

The actual data collection was achieved in workshops organised for the estimators in sample A. Two workshops were held at two different locations. For the purpose of the study, the ten regions were grouped into two zones namely the southern and northern zones. For uniformity, each zone comprised five geographical regions. The geographical regions that comprised the southern zone were Greater Accra, Central, Eastern, Western, and Volta, whilst the Northern, Upper East, Upper West, Brong Ahafo, and Ashanti regions comprised the northern zone. The estimating procedures and the functions of the estimators in the regions forming each zone are supposed to be the same since they work to the same standards. This means any variation in the way they estimate would be a reflection of their personal attributes and not due to their regional context.

The northern zone predominantly lies in the savannah belt of the country. Living standards in this zone are in general lower than that of the southern zone. The availability of labour and the corresponding cost is also lower in this zone compared to the southern zone. The cost data that estimators have to deal with for local works in this environment will differ from that of the southern zone. The organisation of each workshop is discussed in the subsequent sections.

### *7.1.4.1 Southern Zone Workshop*

The workshop for the southern zone was organised in Accra. Several factors that could adversely affect the outcome of the workshop were given due attention. These risks and the mitigation measures are discussed in the below.

**Risk Identification and Mitigation**

The southern zone workshop was organised in the conference room of the Ghana Institute of Engineers. This conference room was located at a fair distance from the work place of the participants. This was done to mitigate the risk of participants leaving to attend to other office duties. It was a day’s workshop that started at 8.00 am and ended at 5.30pm, to provide adequate time for the workshop and to ensure that participants would not be hurried in answering the questions. Food and drinks were provided to create a relaxing atmosphere for the participants and to ensure that the they did not have to spend some of the time unproductively. There were one hour lunch break and twenty minutes break each in the morning and the afternoon sections to ensure that participants were not over-burdened with the demands of the workshop. The breaks were introduced to ensure that the risk of fatigue was mitigated for the participants.

The investigator provided an introductory presentation to inform participants of the purpose of the workshop prior to the commencement of the answering section. The risk of participants' responses not being the true reflection of the participants and the risk of confidentiality of information were identified. The measures to address these risks were discussed in the introductory presentation. Participants were assured that the their responses will be treated confidentially and that the responses will not be used for any official decisions that would compromise their careers. The fear of providing wrong answers, and thus, replicating the responses of other participants believed to be brilliant was also identified and mitigated by emphasizing that there was no right or wrong answers to both the questionnaire and the project cost estimate that participants were required to prepare. These assurances achieved the desired objective of placing the participants in a comfortable and relaxed position at the workshop for the two activities namely, responses to the questionnaires and the preparation of the project cost estimate.

Any inhibitions on the part of the participants was addressed with an ice-breaking session prior to start of the workshop. The risk of working under pressure was one important factor that was also identified by the investigator. The researcher ensured that the workshop did not include the superior officers of participants and adequate time was allowed for each of the activities of the workshop.

Another risk identified by the researcher that could have impacted negatively on the data elicited if not addressed was sitting arrangement. Participants from the same organisation naturally prefer sitting together at events such as this workshop. This could however, result in discussions among the participants from the same organisation thus affecting their opinion on the various questions to be addressed.

The researcher foresaw this risk in advance and therefore prepared adequate mitigation measures for it. The mitigation action was achieved by providing all participants with name tags one of which was given to the participants to wear, and the other was placed at the sitting position of the participant in the conference room prior to their arrival to mitigate their discussions of the responses due to familiarity.

The conditions in the conference room and that of the workshop environment were of utmost importance. This was due to the fact that serene working environment enhances individuals' job performance. The researcher provided all necessary materials needed by the participants for the two activities at the workshop.

**Responses to Questionnaire**

The first part of the workshop was devoted to the elicitation of responses to the personality questionnaire designed for the study. This activity took place in the morning session of the workshop. In all, thirty-one participants attended the southern sector workshop. All the thirty-one participants answered the questionnaire fully for the study. Each participant answered the questionnaire independently. The researcher was present throughout the workshop to ensure that the outcome of the workshop was devoid of the risks identified in the study. The researcher allowed adequate time for the questionnaire to be filled properly.

Appendix A shows a sample of the letter to the participants on the questionnaire for the workshop. The responses to the questionnaire for selected participants are presented in Appendix B. The next stage of the workshop addressed the experimental exercise in the preparation of cost estimate for a project.

**Preparation of Cost Estimate**

This activity took place in the afternoon session of the workshop. The proposed project designed for the estimating exercise was the construction of a speed ramp over a highway. All the parameters of the speed ramp and the relevant drawings were given to the participants. For uniformity, some cost parameters were also given to the participants. The only cost item not given was the assumptions that each individual participant had to make in order to complete the estimating process. These assumptions differ from participant to participant. The participants were then requested to prepare the cost estimate of the proposed project. The researcher was present throughout the estimating process and allowed adequate time for participants to complete the estimating process. All the thirty-one participants participated in the exercise. All the risks previously identified and the mitigation measures adopted were the same for the two sessions of the workshop. The results obtained from the estimating process by participants are presented in Appendix E.

### *7.1.4.2 Northern Sector Workshop*

The organisation of the northern sector workshop was similar to that of the southern sector. This workshop was held at Kumasi in the conference room of a four star hotel. Participants for this workshop were also drawn from the road sector Agencies namely Ghana Highway Authority, Department of Urban Roads and Department of Feeder Roads from the northern sector. As explained in the southern sector workshop, the geographical regions that comprised the northern sector for the study were Northern, Upper East, Upper West, Brong Ahafo, and Ashanti regions.

For the northern sector workshop, similar risks were identified as the southern sector. Subsequently, the mitigation measures against the identified risks for the southern sector were applied to the northern sector. The responses to the questionnaires and the estimating process were done in the same conditions as in the southern sector workshop. For uniformity, the same design and cost parameters that were given to participants at the southern sector workshop were also given to participants at the northern sector workshop. Participants were requested to make all necessary assumptions to estimate the cost of the proposed project. Thus, the assumptions became the subjective element that made the difference from estimator to estimator in accordance to the personality theories. Therefore, as it was in the southern sector workshop, the only variable cost element was the cost attributed by each participant to the assumptions that they make in the estimating process. In all thirty participants attended the northern sector workshop. The results from the northern sector workshop for the responses of the questionnaire are presented in Appendix B whiles that of the cost estimates is presented in Appendix E.

## 7.1.5 Demographic of Data collected

The demographic of the data collected from the two workshops are presented for sample A. Similarly that for the data collected from the questionnaire received from the experienced estimators have been presented for sample B. Each is discussed in detail in the subsequent section.

## *7.1.5.1 Demographic of Sample A Data*

The demographics of Sample size A are indicated in Figure 7.1. This has been categorised into grade, qualification, number of cost estimates prepared per year and years of experience in estimating.

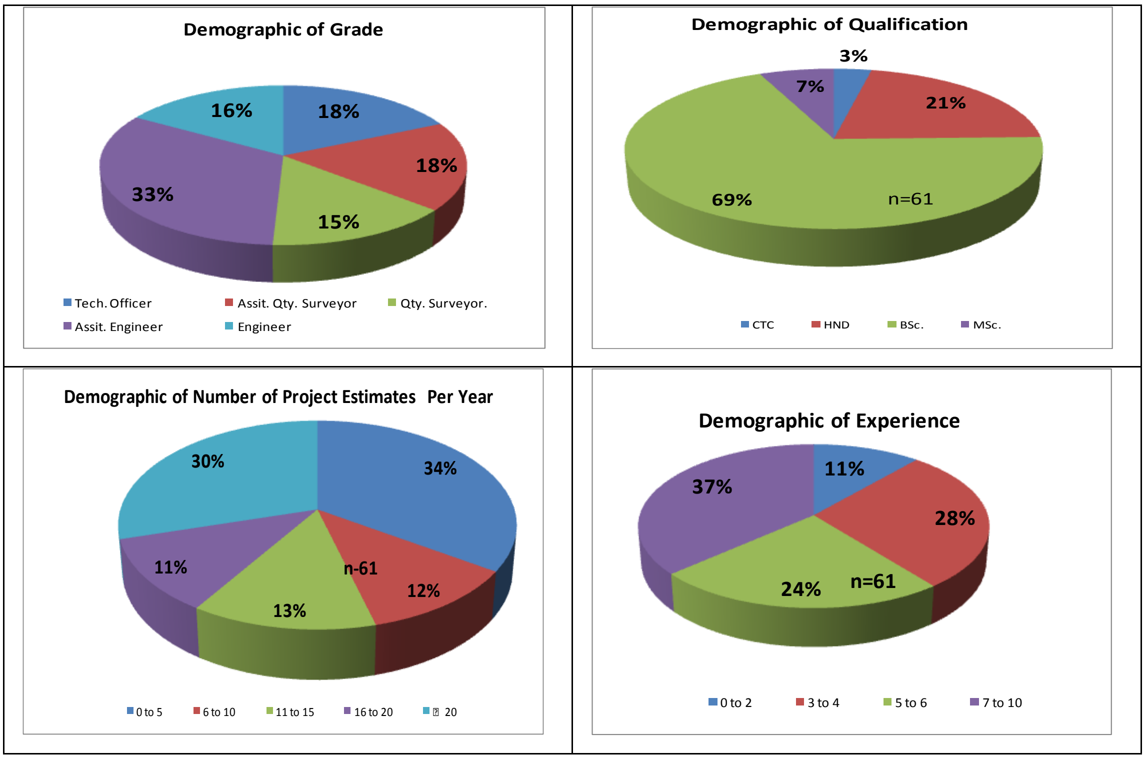



**Figure 7.1: Demographics of Sample size A**

The accuracy of the sample size as the true representative of the population of estimators in Ghana is exhibited as follows.

- all the ten geographical regions have been represented;
- the different Agencies under the Ministry of Roads and Highways were all represented thus eliminating the risk of biased towards the practices of one particular organisation;
- estimators that represented northern zone were different from those that represented the southern zone;
- the researcher was the same person that administered the workshop in the two (2) zones; and
- the workshops were held in free and conducive environment devoid of duress from superiors.

These factors accounted for the true representative of the sample size used in the investigation. The data collected was therefore devoid of the researchers influence.

### *7.1.5.2 Demographic of Sample B*

The demographics of Sample size B are shown in Figure 7.2. As in sample A this has been categorised into grade, qualification and number of cost estimates prepared per year. In this sample, all participants gained ten or more years of experience. Therefore demographics of experience were not provided for sample B. Figure 7.2 shows the demographic of sample size B.

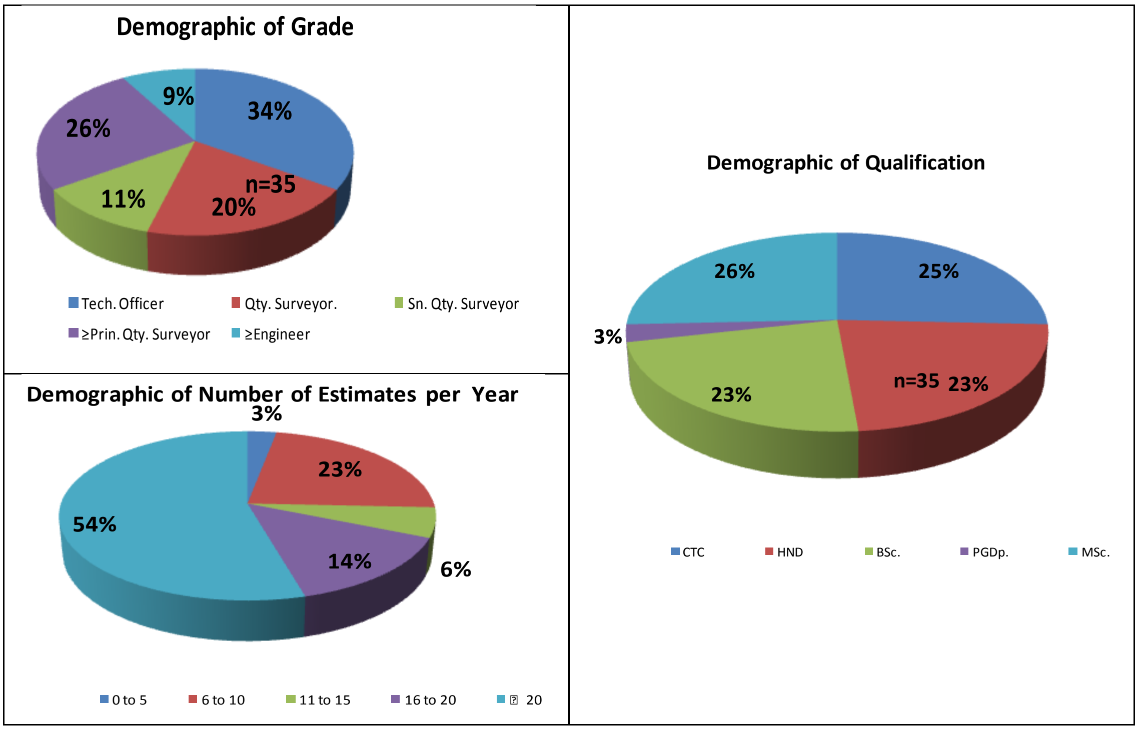



**Figure 7.2: Demographics of Sample Size B**

The characteristics of sample B as the true representative of the population of experienced estimators in Ghana is exhibited as follows.

- All the ten geographical regions were represented.
- The public and private sector estimators in all the ten regions were represented.
- The researcher was the same person that administered the questionnaires.

These factors accounted for the true representative of the sample B used in the investigation. Again, in this sample, the researcher had no influence over the data collected. The significance of the distribution of the data collected is discussed in the subsequent sections.

## 7.2 DATA MANAGEMENT

In a study of this kind, the management of data elicited forms a valuable asset to the investigator. For this reason, data collected on samples A and B for the study were stored in both "hard" and "soft" copies. The "hard" copies were kept in the library of the researcher whiles the soft copies were kept on both the computer of the researcher and on other computer accessories to ensure security for the stored information.

Data for the research was analysed with two techniques. These were the personality instrument developed for the testing personality archetypes and Statistical Package for Social Sciences (SPSS) for statistical analysis on the data collected. The personality instrument for the study was used to analyse responses to the questionnaire and the SPSS for the combined analysis. The researcher therefore organised the data obtained for the study in a form suitable for the application of SPSS. Detailed analyses of the data obtained for the research work is discussed in the subsequent section.

## 7.3 ANALYSIS

The data collected for the research were analysed in two main categories. The first was a classification of the estimators based on their personality archetypes and secondly was statistical analysis to determine the relationships between qualifications, experience and personality types with reliable project estimates. The techniques used in these analyses are discussed in the subsequent sections.

## 7.3.1 Personality Type

The personality instrument developed for the study was used in classification of estimators into their personality archetypes. The data collected from the questionnaire were in two categories namely sample A and sample B. The characteristics of each sample were explained in the previous sections of this chapter. Sample A was the observed group and sample B was the control group. Subsequently, the test was performed on the control and observed groups separately. In both groups, a scale as shown in Figure 7.3 was used for the test. The five traits in the personality instrument for the study namely, Extraversion, Conscientiousness, Agreeableness, Openness and Neuroticism were used in designing the scale. The meanings of these traits were discussed in the previous chapters. The scale was design taking the opposite of each trait into consideration. Figure 7.3 shows the scale on each of the five traits.

**Extraversion**

| -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| High Introversion | | | Low Introversion | | Neutral | Low Extraversion | | High Extraversion | | |

**Neuroticism**

| -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| Low Anxiety | | | | | Neutral | High Anxiety | | | | |

**Openness**

| -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| Pragmatism | | | | | Neutral | Openness | | | | |

**Agreeableness**

| -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| Independence | | | | | Neutral | Agreeableness | | | | |

**Conscientiousness**

| -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| Low Self-Control | | | | | Neutral | High Self-Control | | | | |

**Figure 7.3: Scale for the Research Personality Instrument**

### 7.3.1.1 Profiling Observed and Control Groups

The data in Appendices B and C on the responses of the observed and control groups respectively were extracted into the personality instrument for the research. The scale in Figure 7.3 was used to extract the data from the responses on the questionnaires of the control group and the observed group. Table 7.1 shows the extracted data for the control group and Table 7.2 shows the extracted data for the observed group. The behaviour of each of the traits with respect to its opposite was analysed. The subsequent sections compared the behaviour of the traits of the estimators in each group. Scatter diagram was used to define the behaviour of the data in Tables 7.1 and 7.2. The behaviour of each trait is shown and discussed in the subsequent sections.

### Table 7.1: Extracted Data from Questionnaire for Control Group

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **E**xtraversion | 3.00 | 3.00 | 1.50 | 1.75 | 1.00 | 0.75 | 2.50 | 0.25 | 1.00 | 1.25 | 2.75 | 2.75 | 2.25 | 5.00 | 1.25 | 3.50 | 2.00 | 1.00 |
| **L**ow Self **C**ontrol | 2.25 | 1.00 | 2.25 | 1.50 | 2.75 | 4.25 | 2.50 | 1.25 | 1.25 | 1.25 | 2.25 | 2.50 | 2.25 | 2.25 | 0.75 | 2.00 | 1.75 | 2.50 |
| **H**igh a**N**xiety | 2.50 | 0.75 | 0.50 | 1.25 | 2.25 | 2.25 | 2.50 | 1.25 | 1.50 | 0.25 | 2.00 | 2.25 | 1.25 | 0.75 | 0.75 | 1.25 | 1.25 | 0.75 |
| In**d**ependent | 2.50 | 1.25 | 1.25 | 1.25 | 1.75 | 1.75 | 1.00 | 1.75 | 2.00 | 2.00 | 2.00 | 1.25 | 1.25 | 1.25 | 1.25 | 0.50 | 1.75 | 0.75 |
| **O**penness | 3.25 | 2.75 | 3.25 | 1.75 | 1.75 | 1.75 | 2.25 | 1.50 | 1.75 | 1.00 | 1.25 | 2.50 | 1.50 | 1.00 | 1.25 | 2.00 | 1.25 | 1.50 |
| **I**ntroversion | 2.00 | 1.75 | 2.00 | 2.25 | 2.00 | 3.25 | 0.50 | 4.25 | 3.00 | 4.50 | 2.25 | 0.00 | 1.50 | 3.00 | 0.75 | 2.00 | 1.50 | 1.25 |
| **A**greeable | 2.00 | 4.00 | 4.75 | 3.00 | 4.50 | 1.75 | 4.25 | 3.50 | 4.25 | 4.00 | 4.25 | 3.25 | 2.75 | 5.00 | 1.75 | 4.75 | 3.50 | 4.25 |
| Low aNxiety | 2.75 | 3.25 | 4.25 | 2.75 | 3.50 | 2.75 | 4.00 | 4.75 | 3.00 | 3.75 | 4.00 | 3.75 | 3.00 | 4.75 | 2.00 | 4.00 | 3.75 | 2.75 |
| **H**igh Self **C**ontrol | 2.75 | 4.25 | 4.75 | 3.50 | 5.00 | 4.50 | 4.25 | 2.75 | 4.50 | 5.00 | 4.25 | 4.50 | 4.50 | 5.00 | 3.00 | 5.00 | 4.25 | 5.00 |
| **P**ragmatism | 3.00 | 2.25 | 3.75 | 2.75 | 3.75 | 3.00 | 2.75 | 2.75 | 3.75 | 3.00 | 2.50 | 4.00 | 2.75 | 3.00 | 2.50 | 3.75 | 2.75 | 2.50 |

| | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **E**xtraversion | 2.00 | 2.50 | 2.75 | 1.75 | 1.75 | 3.25 | 2.00 | 1.25 | 2.00 | 3.00 | 2.25 | 3.00 | 0.50 | 1.00 | 2.25 | 1.00 | 2.25 |
| **L**ow Self **C**ontrol | 1.50 | 1.75 | 0.75 | 2.00 | 1.00 | 2.25 | 1.75 | 1.50 | 1.25 | 1.75 | 1.00 | 2.25 | 2.00 | 2.25 | 1.75 | 0.25 | 1.75 |
| **H**igh a**N**xiety | 1.25 | 1.25 | 0.75 | 1.00 | 1.75 | 2.50 | 0.25 | 0.25 | 1.75 | 1.00 | 0.75 | 2.50 | 1.75 | 0.25 | 0.50 | 1.25 | 2.00 |
| In**d**ependent | 0.50 | 0.75 | 0.25 | 1.00 | 3.25 | 2.00 | 2.50 | 0.00 | 1.25 | 1.75 | 1.25 | 2.50 | 2.25 | 1.50 | 0.50 | 0.00 | 2.00 |
| **O**penness | 1.50 | 1.25 | 0.75 | 1.00 | 2.00 | 2.00 | 1.75 | 0.75 | 2.25 | 1.75 | 2.00 | 3.25 | 3.25 | 2.00 | 0.25 | 0.25 | 3.00 |
| **I**ntroversion | 3.00 | 1.00 | 2.00 | 1.25 | 2.25 | 0.50 | 3.00 | 0.00 | 0.25 | 1.25 | 1.00 | 2.00 | 2.75 | 0.50 | 0.25 | 1.50 | 3.75 |
| **A**greeable | 3.25 | 3.50 | 2.50 | 3.75 | 4.00 | 3.75 | 3.75 | 2.75 | 3.50 | 3.50 | 3.75 | 2.00 | 3.25 | 4.50 | 4.25 | 3.25 | 3.00 |
| Low aNxiety | 3.75 | 3.75 | 2.75 | 3.75 | 4.00 | 3.75 | 3.25 | 1.75 | 3.25 | 3.50 | 1.50 | 2.75 | 3.00 | 3.75 | 4.00 | 3.25 | 3.25 |
| **H**igh Self **C**ontrol | 4.50 | 3.50 | 4.75 | 3.50 | 3.75 | 3.75 | 3.75 | 3.75 | 4.50 | 3.50 | 3.00 | 2.75 | 3.25 | 4.00 | 5.00 | 4.00 | 3.50 |
| **P**ragmatism | 3.50 | 4.00 | 3.00 | 2.50 | 2.25 | 2.25 | 3.00 | 2.00 | 2.75 | 3.25 | 2.25 | 3.00 | 3.50 | 3.00 | 5.00 | 2.75 | 3.25 |

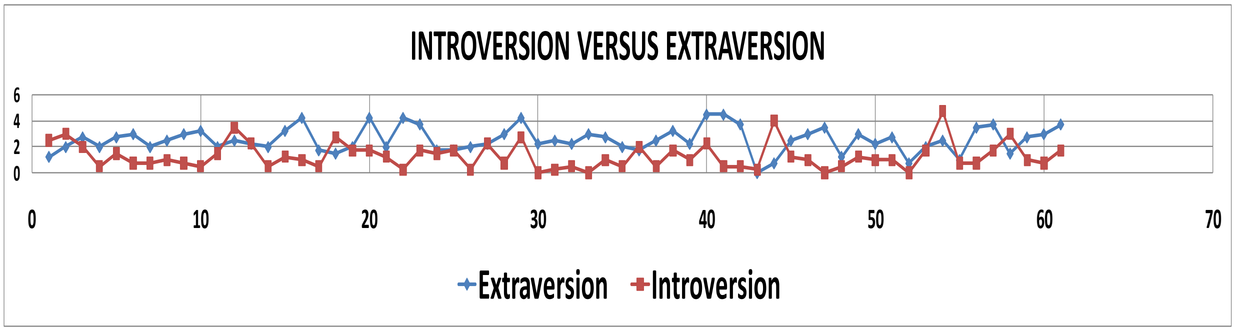
## Table 7.2: Extracted Data from questionnaire for Observed Group

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1.00** | **2.00** | **3.00** | **4.00** | **5.00** | **6.00** | **7.00** | **8.00** | **9.00** | **10.00** | **11.00** | **12.00** | **13.00** | **14.00** | **15.00** | **16.00** | **17.00** | **18.00** | **19.00** | **20.00** | |
| | | | | | | | | | | | | | | | | | | | | | |
| **E**xtraversion | 1.25 | 2.00 | 2.75 | 2.00 | 2.75 | 3.00 | 2.00 | 2.50 | 3.00 | 3.25 | 2.00 | 2.50 | 2.25 | 2.00 | 3.25 | 4.25 | 1.75 | 1.50 | 2.00 | 4.25 | |
| **L**ow Self **C**ontrol | 2.00 | 2.50 | 1.50 | 2.00 | 3.00 | 1.75 | 1.25 | 3.75 | 1.25 | 1.50 | 1.25 | 2.75 | 2.25 | 2.50 | 1.50 | 1.50 | 1.25 | 1.50 | 1.50 | 1.25 | |
| **H**igh a**N**xiety | 1.75 | 1.75 | 1.25 | 0.25 | 1.00 | 2.25 | 1.25 | 2.75 | 2.00 | 0.25 | 2.00 | 2.00 | 2.00 | 1.00 | 0.50 | 2.00 | 1.25 | 0.25 | 1.00 | 3.00 | |
| In**d**ependent | 1.50 | 1.50 | 1.00 | 0.50 | 1.00 | 0.50 | 0.50 | 1.00 | 2.25 | 0.50 | 0.50 | 2.00 | 2.50 | 1.25 | 1.00 | 1.25 | 1.00 | 2.25 | 1.50 | 0.25 | |
| **O**penness | 2.50 | 5.00 | 1.75 | 1.00 | 1.00 | 1.00 | 1.00 | 2.50 | 2.50 | 0.75 | 1.75 | 2.25 | 1.50 | 2.75 | 1.00 | 0.50 | 1.00 | 1.00 | 1.00 | 1.75 | |
| **I**ntroversion | 2.50 | 3.00 | 2.00 | 0.50 | 1.50 | 0.75 | 0.75 | 1.00 | 0.75 | 0.50 | 1.50 | 3.50 | 2.25 | 0.50 | 1.25 | 1.00 | 0.50 | 2.75 | 1.75 | 1.75 | |
| **A**greeable | 2.75 | 3.00 | 3.50 | 3.75 | 3.75 | 3.75 | 4.75 | 4.50 | 3.25 | 2.25 | 5.00 | 4.25 | 2.00 | 3.75 | 3.75 | 4.75 | 3.50 | 3.75 | 2.75 | 4.00 | |
| Low aNxiety | 4.00 | 4.50 | 2.75 | 2.75 | 2.50 | 3.50 | 2.50 | 4.00 | 2.75 | 3.75 | 3.25 | 4.00 | 1.75 | 4.00 | 3.50 | 4.00 | 4.00 | 4.25 | 3.50 | 4.00 | |
| **H**igh Self **C**ontrol | 4.25 | 5.00 | 3.75 | 3.50 | 3.75 | 3.25 | 4.00 | 4.50 | 4.25 | 4.25 | 4.00 | 4.25 | 3.75 | 4.25 | 5.00 | 3.75 | 4.50 | 3.75 | 3.75 | 4.00 | |
| **P**ragmatism | 3.75 | 4.25 | 2.75 | 3.00 | 3.50 | 3.00 | 2.25 | 3.50 | 3.00 | 3.50 | 2.50 | 3.75 | 3.00 | 3.25 | 3.00 | 3.75 | 2.25 | 2.50 | 3.25 | 3.00 | |
| | | | | | | | | | | | | | | | | | | | | | |
| | **21.00** | **22.00** | **23.00** | **24.00** | **25.00** | **26.00** | **27.00** | **28.00** | **29.00** | **30.00** | **31.00** | **32.00** | **33.00** | **34.00** | **35.00** | **36.00** | **37.00** | **38.00** | **39.00** | **40.00** | |
| | | | | | | | | | | | | | | | | | | | | | |
| **E**xtraversion | 2.00 | 4.25 | 3.75 | 1.75 | 1.75 | 2.00 | 2.25 | 3.00 | 4.25 | 2.25 | 2.50 | 2.25 | 3.00 | 2.75 | 2.00 | 1.75 | 2.50 | 3.25 | 2.25 | 4.50 | |
| **L**ow Self **C**ontrol | 1.00 | 2.75 | 2.00 | 1.50 | 3.00 | 0.75 | 0.50 | 2.50 | 4.00 | 1.25 | 0.00 | 1.25 | 1.25 | 2.50 | 1.75 | 2.50 | 1.25 | 1.50 | 1.50 | 2.50 | |
| **H**igh a**N**xiety | 0.75 | 3.00 | 1.75 | 1.75 | 1.00 | 0.00 | 1.00 | 2.25 | 2.00 | 0.50 | 1.25 | 1.25 | 3.25 | 2.25 | 0.75 | 1.00 | 0.25 | 1.25 | 0.50 | 2.50 | |
| In**d**ependent | 0.50 | 0.75 | 0.50 | 1.00 | 3.00 | 1.50 | 0.00 | 1.50 | 1.50 | 0.25 | 0.00 | 0.25 | 0.75 | 0.00 | 0.00 | 2.00 | 0.00 | 1.25 | 0.00 | 1.75 | |
| **O**penness | 0.75 | 1.50 | 0.50 | 2.00 | 3.00 | 1.00 | 3.00 | 1.75 | 1.50 | 0.75 | 3.25 | 1.50 | 1.25 | 1.75 | 0.75 | 1.75 | 1.00 | 1.00 | 0.75 | 3.75 | |
| **I**ntroversion | 1.25 | 0.25 | 1.75 | 1.50 | 1.75 | 0.25 | 2.25 | 0.75 | 2.75 | 0.00 | 0.25 | 0.50 | 0.00 | 1.00 | 0.50 | 2.00 | 0.50 | 1.75 | 1.00 | 2.25 | |
| **A**greeable | 2.00 | 4.50 | 4.00 | 3.75 | 4.75 | 3.25 | 3.50 | 3.50 | 4.25 | 4.75 | 4.00 | 2.75 | 3.25 | 3.25 | 5.00 | 4.00 | 5.00 | 2.50 | 3.75 | 3.50 | |
| Low aNxiety | 2.00 | 3.00 | 3.50 | 2.75 | 4.75 | 4.25 | 3.25 | 3.00 | 3.75 | 4.50 | 2.00 | 2.50 | 2.50 | 3.50 | 3.00 | 3.75 | 3.75 | 3.50 | 4.00 | 1.25 | |
| **H**igh Self **C**ontrol | 2.25 | 4.75 | 4.00 | 3.50 | 5.00 | 4.50 | 2.75 | 4.00 | 4.00 | 4.75 | 3.50 | 4.25 | 4.00 | 4.25 | 4.75 | 4.25 | 4.00 | 4.25 | 4.00 | 1.50 | |
| **P**ragmatism | 2.25 | 3.25 | 3.75 | 2.25 | 3.50 | 3.50 | 2.50 | 3.75 | 3.25 | 2.75 | 2.25 | 4.00 | 2.75 | 1.25 | 2.50 | 3.00 | 3.75 | 2.25 | 2.50 | 3.00 | |
| | | | | | | | | | | | | | | | | | | | | | |
| | **41.00** | **42.00** | **43.00** | **44.00** | **45.00** | **46.00** | **47.00** | **48.00** | **49.00** | **50.00** | **51.00** | **52.00** | **53.00** | **54.00** | **55.00** | **56.00** | **57.00** | **58.00** | **59.00** | **60.00** | **61.00** |
| | | | | | | | | | | | | | | | | | | | | | |
| **E**xtraversion | 4.50 | 3.75 | 0.00 | 0.75 | 2.50 | 3.00 | 3.50 | 1.25 | 3.00 | 2.25 | 2.75 | 0.75 | 2.00 | 2.50 | 1.00 | 3.50 | 3.75 | 1.50 | 2.75 | 3.00 | 3.75 |
| **L**ow Self **C**ontrol | 1.75 | 3.00 | 1.75 | 3.00 | 0.50 | 1.50 | 1.00 | 2.75 | 2.25 | 1.50 | 1.00 | 1.75 | 1.00 | 2.00 | 2.25 | 0.50 | 1.50 | 2.75 | 0.25 | 2.50 | 0.75 |
| **H**igh a**N**xiety | 0.50 | 2.00 | 0.50 | 3.00 | 1.50 | 0.50 | 1.00 | 1.50 | 2.00 | 2.25 | 1.25 | 0.50 | 2.25 | 2.00 | 0.50 | 0.75 | 2.25 | 2.50 | 2.00 | 2.50 | 1.50 |
| In**d**ependent | 0.25 | 0.75 | 0.25 | 2.00 | 0.50 | 0.00 | 0.00 | 1.25 | 1.50 | 0.75 | 0.25 | 1.00 | 1.25 | 2.25 | 0.00 | 0.00 | 0.00 | 1.25 | 1.25 | 1.00 | 0.25 |
| **O**penness | 1.25 | 1.75 | 2.25 | 0.50 | 1.00 | 0.50 | 0.25 | 2.00 | 0.75 | 1.00 | 1.75 | 0.25 | 1.50 | 2.75 | 1.50 | 1.25 | 1.75 | 3.50 | 1.50 | 1.50 | 1.50 |
| **I**ntroversion | 0.50 | 0.50 | 0.25 | 4.00 | 1.25 | 1.00 | 0.00 | 0.50 | 1.25 | 1.00 | 1.00 | 0.00 | 1.75 | 4.75 | 0.75 | 0.75 | 1.75 | 3.00 | 1.00 | 0.75 | 1.75 |
| **A**greeable | 4.75 | 5.00 | 3.50 | 3.75 | 5.00 | 5.00 | 5.00 | 3.75 | 3.75 | 3.50 | 3.75 | 1.50 | 3.00 | 3.50 | 5.00 | 4.50 | 0.00 | 3.75 | 4.25 | 4.75 | 3.50 |
| Low aNxiety | 2.50 | 3.00 | 0.75 | 3.25 | 3.75 | 5.00 | 3.25 | 3.00 | 3.50 | 2.25 | 2.50 | 3.50 | 3.00 | 3.50 | 4.25 | 2.75 | 5.00 | 3.50 | 2.25 | 2.75 | 2.50 |
| **H**igh Self **C**ontrol | 4.50 | 3.75 | 3.00 | 4.50 | 5.00 | 5.00 | 3.25 | 3.75 | 4.25 | 3.00 | 3.75 | 3.75 | 4.25 | 4.50 | 4.25 | 3.75 | 2.75 | 3.50 | 5.00 | 4.50 | 4.00 |
| **P**ragmatism | 4.00 | 3.25 | 1.00 | 3.25 | 2.25 | 3.00 | 3.00 | 2.75 | 3.25 | 2.50 | 2.25 | 2.75 | 2.25 | 3.25 | 3.25 | 2.25 | 3.00 | 2.25 | 3.50 | 3.25 | 2.75 |

### i. Introversion Versus Extraversion

Figure 7.4 presents the profile of the Extraversion trait from the data in Tables 7.1 and 7.2 for control and observed groups respectively.

**Observed Group**




**Control Group**

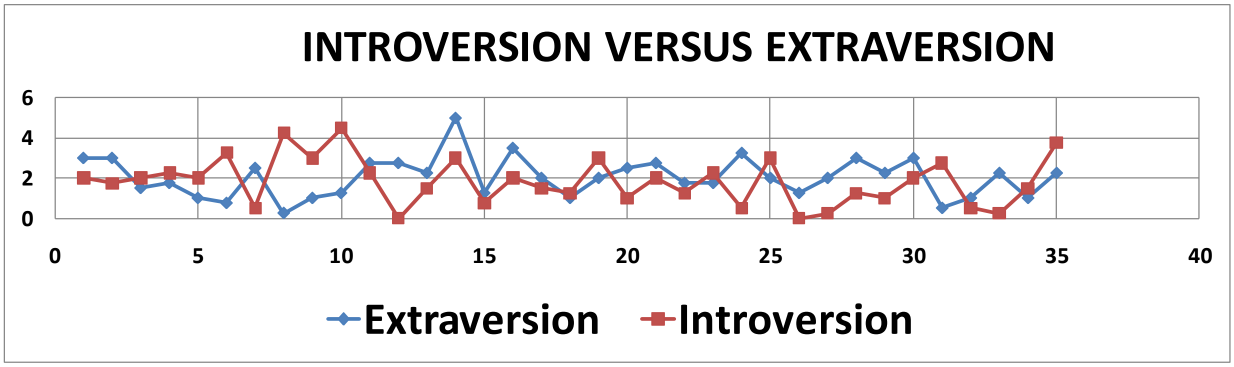



**Figure 7.4: Profile of Extraversion of Estimators**

The extraversion profile classifies estimators in accordance to the level of consultations and opinions they gather from other organisations and people in estimating. The profile exhibited in Figure 7.4 for the control group indicated closeness of the two lines for extroversion and introversion. This is an indication that this group of estimators consult other professional, other estimators and in estimating but the level of consultation is very low. This is because they are experienced estimators and although they could carry out the estimating without any assistance, they relied on some level of consultation to improve the reliability of their project estimates. Figure 7.4 for control group also indicate that this group of estimators do not totally disagree with any negative comments on their work but rather analyses those comments to ascertain their validity. The mean of Figure 7.4 for control group was 0.2 which is an indication that experienced estimators are extraverts but on very low side. Again this implies their judgements in estimating are based on proven and tested ideas but not just utilising any available idea in estimating.

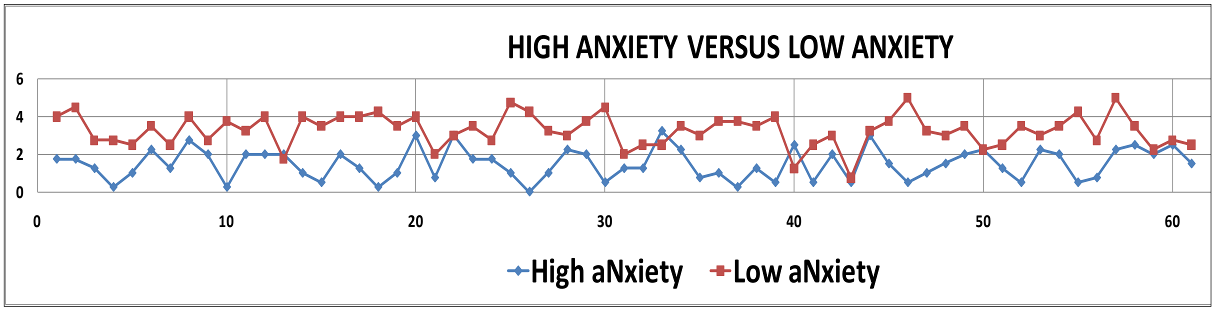
For the observed group, there was wider spread in the graph of Figure 7.4. The spread was more towards the extroversion line. This is an indication that this group of estimators make adequate consultations in estimating. The mean of this group of estimators also substantiate this fact as the mean was 1.25 as compared to that of control group of 0.2. Estimators in this group therefore rely on ideas from superiors and other estimating professionals in the organisation. They turn to discuss their work with others frequently in order to be sure that they are doing the right thing. This group of estimators do agree with negative comments on their work and in most instances, they change their project estimates due to comments from other people. These characteristics of the observed group of estimators make their estimates not reliable. The question is how these shortfalls could be addressed for the desired reliability in project estimates prepared by the observed group of estimators.

To improve the reliability of project cost estimates of the observed group of estimators, there is the need for training. Training could be done in the formal way or informal way. On the short run, on-the-job training should be organised for this group of estimators. On the long run, short and long courses could be organised to address the observations in Figure 7.4 for the observed group. Other measures to improve the reliability of project cost estimates of the observed group spread across other profiles and are discussed in the subsequent sections.

**ii. Low Anxiety Versus High Anxiety**

Figure 7.5 presents the profile of neuroticism from the data in Tables 7.1 and 7.2 for control and observed groups respectively. Each of the figures is discussed in the subsequent sections.

**Observed Group**




**Control Group**

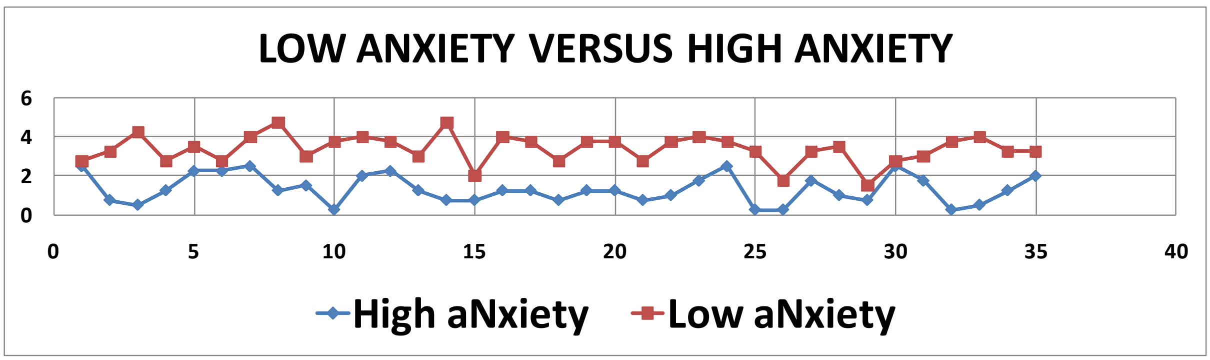



**Figure 7.5: Profile of Neuroticism of Estimators**

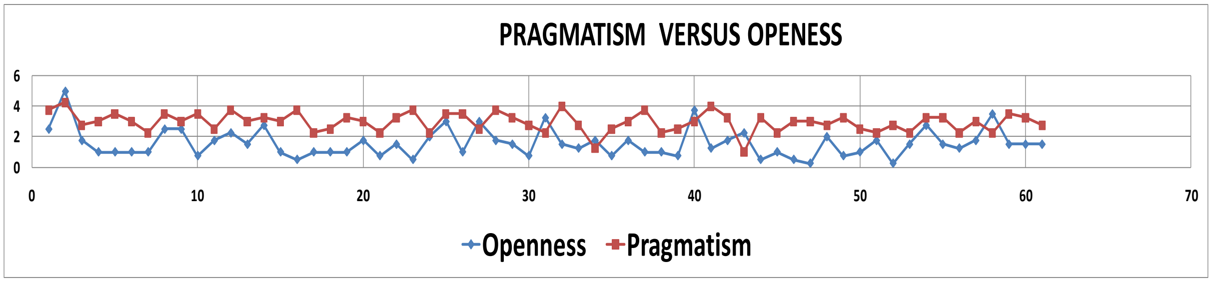
The profile in Figure 7.5 for the control group is more to the low anxiety side of the graph. This is an indication that this group of estimators are calm in making decisions in estimating. They are also definitive on any decision they make. These are attributed to the experience they gained over the years. The mean obtained from the data for figure 7.5 for the control group is -2.05. This again substantiates the profile of the control group of estimators as estimators with low anxiety. Estimators in this group are not nervous when different person is reviewing their work and they generally are able to work under pressure. This group of estimators are able to defend any decisions they make in estimating because their decisions are based on experience in estimating cost for projects of similar nature and conditions.

Figure 7.5 for the observed group indicate a similar trend to that of the control group but on a smaller scale. The graph of this group of estimators also was more to the low anxiety side but deviation was less, compared with the control group. The reasons of this behaviour of observed group of estimators of neuroticism personality profile is that as estimators there should be some level of calmness in the estimating due to the numerous procedures involved. Furthermore, estimators are supposed to make sound judgement and this judgement is dependent on the level of amount of experience of the estimator in the field of estimating. Thus, some basic qualities are necessary if one aspires to become an estimator. These qualities however vary according to the level of experience gained. This therefore explained why both control and observed group of estimators are all having low anxiety. Again as explained, the level differs due to ones experience. An experienced estimator is more confident in the decisions that are made due to experience gained and also the decisions are most of the time tried and tested on other past projects. This therefore accounted for the difference in the control group's level of neuroticism profile compared to that of observed group. Again the means obtained for both also ascertained the explanations on neuroticism profile for the control group and the observed group. The mean from the data of figure 7.5 was -2.5 for the control group and -1.79 for the observed group. Again, the negative of the two values indicate that as estimators they all have low anxiety in their various estimating activities but the influence varies from the control group to the observed group as explained above. For example, estimators with this profile are calm and definitive in their decisions. However, an experienced estimator as in control group exhibit higher level of calmness in decision making and more precise in their decisions than the observed group of estimators.

**iii. Pragmatism and Openness**

Figure 7.6 presents the profile of Openness from the data in Tables 7.1 and 7.2 for control and observed groups respectively. Each of the figures is discussed in the subsequent sections.

**Observed Group**




**Control Group**

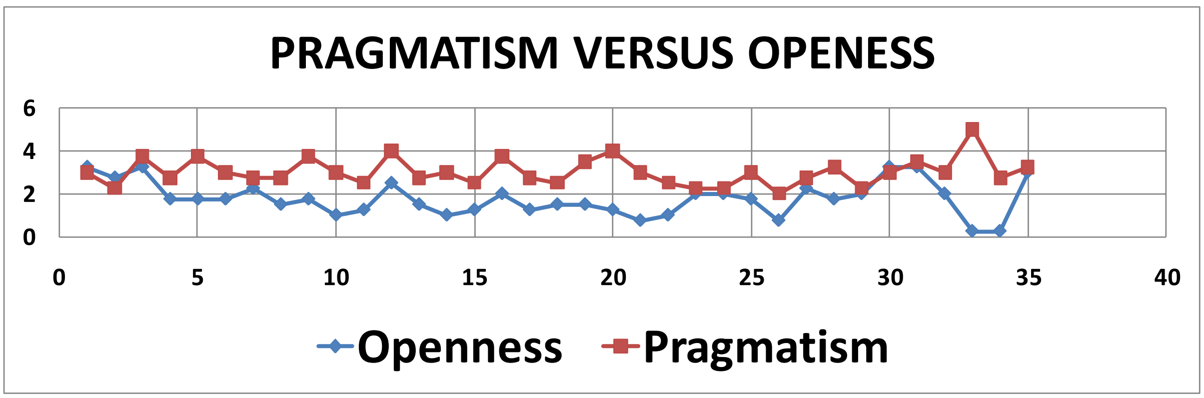



**Figure 7.6: Profile of Openness of Estimators**

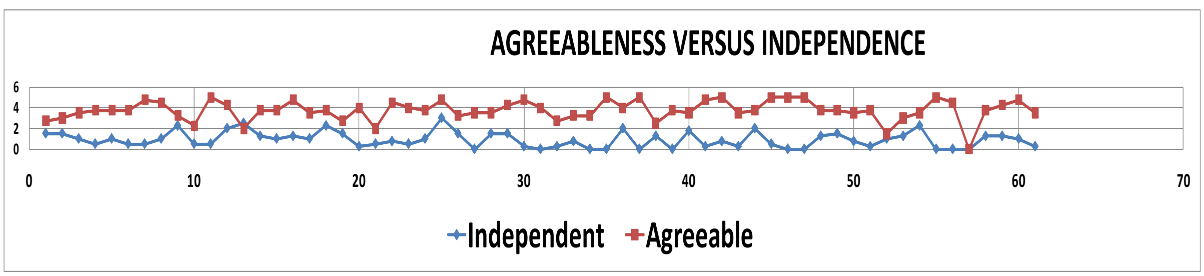
From Figure 7.6 both control and observed group of estimators were more pragmatic than openness. Again this profile shows that as estimators, decisions must be based on proven and justifiable evidence. Project cost estimates could only be reliable if the evidence used in the preparation of the estimates is also reliable. Again estimating procedures are the same for the source of data for the study. The literature review also revealed that the same procedure in estimating is used in the samples obtained for the research. Figure 7.6 therefore proved that estimators in their organisation follow the same estimating procedures and these procedures are followed in estimating project estimates. Therefore both control and observed estimators abide by the procedures established in their organisations. This therefore accounted for the negative profile of openness of estimators in both control and observed groups.

The level of the profiles again is not the same. The means of the two groups also proved the differences. The mean for the control group was -1.24 whiles that of the observed group was -1.37. The difference of the control group's mean from that of the observed group was because as experienced estimators they seek for new ways that will improve the reliability of the method being used. The seeking of new ways means the control group of estimators are somehow open to some new ways of performing the same task. The idea is the control group will like to use their experience gained from the past to improve upon the procedure being used in order for the project cost estimates to be more reliable compared with the current procedure. This attribute of the control group accounted for the difference in the means of the two groups. This exploring nature of the control group as the result of the experienced gained accounted for some openness thus reducing the pragmatism as compared to that of the observed group who stick to the laid down procedures in their work.

**iv. Agreeableness and Independence**

Figure 7.7 presents the profile of Agreeableness from the data in Tables 7.1 and 7.2 for control and observed groups respectively. Each of the figures is discussed in the subsequent sections.

**Observed Group**




**Control Group**

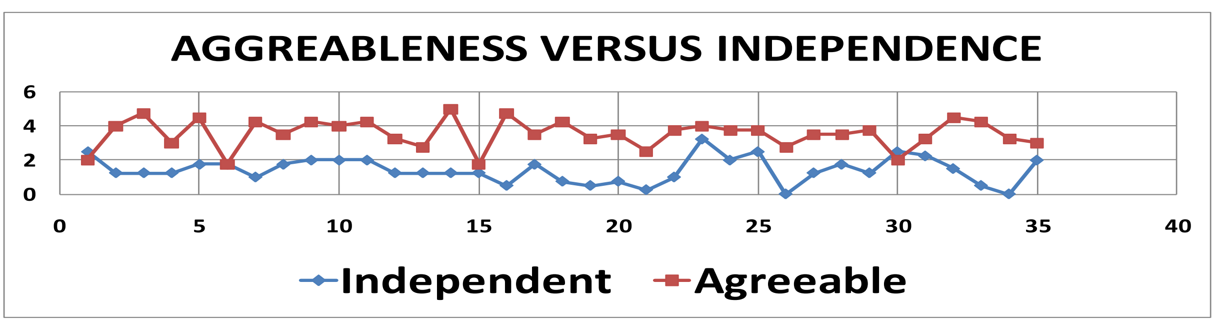



**Figure 7.7: Profile of Agreeableness of Estimators**

Figure 7.7 show wider spread of the data for observed group as compared to the control group. Figure 7.7 also show the profile of both groups was more agreeableness as compared to independence. The difference in the spread is attributed to a number of reasons which are explained in the subsequent section.

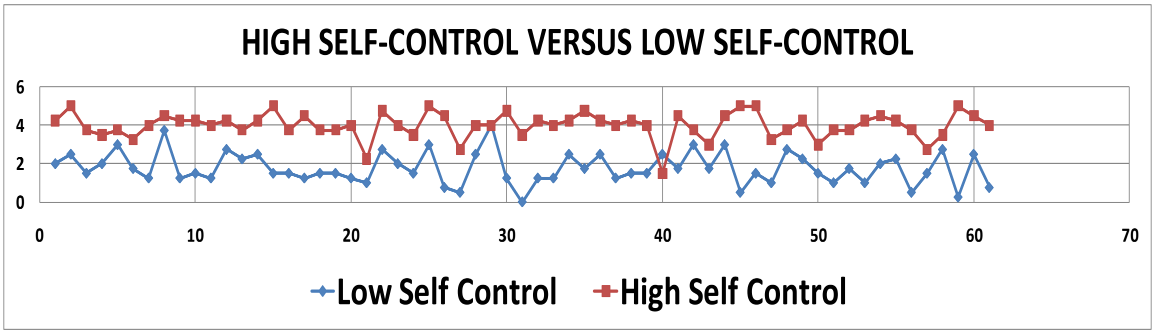
The control group are experienced estimators who sometimes agree with the views of others in estimating. They also tolerate to criticism on their work to a reasonable level. This group of estimators are ready to lend support to subordinates. They are the type of estimators that organise on-the-job training for subordinates with the aim of improving reliability of estimates. The literature review identified high workload to experienced estimator ratio in the road sector of Ghana. This therefore demands lot of responsibilities on the experienced estimators who were the control group in the research. The resultant effect is fatigue among others on the control group of estimators thus influencing their decision making orientations. To address this abnormally requires urgent short-term measures. This is where the control group of estimators exhibit the attribute in this profile by helping subordinates and organising on-the-job training to bring the observed group of estimates to the required standard. The benefit to the control group from this short term measures could therefore not be overemphasised. Again the control group sometimes regard themselves as the approving authority due to the experienced gained over the years. This therefore accounted for the trace of independence in the profile thus making the mean of the control group 2.11 as against that of the observed group of 2.83.

The observed group were high on the openness profile. This is understandable since observed group of estimators lack the required experience hence turn to listen to views from other people. The lack of experience also accounted for the fact that they tolerate any criticism on their work. They easily agree with the views of others due to the fact that they do not have any proven and tested instances of works of similar nature in the past. Again, lack of experience is the main reason of this development on the part of the observed group of estimators.

**High Self-Control and Low Self-Control**

Figure 7.8 presents the profile of neuroticism from the data in Tables 7.1 and 7.2 for control and observed groups respectively. Each of the Figures is discussed in the subsequent sections.

**Observed Group**




**Control Group**

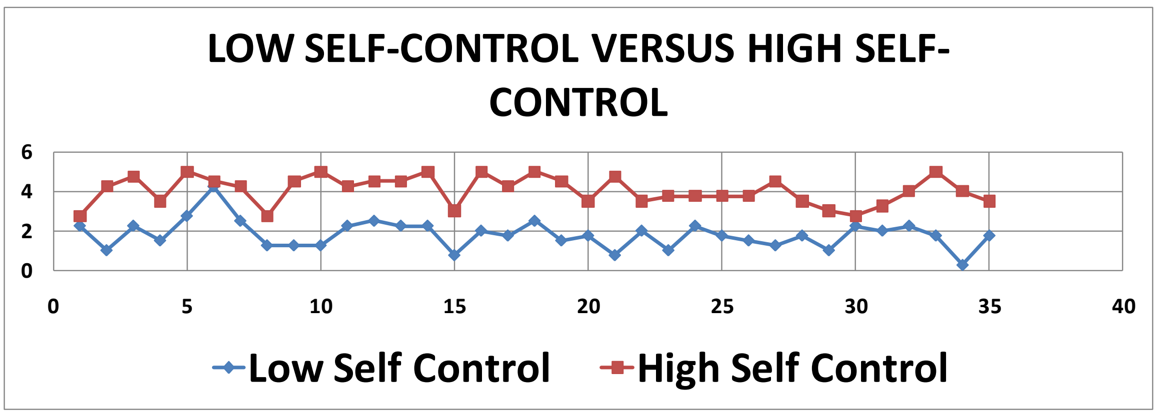



**Figure 7.8: Profile of Conscientiousness of Estimators**

This profile exhibited conscientiousness trait of estimators. Figure 7.8 indicate that the profile of both group of estimators on conscientiousness is high. This implies that both groups of estimators exhibit high self-control in their work. Figure 7.8 show that the spread of low and high self-control in both groups are almost the same. This is because estimators are expected to keep to the same task until it is completed. They are supposed to analyse all information on the project before making decisions. The ethics of estimating profession requires estimators to have the satisfaction of their customers as their priority. In so doing, estimators are mindful to what the public say about their work. All these are attributes of an estimator whether one is experienced or not experienced. This therefore explained the similarity in the behaviour of the traits in Figure 7.8 for both control group of estimators and the observed group of estimators. The mean for the control group of estimators was 2.24 and that of the observed group of estimators was 2.22. The slight difference is because the control group of estimators are more conscious of the ethics of the profession, which requires customer satisfactions as a priority.

### *7.3.1.2 Comparing Traits of Estimators*

The personality trait of the control and observed estimators were determined from Tables 7.3 and 7.4 respectively. Table 7.3 was derived from Table 7.1 for the control group of estimators whiles Table 7.4 was derived from Table 7.2 for the observed group of estimators. The method used in the derivation is shown for each trait as follows:

**i. Determination of Formula**

***Extraversion (E)***

$E\text{-}I=P_{ei}$

where E is Extraversion, I is Introversion and $P_{ei}$ is the Extraversion personality type

***Neuroticism (N)***

$HN\text{-}LN= P_n$

where HN is High Anxiety, LN is Low Anxiety and $P_n$ is the Neuroticism personality type

***Openness (O)***

$O\text{-}P=P_o$

where O is Openness, P is Pragmatism and $P_o$ is the Openness personality type

***Agreeableness (A)***

$A\text{-}Id=P_A$

where A is Agreeableness, Id is Independence and $P_A$ is the Agreeableness personality type

***Conscientiousness ( C)***

HC-LC= Pc

where HC is High Self-Control, LC is Low Self-Control and $P_C$ is the Conscientiousness personality type

The formulas were used in the computation of the personality traits as shown in Tables 7.3 and 7.4 for the control and observed group of estimators respectively.

**ii. Combined Profile of the Control and Observed Groups.**

Figure 7.9 shows the graphical behaviour of the combined traits in a form of scatter diagram and Table 7.5 shows the means of the traits for the control group of estimators. Similarly, Figure 7.10 and Table 7.6 show the scatter diagram and means respectively of the traits of the observed group of estimators.

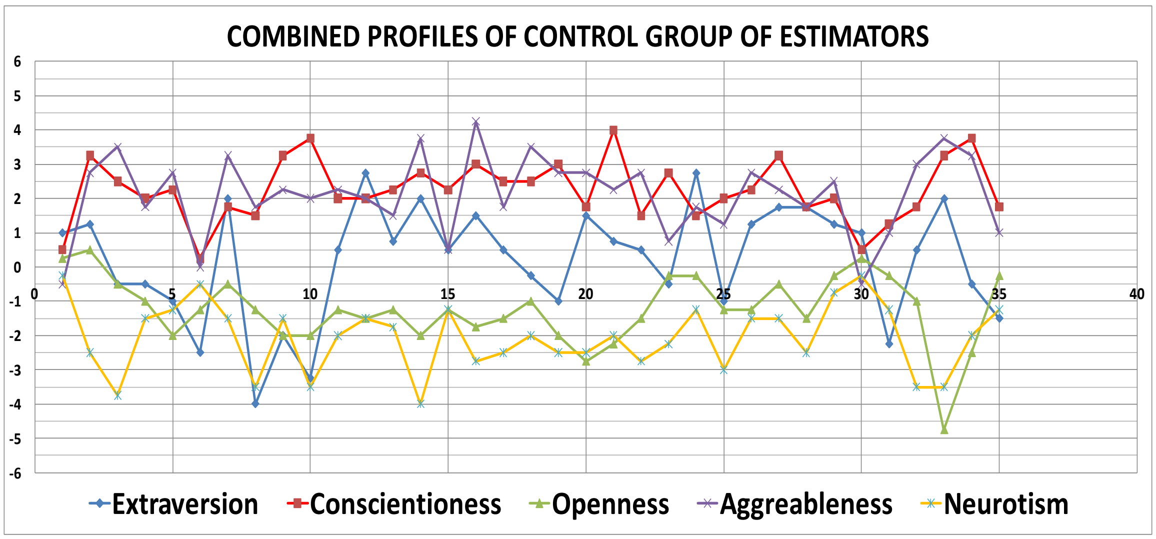



**Figure 7.9: Combined Profiles of Control Group of Estimators**

**Table 7.5: Mean of Control Group**

| No | Trait | Mean |
|---|---|---|
| 1 | Extraversion | 0.2 |
| 2 | Conscientiousness | 2.23571 |
| 3 | Openness | -1.2429 |
| 4 | Agreeableness | 2.11429 |
| 5 | Neuroticism | -2.05 |

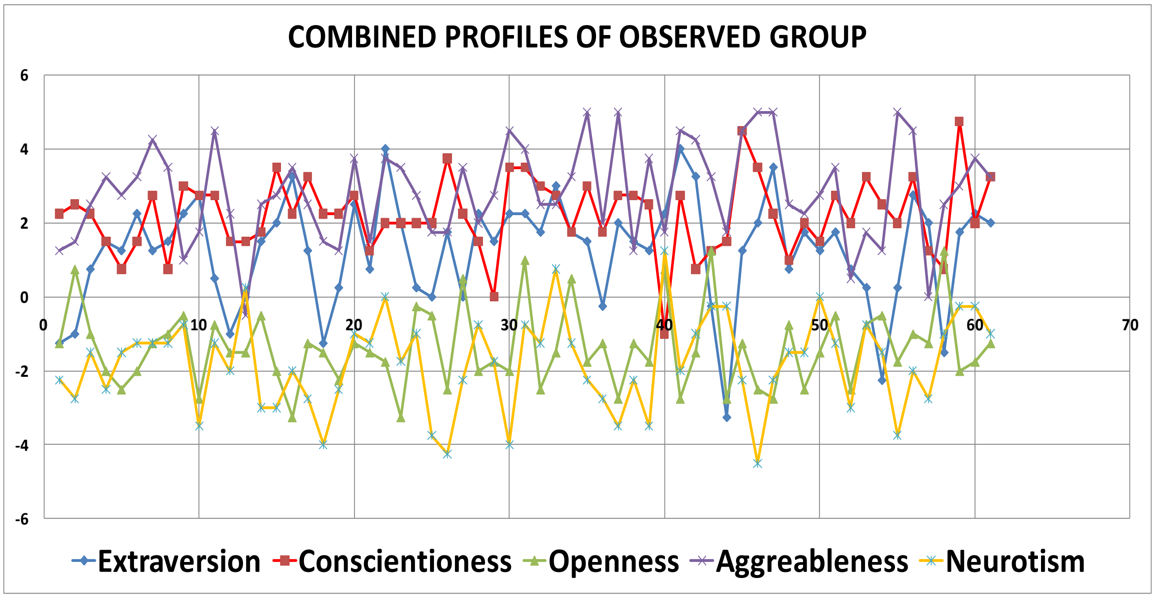



**Figure 7.10: Combined Profiles of Observed Group of Estimators**

The means of the personality traits of the control group is shown in Table 7.6

**Table 7.6: Mean of Observed Group**

| No | Trait | Mean |
|---|---|---|
| 1 | Extraversion | 1.25 |
| 2 | Conscientiousness | 2.221311 |
| 3 | Openness | -1.37295 |
| 4 | Agreeableness | 2.827869 |
| 5 | Neuroticism | -1.78689 |

Each of the traits in the control and observed group of estimators are discussed in the next section.

***Extraversion***

Figure 7.9 and Table 7.5 showed that the control group was extravert. However, the extraversion of the control group was at the lower side with the research personality instrument scale in Figure 7.3. This implies estimators in this group although do consult other estimators and professionals in other fields; the level of consultation is low. This is because of the experienced gained over the years thus, they rely on their thoughts in making some of the decisions. Again, the low extraversion of the estimators in this group is also attributed to their behaviour in terms of negative comments on their work. This group of estimators believe that the experience gained is sufficient for the work hence do sometimes disagree with such negative comments. This is more pronounced in estimating in the field that the estimator has been practicing for considerable number of years. Such an estimator therefore believes in the outcome of the estimate and therefore is unyielding to any other person's suggestions. In general, estimators in the control group do seek other people opinions when estimating but they do this in a milder scale due the experienced they gained over the years.

On the other hand Figure 7.10 and Table 7.6 shows that the observed group of estimators have reasonable extraversion which was on the higher side compared with that of control group. Figures 7.9 and 7.10; and Tables 7.5 and 7.6 explained this assertion. This is because this group of estimators lack experience hence they turn to seek much opinion on their work to be sure they are doing the right thing. Again they also result in discussions on their work with their superior for approval before continuing with the next stage in order to be sure they are on the right path.

These attributes of the control and the observed groups of estimators accounted for the difference in the level of extraversion and also explained why estimators in both groups are extraverts.

***Conscientiousness***

From Figure 7.9, the estimators in the control group are generally high self-control. The mean for the Conscientiousness trait of 2.23571 from Table 7.5 with the personality instrument scale in figure 7.3 was also an indication that estimators in this group are of generally high self-control trait. It should be of interest that Conscientiousness trait in Figure 7.10 for the observed group has also a mean of 2.221311 from Table 7.6 using the research personality instrument scale in Figure 7.3. Equally of great importance is the closeness of the means in both the control and observed groups of estimators for the conscientiousness traits. This is because estimators analyses information critically prior to decision-making. Also the ethics of the estimating profession attaches the importance to customer satisfaction. These are attributes of any estimator. The attribute however are developed as experience is gained. It should however be noted that the development of these attributes are on marginal scale since this is an inherent attribute of all estimators. This therefore accounted for the closeness of the control group and the observed group in the conscientiousness trait, and the marginal difference in the control and observed group of estimators.

It should therefore be noted that the trait conscientiousness do not vary significantly with experience. This is of great interest in understanding which part of estimator attributes that influence reliability of project estimates. It will therefore assist in deciding which of the traits to be given much attention for the desired reliability to be achieved on project estimates.

***Openness***

Figure 7.9 and 7.10 show the scatter diagram of the openness trait for the control and observed group of estimators respectively. Similarly, Tables 7.5 and 7.6 show the means of the control and the observed group of estimators respectively. The Figures in 7.9 and 7.10 show an indication that both groups of estimators are pragmatic in accordance to the research personality instrument scale in Figure 7.3. This is so because as estimators, decisions have to be made in estimating with facts that are justified and proven to be accurate. Again, every organisation has its own procedure in estimating. The closeness of the mean in both group of estimators indicate that both groups follow laid down procedures in estimating. This revelation from Figure 7.9 and 7.10, and also Tables 7.5 and 7.6 substantiate the fact that both group of estimators are drawn from the same population that have the same procedure in estimating. This also concurred with the review of estimating practice in the previous chapters that identified estimating procedures as the same in the source of the data for the research.

The marginal difference in the mean of the control group and that of the observed group is because as experienced estimators, they explore new ways of doing the same task as a form of innovations, which is aim at improving the outcome of their work, thus improving reliability of project estimates. The procedures currently being used were developed by people of the same calibre of experience hence the control group continually try to bring innovations into the estimating through their experience gained over the years. This will have added advantage in that the procedures are not stagnant but changes with the technological advancement and with time.

Therefore, openness trait influences the estimator behaviour in decision making orientations although the level of influence is not as high as that of extraversion, agreeableness, and neuroticism.

***Agreeableness***

From Figure 7.9, the estimators in the control group generally have the agreeableness trait. The mean for the agreeableness trait of 2.11429 from Table 7.5 with the research personality instrument scale in Figure 7.3 is also an indication of general agreeableness in trait for the control group of estimators. The mean on the other hand of the agreeableness trait in Figure 7.10 for the observed group was 2.827869 from Table 7.6 using the personality instrument scale in Figure 7.3.

The difference in both groups of estimators is significant. Firstly, this is an indication that the agreeableness trait is of outmost importance in the achievement of reliable project cost estimates. The significant difference also showed that the observed group of estimators are venerable to tolerate criticism on their work, and most agree with the views that other people express on their work without analysing those views thoroughly.

This trait should be given the needed attention in analysing the influence of traits on the individual estimator's decision-making orientations. The revelation from Figures 7.9 and 7.10 was that there is lack of adequate self-confidence in the observed group when preparing cost estimates on projects. This observation has to be addressed for the reliability desired for. On way of addressing this is through continues interaction of the experienced estimators with the estimators with the characteristics of the observed group in the organisation, and through on-the-job training.

***Neuroticism***

Figure 7.9 show that estimators in the control group generally have low anxiety type of personality trait. The mean for the Neuroticism trait from Table 7.5 with the research personality instrument scale in Figure 7.3 also indicate that the control group of estimators have low anxiety trait. The mean on the other hand of the Neuroticism trait in Figure 7.10 for the observed group was -1.78689 from Table 7.6 using the research personality instrument scale in Figure 7.3. The significant difference between the means of both groups is an indication that neuroticism trait is of outmost importance in addressing the endogenous factors that influence decision-making orientations of estimators thus reliability of project estimates.

Again, the experienced estimators are naturally calm in making decisions due to experienced gained over the years. The calmness becomes greater when the control group of estimators are estimating in the field they have being practicing over the years. On the other hand, the observed group of estimators are cautious in their work hence are not in the position to make fast decisions in such instances. Again, the observed group of estimators make mistakes if working under pressure. This is because they needed adequate time for analysing information before making decisions since in most cases; they have no experience in the area of estimating. Even if they have done some estimating in that area, they do not have sufficient experience that will enable them to make fast decisions. You will recalled from the earlier explanations on some of the traits that the observed group of estimators consult their superiors in most instances when preparing cost estimates on projects.

The neuroticism trait is therefore of outmost importance in understanding the influence of personality traits on the decision making orientations of estimators, and thus on the reliability of project cost estimates.

## Table 7.3: Personality Traits of Control Group of Estimators

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraversion | 1.00 | 1.25 | -0.50 | -0.50 | -1.00 | -2.50 | 2.00 | -4.00 | -2.00 | -3.25 | 0.50 | 2.75 | 0.75 | 2.00 | 0.50 | 1.50 | 0.50 | |
| Conscientiousness | 0.50 | 3.25 | 2.50 | 2.00 | 2.25 | 0.25 | 1.75 | 1.50 | 3.25 | 3.75 | 2.00 | 2.00 | 2.25 | 2.75 | 2.25 | 3.00 | 2.50 | |
| Openness | 0.25 | 0.50 | -0.50 | -1.00 | -2.00 | -1.25 | -0.50 | -1.25 | -2.00 | -2.00 | -1.25 | -1.50 | -1.25 | -2.00 | -1.25 | -1.75 | -1.50 | |
| Agreeableness | -0.50 | 2.75 | 3.50 | 1.75 | 2.75 | 0.00 | 3.25 | 1.75 | 2.25 | 2.00 | 2.25 | 2.00 | 1.50 | 3.75 | 0.50 | 4.25 | 1.75 | |
| Neuroticism | -0.25 | -2.50 | -3.75 | -1.50 | -1.25 | -0.50 | -1.50 | -3.50 | -1.50 | -3.50 | -2.00 | -1.50 | -1.75 | -4.00 | -1.25 | -2.75 | -2.50 | |
| | | | | | | | | | | | | | | | | | | |
| | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| Extraversion | -0.25 | -1.00 | 1.50 | 0.75 | 0.50 | -0.50 | 2.75 | -1.00 | 1.25 | 1.75 | 1.75 | 1.25 | 1.00 | -2.25 | 0.50 | 2.00 | -0.50 | -1.50 |
| Conscientiousness | 2.50 | 3.00 | 1.75 | 4.00 | 1.50 | 2.75 | 1.50 | 2.00 | 2.25 | 3.25 | 1.75 | 2.00 | 0.50 | 1.25 | 1.75 | 3.25 | 3.75 | 1.75 |
| Openness | -1.00 | -2.00 | -2.75 | -2.25 | -1.50 | -0.25 | -0.25 | -1.25 | -1.25 | -0.50 | -1.50 | -0.25 | 0.25 | -0.25 | -1.00 | -4.75 | -2.50 | -0.25 |
| Agreeableness | 3.50 | 2.75 | 2.75 | 2.25 | 2.75 | 0.75 | 1.75 | 1.25 | 2.75 | 2.25 | 1.75 | 2.50 | -0.50 | 1.00 | 3.00 | 3.75 | 3.25 | 1.00 |
| Neuroticism | -2.00 | -2.50 | -2.50 | -2.00 | -2.75 | -2.25 | -1.25 | -3.00 | -1.50 | -1.50 | -2.50 | -0.75 | -0.25 | -1.25 | -3.50 | -3.50 | -2.00 | -1.25 |

## Table 7.4: Personality Traits of Observed Group of Estimators

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Extraversion | -1.25 | -1.00 | 0.75 | 1.50 | 1.25 | 2.25 | 1.25 | 1.50 | 2.25 | 2.75 | 0.50 | -1.00 | 0.00 | 1.50 | 2.00 | 3.25 | 1.25 | -1.25 | 0.25 | 2.50 | |
| Conscientiousness | 2.25 | 2.50 | 2.25 | 1.50 | 0.75 | 1.50 | 2.75 | 0.75 | 3.00 | 2.75 | 2.75 | 1.50 | 1.50 | 1.75 | 3.50 | 2.25 | 3.25 | 2.25 | 2.25 | 2.75 | |
| Openness | -1.25 | 0.75 | -1.00 | -2.00 | -2.50 | -2.00 | -1.25 | -1.00 | -0.50 | -2.75 | -0.75 | -1.50 | -1.50 | -0.50 | -2.00 | -3.25 | -1.25 | -1.50 | -2.25 | -1.25 | |
| Agreeableness | 1.25 | 1.50 | 2.50 | 3.25 | 2.75 | 3.25 | 4.25 | 3.50 | 1.00 | 1.75 | 4.50 | 2.25 | -0.50 | 2.50 | 2.75 | 3.50 | 2.50 | 1.50 | 1.25 | 3.75 | |
| Neuroticism | -2.25 | -2.75 | -1.50 | -2.50 | -1.50 | -1.25 | -1.25 | -1.25 | -0.75 | -3.50 | -1.25 | -2.00 | 0.25 | -3.00 | -3.00 | -2.00 | -2.75 | -4.00 | -2.50 | -1.00 | |
| | | | | | | | | | | | | | | | | | | | | | |
| | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | |
| Extraversion | 0.75 | 4.00 | 2.00 | 0.25 | 0.00 | 1.75 | 0.00 | 2.25 | 1.50 | 2.25 | 2.25 | 1.75 | 3.00 | 1.75 | 1.50 | -0.25 | 2.00 | 1.50 | 1.25 | 2.25 | |
| Conscientiousness | 1.25 | 2.00 | 2.00 | 2.00 | 2.00 | 3.75 | 2.25 | 1.50 | 0.00 | 3.50 | 3.50 | 3.00 | 2.75 | 1.75 | 3.00 | 1.75 | 2.75 | 2.75 | 2.50 | -1.00 | |
| Openness | -1.50 | -1.75 | -3.25 | -0.25 | -0.50 | -2.50 | 0.50 | -2.00 | -1.75 | -2.00 | 1.00 | -2.50 | -1.50 | 0.50 | -1.75 | -1.25 | -2.75 | -1.25 | -1.75 | 0.75 | |
| Agreeableness | 1.50 | 3.75 | 3.50 | 2.75 | 1.75 | 1.75 | 3.50 | 2.00 | 2.75 | 4.50 | 4.00 | 2.50 | 2.50 | 3.25 | 5.00 | 2.00 | 5.00 | 1.25 | 3.75 | 1.75 | |
| Neuroticism | -1.25 | 0.00 | -1.75 | -1.00 | -3.75 | -4.25 | -2.25 | -0.75 | -1.75 | -4.00 | -0.75 | -1.25 | 0.75 | -1.25 | -2.25 | -2.75 | -3.50 | -2.25 | -3.50 | 1.25 | |
| | | | | | | | | | | | | | | | | | | | | | |
| | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 |
| Extraversion | 4.00 | 3.25 | -0.25 | -3.25 | 1.25 | 2.00 | 3.50 | 0.75 | 1.75 | 1.25 | 1.75 | 0.75 | 0.25 | -2.25 | 0.25 | 2.75 | 2.00 | -1.50 | 1.75 | 2.25 | 2.00 |
| Conscientiousness | 2.75 | 0.75 | 1.25 | 1.50 | 4.50 | 3.50 | 2.25 | 1.00 | 2.00 | 1.50 | 2.75 | 2.00 | 3.25 | 2.50 | 2.00 | 3.25 | 1.25 | 0.75 | 4.75 | 2.00 | 3.25 |
| Openness | -2.75 | -1.50 | 1.25 | -2.75 | -1.25 | -2.50 | -2.75 | -0.75 | -2.50 | -1.50 | -0.50 | -2.50 | -0.75 | -0.50 | -1.75 | -1.00 | -1.25 | 1.25 | -2.00 | -1.75 | -1.25 |
| Agreeableness | 4.50 | 4.25 | 3.25 | 1.75 | 4.50 | 5.00 | 5.00 | 2.50 | 2.25 | 2.75 | 3.50 | 0.50 | 1.75 | 1.25 | 5.00 | 4.50 | 0.00 | 2.50 | 3.00 | 3.75 | 3.25 |
| Neuroticism | -2.00 | -1.00 | -0.25 | -0.25 | -2.25 | -4.50 | -2.25 | -1.50 | -1.50 | 0.00 | -1.25 | -3.00 | -0.75 | -1.50 | -3.75 | -2.00 | -2.75 | -1.00 | -0.25 | -0.25 | -1.00 |

Table 7.7 show the qualification and experience of the estimators used in the analyses. Table 7.7 was derived from Appendix B. The meanings of the symbols in Table 7.7 are presented for each variable as follows:

i. **Qualifications:** X=HND or equivalent, Y=BSc. or equivalent and Z=MSc. or equivalent

ii. **Experience:** A=0-2 years, B=3-4 years, C=5-6 years and D=7-10 years

The hypothesis test was conducted to ascertain the influences of qualification and experience on reliability are discussed in the subsequent section.

.

## Table 7.7: Experience and Qualifications (Observed Group of Estimators)

| Estimator | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Qualification** | Y | X | Y | Y | Y | Y | Y | X | Y | Y | Y | Y | Y | Y | Y |
| **Experince** | B | D | B | B | D | C | D | B | A | B | A | C | D | A | B |
| **StdReliability** | -0.0579 | -0.0068 | -0.0014 | -0.0786 | -0.0343 | 0.0074 | -0.0558 | 0.3993 | 0.6524 | 0.1401 | 0.1672 | -0.0641 | -0.0738 | 0.5942 | -0.0443 |

| Estimator | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Qualification** | Y | Y | Y | Y | Z | X | X | Y | Y | X | Y | Y | X | X | Y |
| **Experince** | C | C | C | C | C | D | D | B | D | C | B | C | D | B | C |
| **StdReliability** | 0.1825 | 0.2363 | 0.1653 | 0.1119 | -0.0383 | -0.0821 | -0.0641 | 0.6841 | -0.0733 | 0.2027 | 0.2858 | -0.0405 | 2.0118 | 0.0132 | 0.0693 |

| Estimator | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Qualification** | X | X | Y | Y | Y | Y | Y | Y | Y | X | X | Y | Y | X | Y |
| **Experince** | B | A | B | C | A | D | B | B | B | A | C | B | D | D | C |
| **StdReliability** | 0.3798 | 0.2058 | 0.0503 | -0.1736 | 0.0373 | 0.0479 | 0.5434 | -0.0850 | -0.0551 | -0.8867 | 0.0390 | 0.3092 | -0.4042 | 0.1094 | -0.0509 |

| Estimator | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Qualification** | Y | Y | X | Z | X | Y | Y | Y | Z | Y | Y | Y | Z | Y | X | Y |
| **Experince** | C | A | C | D | C | C | B | C | D | B | B | C | D | D | D | C |
| **StdReliability** | -0.0273 | 0.6201 | -0.1674 | -0.0062 | 0.0367 | -0.0943 | 0.4042 | -0.0229 | -0.2436 | 0.0244 | 0.0418 | 0.2486 | -0.1216 | -0.1026 | -0.0842 | -0.1611 |

**KEY:**

**Qualification:**

X = HND or equivalent

Y = BSc. or equivalent

Z = MSc or equivalent

**Experience:**

A = 0-2 years

B = 3-4 years

C = 5-6 years

D = 7-10 years

## 7.3.2 Analysis of Traits Variables

The research personality instrument traits variables namely Extraversion, Conscientiousness, Openness, Agreeableness and Neuroticism were analysed using Statistical Packaged for Social Sciences (SPSS) from data on the observed group. The analysis was to either reject or not to reject the Null Hypothesis and vice versa for the Alternate Hypothesis. Three types of analysis were performed on three different variables. The variables tested were qualification and experience in Table 7.7, and personality archetype in Table 7.4 with the standardised scores in Appendix F. The statistical technique employed in the analysis was One Way Analyses of Variance (ANOVA).

### *7.3.2.1 Testing of Reliability*

The influence of qualification, experience and personality archetype on reliability was analysed using ANOVA. Each of the analysis is discussed as follows:

***QUALIFICATION***

The test of the influence of qualification on reliability was to provide justifications for the results of the trait influence on reliability. This is because from logical stance, the more qualification the better performance.

The Null Hypothesis tested was "there is no systematic difference in reliability across various qualification variables"

**$H_0$ : Mx = My =Mz** where $H_0$ is the Null Hypothesis, Mx, My, Mz are means of variables X, Y and Z respectively.

The Alternate Hypothesis was "there is systematic difference in reliability across various qualification variables".

**$H_1$: Mx≠ My; Mx≠ Mz; My≠ Mz** where $H_1$ is the Alternate Hypothesis, Mx, My, Mz are means of variables X, Y and Z respectively.

Data in table 7.7 on qualifications of the various estimators and the standardised scores in Appendix F and table 7.7 were used in the analysis. The results of the analysis are presented in the next chapter.

***EXPERIENCE***

The Null Hypothesis tested was "there is no systematic difference in reliability across various experience variables"

**$H_0$ : Ma = Mb =Mc = Md** where $H_0$ is the Null Hypothesis, Ma, Mb, Mc. Md are means of variables A, B, C and D respectively.

The Alternate Hypothesis was "there is systematic difference in reliability across various experience variables".

**$H_1$: Ma≠ Mb; Ma≠ Mc; Ma≠ Md**; **Mb≠ Mc; Mb≠ Md; Mc≠ Md** where $H_1$ is the Alternate Hypothesis, Ma, Mb, Mc and Md are means of variables A, B, C and D respectively.

Data in table 7.7 on experience of the various estimators and the standardised scores in Appendix F and table 7.7 were used in the analysis. The results of the analysis are presented in the next chapter.

***PERSONALITY ARCHETYPE***

The Null Hypothesis tested was "there is no systematic difference in reliability across various traits variables"

**$H_0$ : Me = Mc =Mo = Ma = Mn** where $H_0$ is Null Hypothesis, Me, Mc, Mo. Ma, Mn are means of variables Extraversion, Conscientiousness, Openness, Agreeableness and Neuroticism respectively. If there is equality of means, then analysis of variance should prove that the means are equal.

The Alternate Hypothesis was "there is systematic difference in reliability across various traits variables".

**$H_1$: Me≠ Mc; Me≠ Mo; Me≠ Ma**; **Me≠ Mn; Mc≠ Mo; Mc≠ Ma; Mc≠ Mn**; **Mo≠ Ma; Mo≠ Mn; Ma≠ Mn** where $H_1$ is the Alternate Hypothesis, Me, Mc, Mo. Ma, Mn are means of variables Extraversion, Conscientiousness, Openness, Agreeableness and Neuroticism respectively.

Data in personality archetype in table 7.4 and standardised scores in Appendix F were used in the analysis. The results of the analyses are presented in the next chapter.

### *7.3.2.2 Bivariate Analysis*

Bivariate analysis was performed on the variables to determine if there is a relationship between the various variables. The various traits were analysed and the results from the analysis are presented in Appendix G. Table 7.8 represents the summary of Pearson's Correlation Coefficient derived from Appendix G demonstrating that the various traits are not collinear.

**Table 7.8: Table of Pearson's Correlation Coefficient**

| | **E** | **C** | **O** | **A** | **N** |
|---|---|---|---|---|---|
| **E** | | 0.165 | -0.332 | 0.435 | 0.072 |
| **C** | 0.165 | | -0.192 | 0.263 | -0.317 |
| **O** | -0.332 | -0.192 | | -0.120 | 0.300 |
| **A** | 0.435 | 0.263 | -0.120 | | -0.112 |
| **N** | 0.072 | -0.317 | 0.300 | -0.112 | |

From Table 7.8, the correlation coefficients for the various variables were low. These low figures are indication that all the variables are not collinear. Hence, the traits cannot be compared with each other. The study was to compare the reliability with the control group. Hence the change in the means of each trait with that of the control group was analysed to ascertain the trait that have the most significant difference between the observed and control groups. The means of the various traits for control group was derived from Table 7.5 and that of the observed group was derived from Table 7.6. Tables 7.9 shows the means derived for both groups.

**Table 7.9: Means of Variables**

| **Variable** | **Mean of Control** | **Mean of Observed** | **% Change** | **Rank** |
|---|---|---|---|---|
| Extraversion | 0.2000 | 1.2500 | 525.0000 | 1 |
| Concientiousness | 2.2357 | 2.2213 | -0.6442 | 5 |
| Openness | -1.2429 | -1.3730 | 10.4673 | 4 |
| Agreeableness | 2.1143 | 2.8279 | 33.7506 | 2 |
| Neuroticism | -2.0500 | -1.7869 | -12.8349 | 3 |

The traits of the observed group were compared with the control group for the transition test. The control group are the experienced estimators and the reliability of the estimates of the observed group is compared with that of the control group. The percentage changes in table 7.9 therefore indicate the traits that have significant change in transition from observed to control group of estimators. In other words, the changes indicate transition of trait from inexperienced to experienced estimators.

### *7.3.2.3 Trait Classification of Observed Group*

The trait classification of the observed group was derived from Table 7.4. Table 7.10 show the trait classification of the observed group. From Table 7.10 thirty-two estimators in the observed group were classified to have Agreeableness traits, nine as Conscientiousness, five as Extraversion, thirteen as Neuroticism and two as Openness traits.

The estimators in the observed group prepared project estimates on a proposed project. The project was to compute the cost of concrete speed ramp across a highway. The parameters on the speed ramp and all information including the cost of the resources were given to the estimators. The contingency to be allowed and some other assumptions were not given. The objective was to ascertain the variability in the project estimate as the result of the influence of the endogenous factors that relate to the decision-making orientations of the individual estimators. The data on the project cost estimates prepared are presented in Appendix E and Table 7.11. The raw data on the cost estimates were standardised for analysis purposes to z-scores. Appendix F and Table 7.11 show the standardised scores. Figure 7.11 show the graphical presentations of the standardised z-scores.

Analysis of Variance (ANOVA) was performed using the standardised scores in Table 7.11 and trait classification in Table 7.10. The results are presented in the next chapter.

**Table 7.10: Trait Classification of Observed Group**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Estimator** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Trait** | N | N | A | A | A | A | A | A | E | N |
| **Estimator** | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **Trait** | A | A | O | N | C | A | C | N | N | A |
| **Estimator** | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| **Trait** | A | A | A | A | N | N | A | E | A | N |
| **Estimator** | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| **Trait** | C | C | E | A | C | N | N | C | A | E |
| **Estimator** | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| **Trait** | A | A | A | E | A | A | A | A | O | A |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Estimator** | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 |
| **Trait** | A | N | C | C | A | A | N | A | C | A | A |

**KEY:**

**E** = Extraversion
**O** = Openness
**N** = Neuroticism
**C** = Conscientiousness
**A** = Agreeableness

**Table 7.11: Cost Estimates and Standardised Scores**

| Estimator | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cost Estimate | 339.16 | 357.55 | 359.48 | 331.69 | 347.67 | 362.66 | 339.91 | 503.75 | 594.88 | 410.44 | |
| Variance | -20.84 | -2.45 | -0.52 | -28.31 | -12.33 | 2.66 | -20.09 | 143.75 | 234.88 | 50.44 | |
| Z-Score | -0.0579 | -0.0068 | -0.0014 | -0.0786 | -0.0343 | 0.0074 | -0.0558 | 0.3993 | 0.6524 | 0.1401 | |
| Estimator | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
| Cost Estimate | 420.20 | 336.91 | 333.42 | 573.91 | 344.04 | 425.71 | 445.08 | 419.49 | 400.28 | 346.22 | |
| Variance | 60.2 | -23.09 | -26.58 | 213.91 | -15.96 | 65.71 | 85.08 | 59.49 | 40.28 | -13.78 | |
| Z-Score | 0.1672 | -0.0641 | -0.0738 | 0.5942 | -0.0443 | 0.1825 | 0.2363 | 0.1653 | 0.1119 | -0.0383 | |
| Estimator | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | |
| Cost Estimate | 330.44 | 336.92 | 606.28 | 333.63 | 432.96 | 462.89 | 345.43 | 1,084.26 | 364.75 | 384.94 | |
| Variance | -29.56 | -23.08 | 246.28 | -26.37 | 72.96 | 102.89 | -14.57 | 724.26 | 4.75 | 24.94 | |
| Z-Score | -0.0821 | -0.0641 | 0.6841 | -0.0733 | 0.2027 | 0.2858 | -0.0405 | 2.0118 | 0.0132 | 0.0693 | |
| Estimator | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | |
| Cost Estimate | 496.71 | 434.08 | 378.10 | 297.50 | 373.43 | 377.24 | 555.61 | 329.40 | 340.15 | 40.79 | |
| Variance | 136.71 | 74.08 | 18.1 | -62.5 | 13.43 | 17.24 | 195.61 | -30.6 | -19.85 | -319.21 | |
| Z-Score | 0.3798 | 0.2058 | 0.0503 | -0.1736 | 0.0373 | 0.0479 | 0.5434 | -0.0850 | -0.0551 | -0.8867 | |
| Estimator | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | |
| Cost Estimate | 374.05 | 471.30 | 214.48 | 399.40 | 341.69 | 350.16 | 583.22 | 299.74 | 357.78 | 373.22 | |
| Variance | 14.05 | 111.3 | -145.52 | 39.4 | -18.31 | -9.84 | 223.22 | -60.26 | -2.22 | 13.22 | |
| Z-Score | 0.0390 | 0.3092 | -0.4042 | 0.1094 | -0.0509 | -0.0273 | 0.6201 | -0.1674 | -0.0062 | 0.0367 | |
| Estimator | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 |
| Cost Estimate | 326.06 | 505.50 | 351.76 | 272.32 | 368.78 | 375.05 | 449.49 | 316.21 | 323.07 | 329.67 | 302.00 |
| Variance | -33.94 | 145.5 | -8.24 | -87.68 | 8.78 | 15.05 | 89.49 | -43.79 | -36.93 | -30.33 | -58 |
| Z-Score | -0.0943 | 0.4042 | -0.0229 | -0.2436 | 0.0244 | 0.0418 | 0.2486 | -0.1216 | -0.1026 | -0.0842 | -0.1611 |

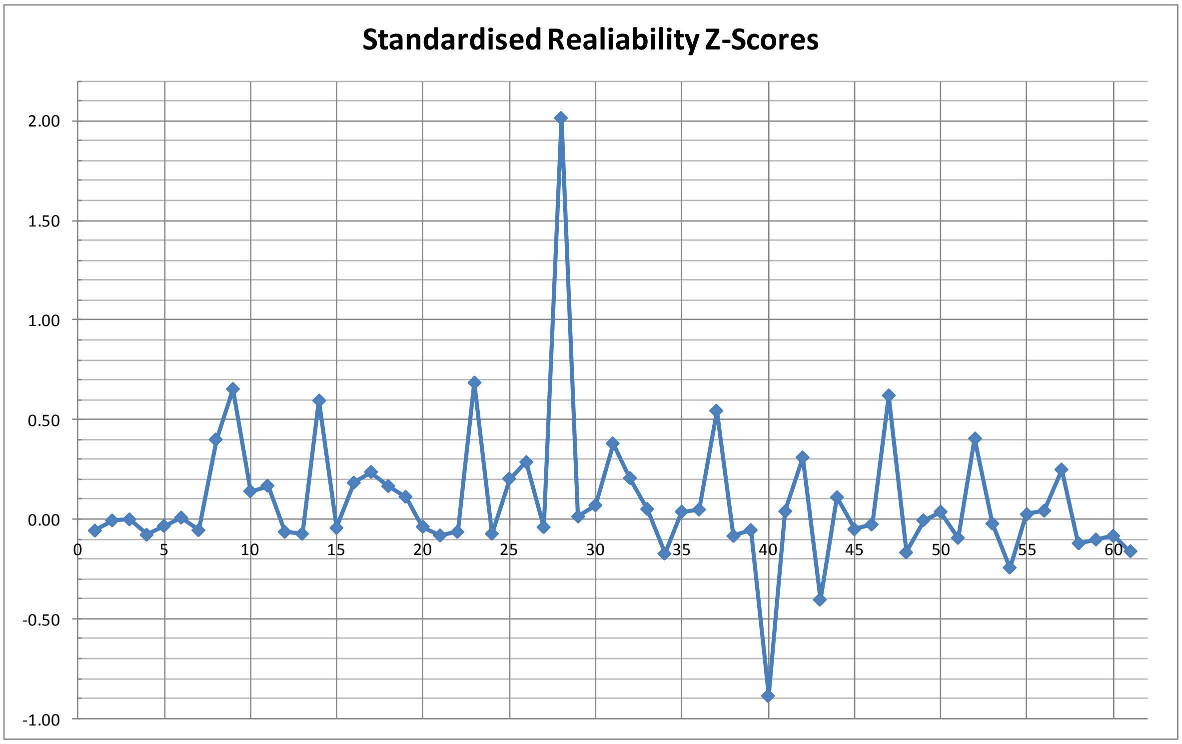



**Figure 7.11: Graphical Presentation of Standardised Z-Scores of Estimates**

Figure 7.11 show the boundaries of reliability due to trait influence in decision making orientations of individual estimators. Different targeted training programs for each of the boundaries will bring the estimates close to zero on the graph, the desired reliability.

## 7.4 SUMMARY

The chapter has addressed the data elicitation for the study. The risks associated with questionnaire design were discussed and appropriate mitigations measures were put in place in the design of the questionnaire. The chapter discussed stratified sampling followed by systematic sampling as the methods used in sampling for the respondents for the study. The risks identified and the mitigations measures employed in the sampling were discussed in the chapter. Two samples namely control group and the observed group of estimators were discussed in the chapter.

The chapter discussed the workshops held for the elicitation of data for the study. Risks identified in the organisation of the workshop were addressed in the chapter. Two sets of data were collected. The chapter discussed the personality data and the cost estimates data. The chapter presented the characteristics of the data collected from the workshops in a form of tabulations and graphical presentations. The chapter discussed how the observed group of estimators were classified for their personality traits. Correlation of the variables was determined and it was established from the low person's correlation coefficients that the various traits are not collinear.

The chapter discussed transition in each trait from inexperienced to experienced estimators and revealed that Extraversion trait showed highest change and conscientiousness the least.

The chapter presented the Null and Alternate hypotheses tested for the three types of variables namely qualification, experience and personality archetype with standardised scores of estimates. The results of the analyses are presented in the next chapter.

# CHAPTER EIGHT

# RESULTS AND ANALYSES

## 8.0 OVERVIEW

The chapter presents the statistical analysis of personality profiles as they relate to the hypothesis that various traits correlate with each other. The chapter commences by presenting the summaries statistics for each of the variables for the research. The results for the summary statistics were generated using frequencies. The statistical results showed that all the variables for both the control and observed groups suggest normality. The chapter presents the results from Bivariate analysis on the variables and established that the variables are not collinear. The results from the analyses of qualification on reliability, experience on reliability and personality archetype on reliability are presented in this chapter.

## 8.1 SUMMARY STATISTICS OF VARIABLES

The frequency procedure was used to obtain the summary of individual variables. The summaries were generated using SPSS. The results for the control and observed groups are presented in the subsequent sections.

### 8.1.1 Summary Statistics for Control Group

The variables from the control group include Extraversion, Conscientiousness, Openness, Agreeableness and Neuroticism. The summary of statistics of theses variable are presented in Tables 8.1 to 8.5 and the histogram of the distributions are presented in Figures 8.1 to 8.5.

#### *8.1.1.1 Extraversion*

The closeness of the mean and median suggests that the distribution is symmetrical. The skewness and kurtosis were low thus bringing the distribution closer to normality. The -0.712 skewness suggest that extraversion was slightly sifted to the left of the centre of the symmetry and the data was slightly more at the left side. However, the movement was not significant and the extraversion variable was therefore assumed to have the properties of normality.

The histogram in Figure 8.1 and Table 8.1 presents the visual summary of the distribution of the extraversion and the summary statistics of the variable respectively, for the control group.

**Table 8.1: Statistics for Extraversion variable for Control Group**

**Statistics**

Extraversion

| | | |
|---|---|---|
| N | Valid | 35 |
| | Missing | 0 |
| Mean | | .2000 |
| Median | | .5000 |
| Mode | | .50 |
| Std. Deviation | | 1.65920 |
| Skewness | | -.712 |
| Std. Error of Skewness | | .398 |
| Kurtosis | | .045 |
| Std. Error of Kurtosis | | .778 |
| Minimum | | -4.00 |
| Maximum | | 2.75 |
| Percentiles | 25 | -1.0000 |
| | 50 | .5000 |
| | 75 | 1.5000 |

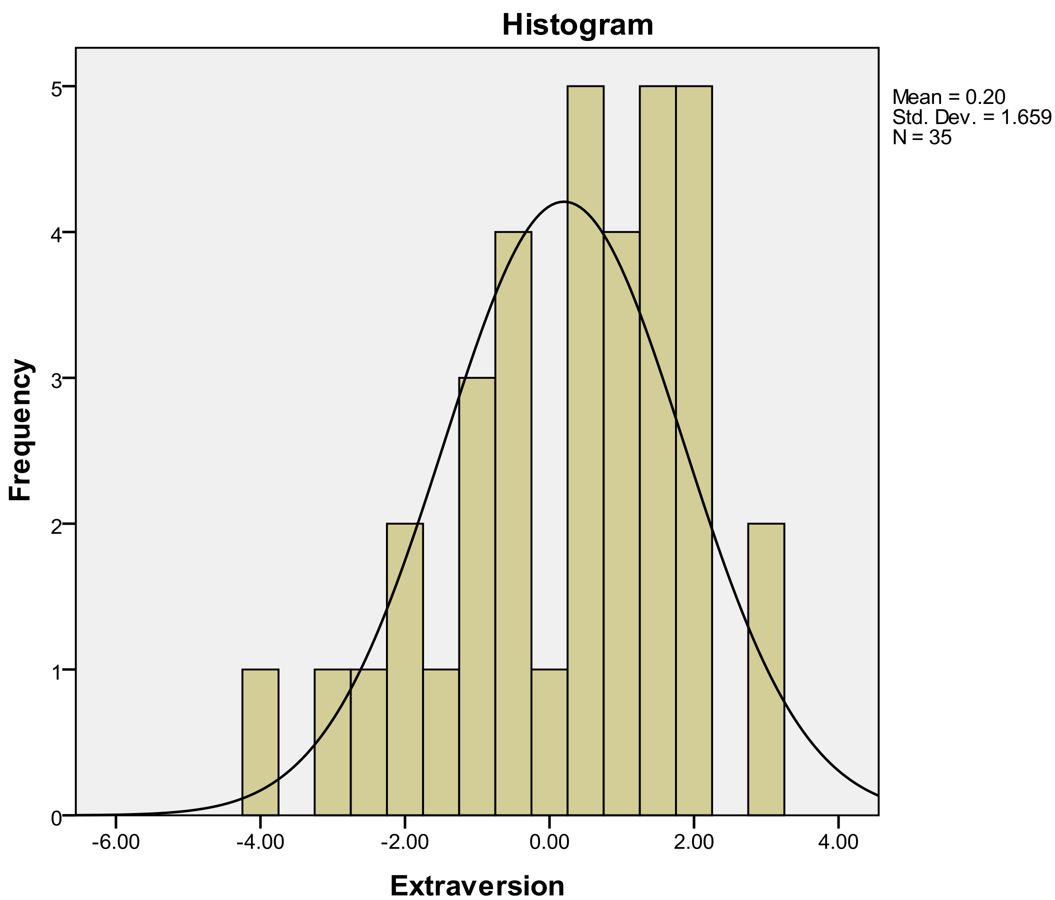



**Figure 8.1: Histogram of Extraversion Distribution for Control Group**

## *8.1.1.2. Conscientiousness*

From Table 8.2 the mean was 2.2357 and the median was 2.25. This showed that the mean and the median were very close. The variable distribution therefore suggests normality. The skewness of –0.137 and kurtosis of -0.064 showed a strong evidence that the distribution of conscientiousness variable for the control group indicate normality. The negative values of the skewness and kurtosis only indicate that the skewness was to the left side from the median. The mean was at the left side of the median, which is an indication that the variable distribution was towards the right. However, the closeness of the mean to the median showed that the deviation was not significant. Therefore the conscientiousness variable was considered to exhibit normal distribution.

The histogram in Figure 8.2 and Table 8.2 presents the visual summary of the distribution of the conscientiousness and the summary statistics of variable respectively, for the control group.

**Table 8.2: Statistics for Conscientiousness variable for Control Group**

**Statistics**

Conscientioness

| | | |
|---|---|---|
| N | Valid | 35 |
| | Missing | 0 |
| Mean | | 2.2357 |
| Median | | 2.2500 |
| Mode | | 1.75[a] |
| Std. Deviation | | .90331 |
| Skewness | | -.137 |
| Std. Error of Skewness | | .398 |
| Kurtosis | | -.064 |
| Std. Error of Kurtosis | | .778 |
| Minimum | | .25 |
| Maximum | | 4.00 |
| Percentiles | 25 | 1.7500 |
| | 50 | 2.2500 |
| | 75 | 3.0000 |

a. Multiple modes exist. The smallest value is shown

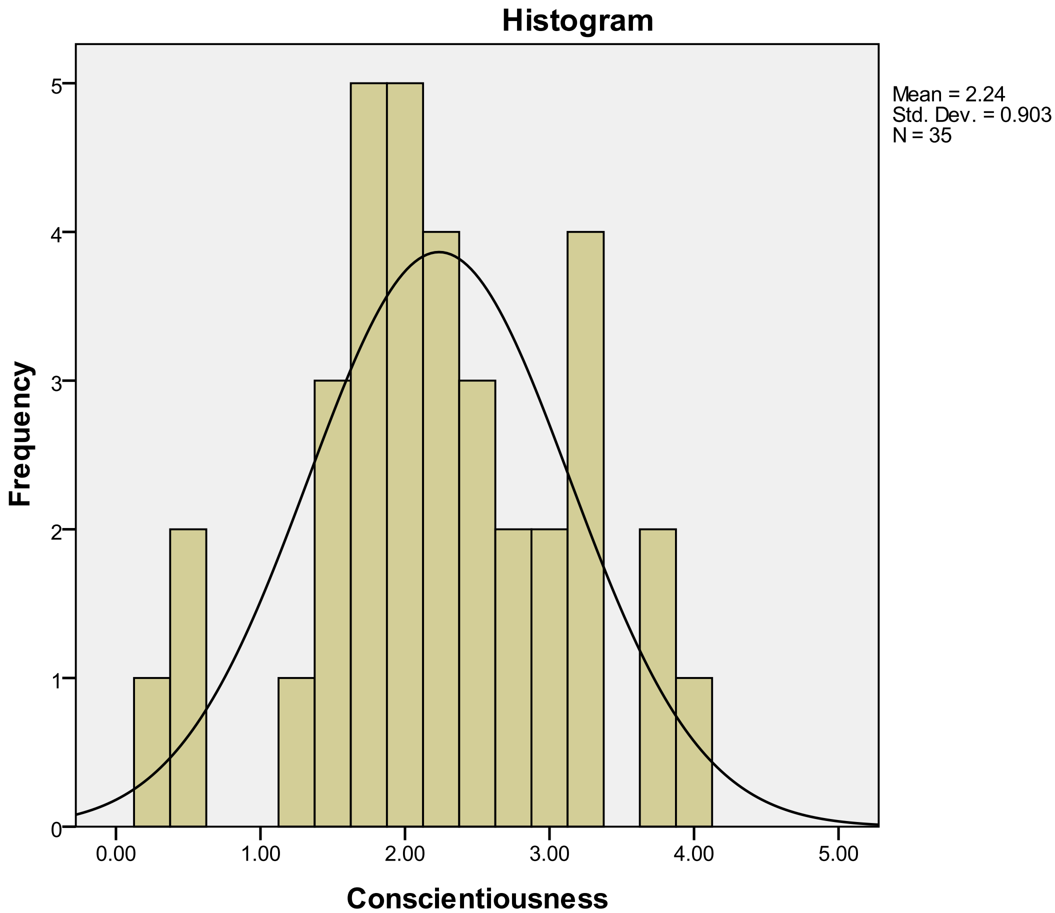



**Figure 8.2: Histogram of Conscientiousness Distribution for Control Group**

### *8.1.1.3 Openness*

From Table 8.3 the mean and median were very close. This is an indication that the distribution suggests normality. The negative value of both the mean and the median indicate that the variable distribution was towards the left. This was also confirmed by the skewness value of -1.018. The kurtosis in this case was slightly high but not significant. The mean in this variable was at the right side of the median, which was another confirmation that the distribution of the variable was towards the left. However, the closeness of the mean to the median showed a strong indication of the normality of the distribution. Therefore the openness variable was considered to exhibit normal distribution.

The histogram in Figure 8.3 and Table 8.3 presents the visual summary of the distribution of the openness and the summary statistics of variable respectively, for the control group.

**Table 8.3: Statistics for Openness variable for Control Group**

**Statistics**

Openness

| | | |
|---|---|---|
| N | Valid | 35 |
| | Missing | 0 |
| Mean | | -1.2429 |
| Median | | -1.2500 |
| Mode | | -1.25 |
| Std. Deviation | | 1.01185 |
| Skewness | | -1.018 |
| Std. Error of Skewness | | .398 |
| Kurtosis | | 2.964 |
| Std. Error of Kurtosis | | .778 |
| Minimum | | -4.75 |
| Maximum | | .50 |
| Percentiles | 25 | -2.0000 |
| | 50 | -1.2500 |
| | 75 | -.5000 |

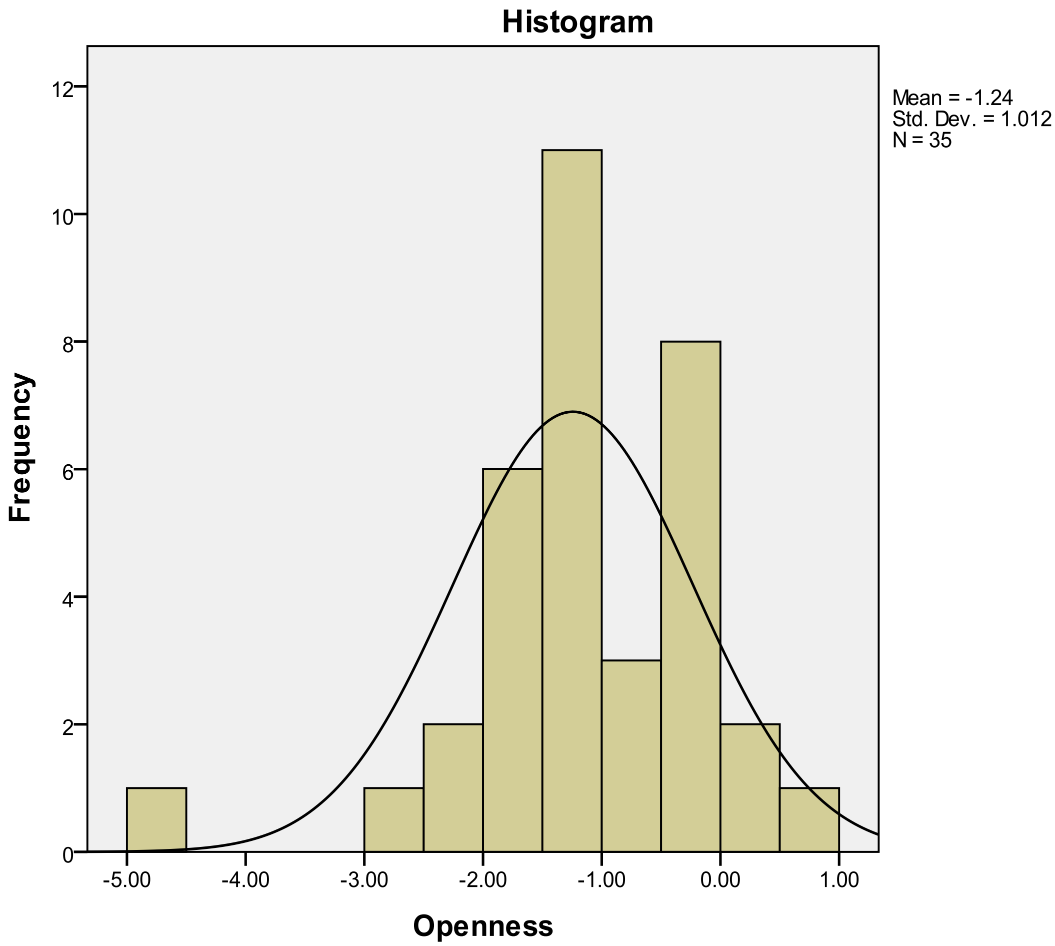



**Figure 8.3: Histogram of Openness Distribution for Control Group**

### *8.1.1.4 Agreeableness*

The mean and median of 2.114 and 2.5 respectively from Table 8.4 showed an indication of normality of the distribution. The distribution skewed very slightly to the left as indicated by the skewness of -0.519. The kurtosis of -0.025 which was almost zero confirmed that the distribution was symmetry. Again, the mean was towards the left side of the median which was also a confirmation that the variable was distributed to the left. However, the closeness of the mean and median together with the low values of the skewness and the kurtosis showed reasonable evidence that the distribution of Agreeableness variable for the control group indicate normality. Therefore, the agreeableness variable was considered to exhibit normal distribution.

The histogram in Figure 8.4 and Table 8.4 presents the visual summary of the distribution of the Agreeableness and the summary statistics of variable respectively, for the control group.

**Table 8.4: Statistics for Agreeableness variable for Control Group**

**Statistics**

Aggreableness

| | | |
|---|---|---|
| N | Valid | 35 |
| | Missing | 0 |
| Mean | | 2.1143 |
| Median | | 2.2500 |
| Mode | | 2.75 |
| Std. Deviation | | 1.17157 |
| Skewness | | -.519 |
| Std. Error of Skewness | | .398 |
| Kurtosis | | -.025 |
| Std. Error of Kurtosis | | .778 |
| Minimum | | -.50 |
| Maximum | | 4.25 |
| Percentiles | 25 | 1.5000 |
| | 50 | 2.2500 |
| | 75 | 2.7500 |

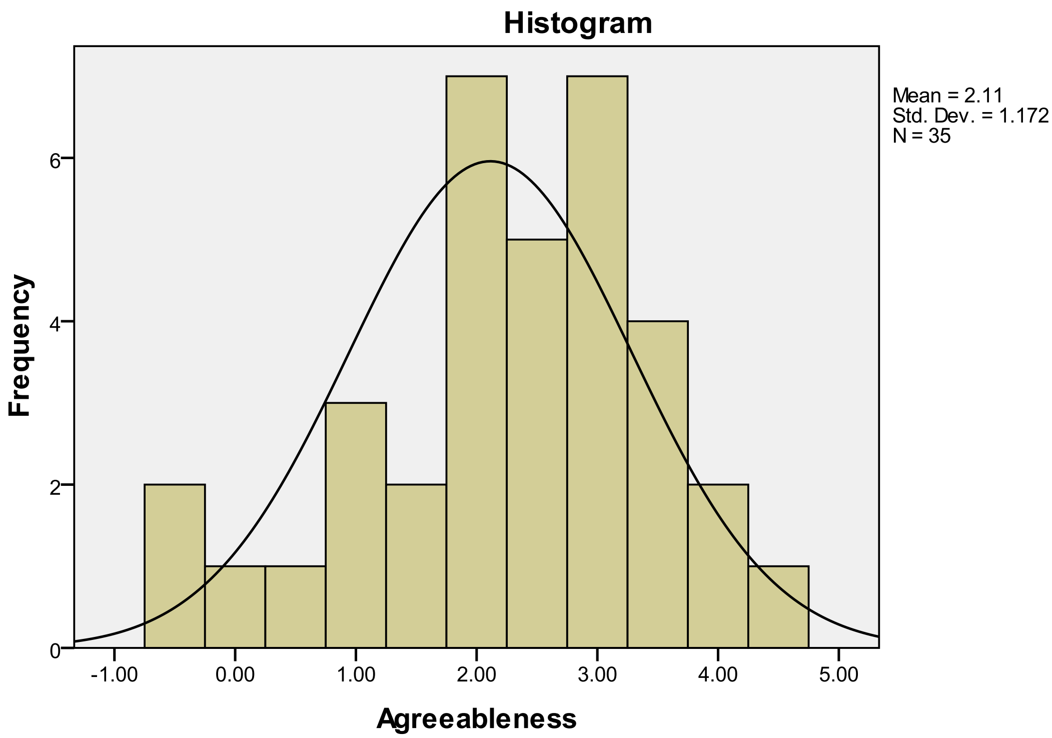



**Figure 8.4: Histogram of Openness Distribution for Control Group**

### *8.1.1.5 Neuroticism*

From Table 8.5, the closeness of the mean and median suggests that the distribution was symmetrical. The skewness and kurtosis were low thus bringing the distribution closer to normality. The negative value of skewness suggests that neuroticism has a slight shift to the left of the centre of the symmetry and the data was slightly more distributed to the left of the mean. However, the shift was not very significant and the neuroticism variable was therefore, assumed to have the properties of normality.

The histogram in Figure 8.5 and Table 8.5 presents the visual summary of the distribution of the neuroticism and the summary statistics of variable respectively, for the control group.

**Table 8.5: Statistics for Neuroticism variable for Control Group**

**Statistics**

Neurotism

| | | |
|---|---|---|
| N | Valid | 35 |
| | Missing | 0 |
| Mean | | -2.0500 |
| Median | | -2.0000 |
| Mode | | -1.50 |
| Std. Deviation | | .99595 |
| Skewness | | -.169 |
| Std. Error of Skewness | | .398 |
| Kurtosis | | -.637 |
| Std. Error of Kurtosis | | .778 |
| Minimum | | -4.00 |
| Maximum | | -.25 |
| Percentiles | 25 | -2.7500 |
| | 50 | -2.0000 |
| | 75 | -1.2500 |

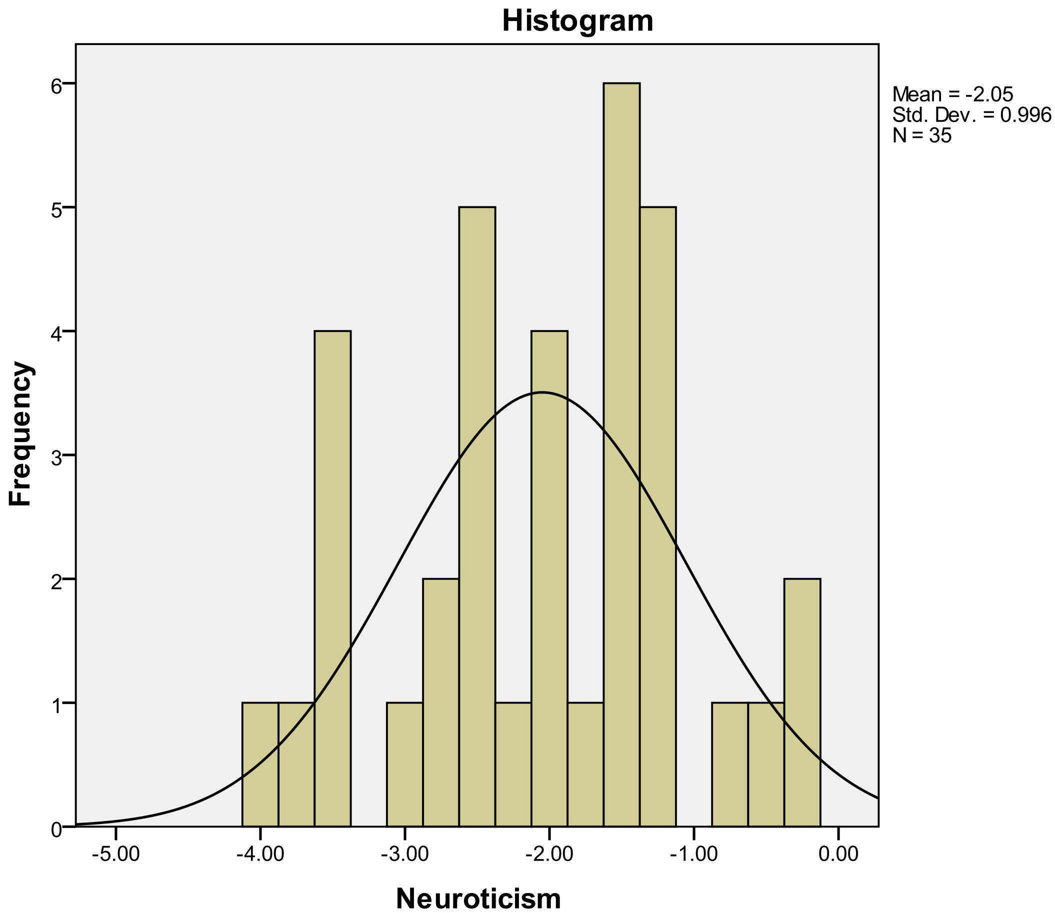



**Figure 8.5: Histogram of Neuroticism Distribution for Control Group**

## 8.1.2 Summary Statistics of Observed Group

The variables from the observed group were Extraversion, Conscientiousness, Openness, Agreeableness and Neuroticism. The summary of statistics of theses variable are presented in Tables 8.6 to 8.10 and the histogram of the distributions are presented in Figures 8.6 to 8.10. The subsequent section discussed the behaviour of each of the variables

### *8.1.2.1 Extraversion*

From Table 8.6, the mean and the median and were reasonably close and this suggests that the distribution is symmetrical. The values of the skewness and kurtosis were low thus bringing the distribution closer to normality. The negative value of the skewness suggests that the variable was slightly shifted to the left of the centre of the symmetry and the data was slightly more at the left side. However, the shift was not significant and the extraversion variable was therefore, assumed to have the properties of normality. The histogram in figure 8.6 and table 8.6 presents the visual summary of the distribution of the extraversion and the summary statistics of variable respectively, for the observed group.

**Table 8.6: Statistics for Extraversion variable for Observed Group**

**Statistics**

Extraversion

| | | |
|---|---|---|
| N | Valid | 61 |
| | Missing | 0 |
| Mean | | 1.2500 |
| Median | | 1.5000 |
| Mode | | 2.25 |
| Std. Deviation | | 1.45488 |
| Skewness | | -.744 |
| Std. Error of Skewness | | .306 |
| Kurtosis | | .840 |
| Std. Error of Kurtosis | | .604 |
| Minimum | | -3.25 |
| Maximum | | 4.00 |
| Percentiles | 25 | .2500 |
| | 50 | 1.5000 |
| | 75 | 2.2500 |

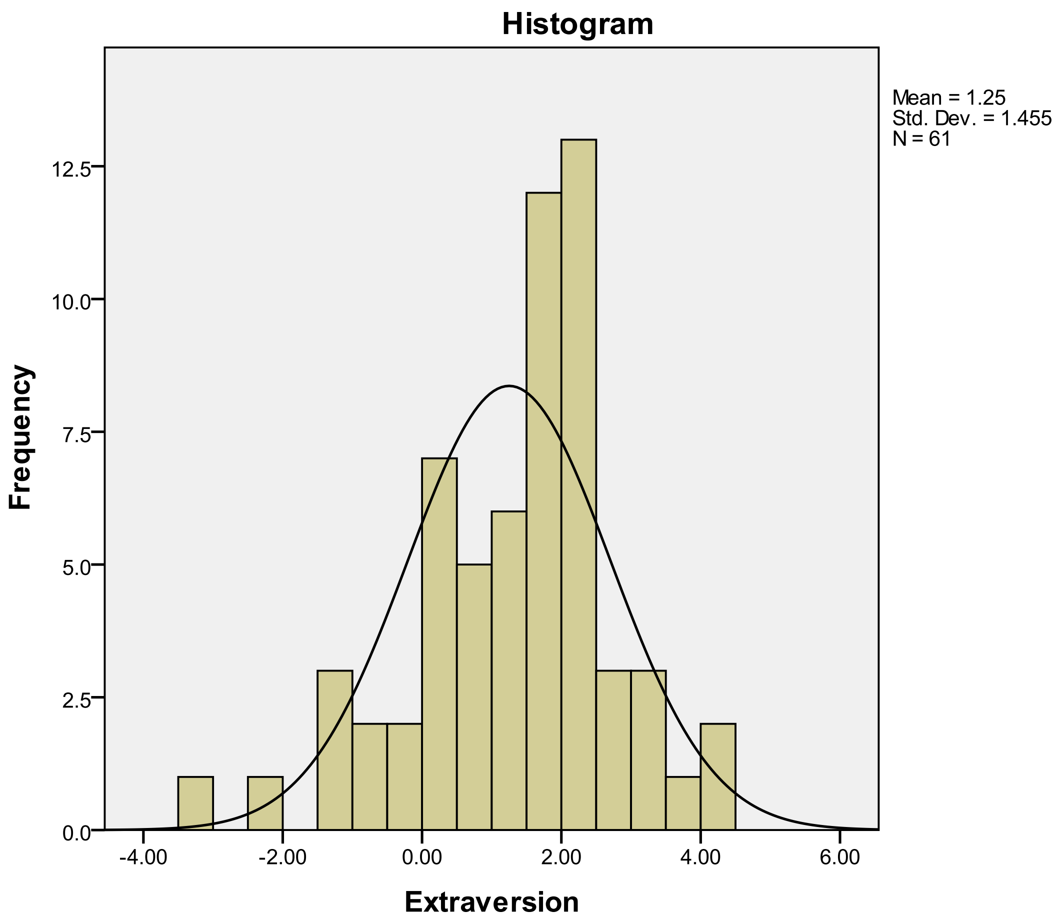



**Figure 8.6: Histogram of Extraversion Distribution for Observed Group**

## *8.1.2.2 Conscientiousness*

The closeness of the mean and the median from Table 8.7 suggest that the distribution was symmetrical. The values of the skewness and kurtosis were low thus bringing the distribution closer to normality. The negative value of the skewness suggests that the variable was slightly shifted to the left of the centre of the symmetry and the data was slightly more at the left side of the symmetry. However, the drift was not significant and the conscientiousness variable was therefore, assumed to have the properties of normality.

The histogram in Figure 8.7 and Table 8.7 presents the visual summary of the distribution of the conscientiousness and the summary statistics of variable respectively, for the observed group.

**Table 8.7: Statistics for conscientiousness variable for Observed Group**

**Statistics**

Conscientioness

| | | |
|---|---|---|
| N | Valid | 61 |
| | Missing | 0 |
| Mean | | 2.2213 |
| Median | | 2.2500 |
| Mode | | 2.75 |
| Std. Deviation | | 1.01868 |
| Skewness | | -.287 |
| Std. Error of Skewness | | .306 |
| Kurtosis | | 1.087 |
| Std. Error of Kurtosis | | .604 |
| Minimum | | -1.00 |
| Maximum | | 4.75 |
| Percentiles | 25 | 1.5000 |
| | 50 | 2.2500 |
| | 75 | 2.7500 |

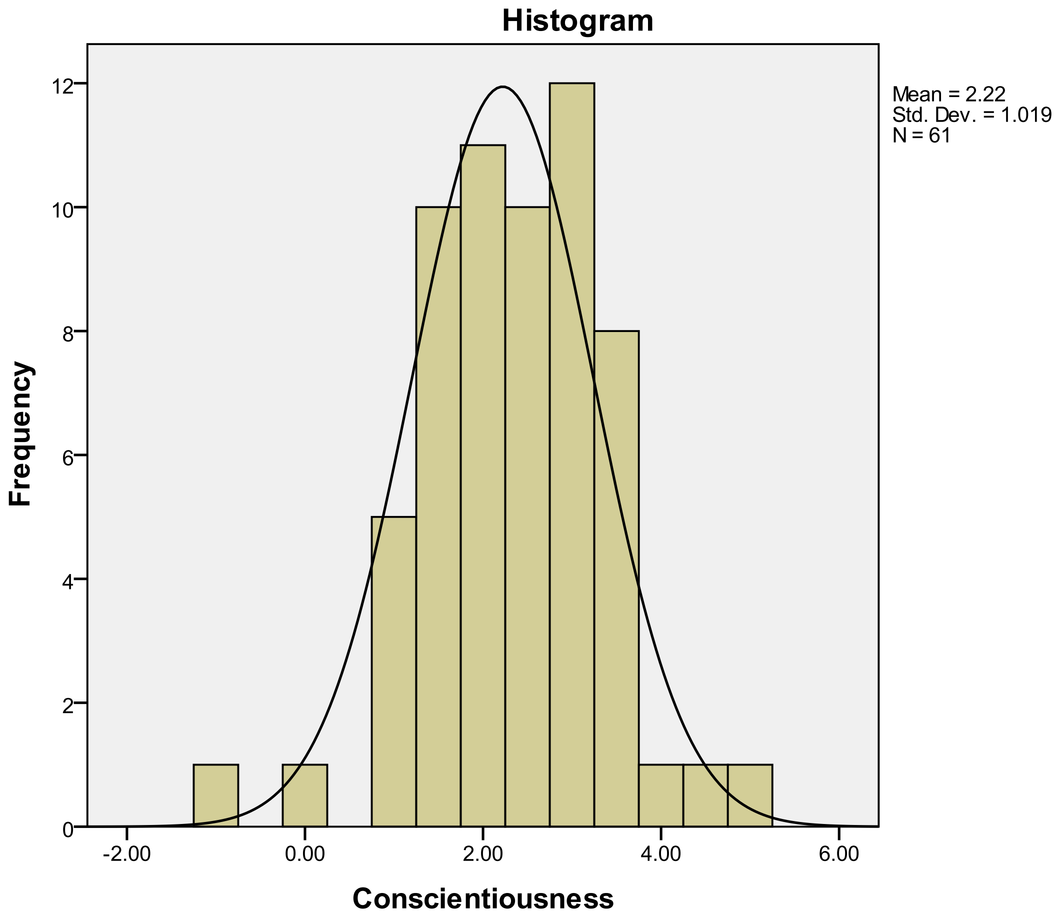



**Figure 8.7: Histogram of Conscientiousness Distribution (Observed Group)**

### *8.1.2.3 Openness*

The closeness of the mean and the median from Table 8.8 suggest that the distribution was symmetrical. The negative values was an indication that the variable was slightly sifted to the left of the centre of the symmetry and the data was slightly more at the left side The values of the skewness and kurtosis were low thus bringing the distribution closer to normality. However, this was considered as not significant and therefore Openness variable was assumed to have the properties of normality.

The histogram in Figure 8.8 and Table 8.8 presents the visual summary of the distribution of the Openness and the summary statistics of variable respectively, for the observed group.

**Table 8.8: Statistics for Openness variable for Observed Group**

**Statistics**

Openness

| | | |
|---|---|---|
| N | Valid | 61 |
| | Missing | 0 |
| Mean | | -1.3730 |
| Median | | -1.5000 |
| Mode | | -1.25 |
| Std. Deviation | | 1.08361 |
| Skewness | | .677 |
| Std. Error of Skewness | | .306 |
| Kurtosis | | .194 |
| Std. Error of Kurtosis | | .604 |
| Minimum | | -3.25 |
| Maximum | | 1.25 |
| Percentiles | 25 | -2.0000 |
| | 50 | -1.5000 |
| | 75 | -.7500 |

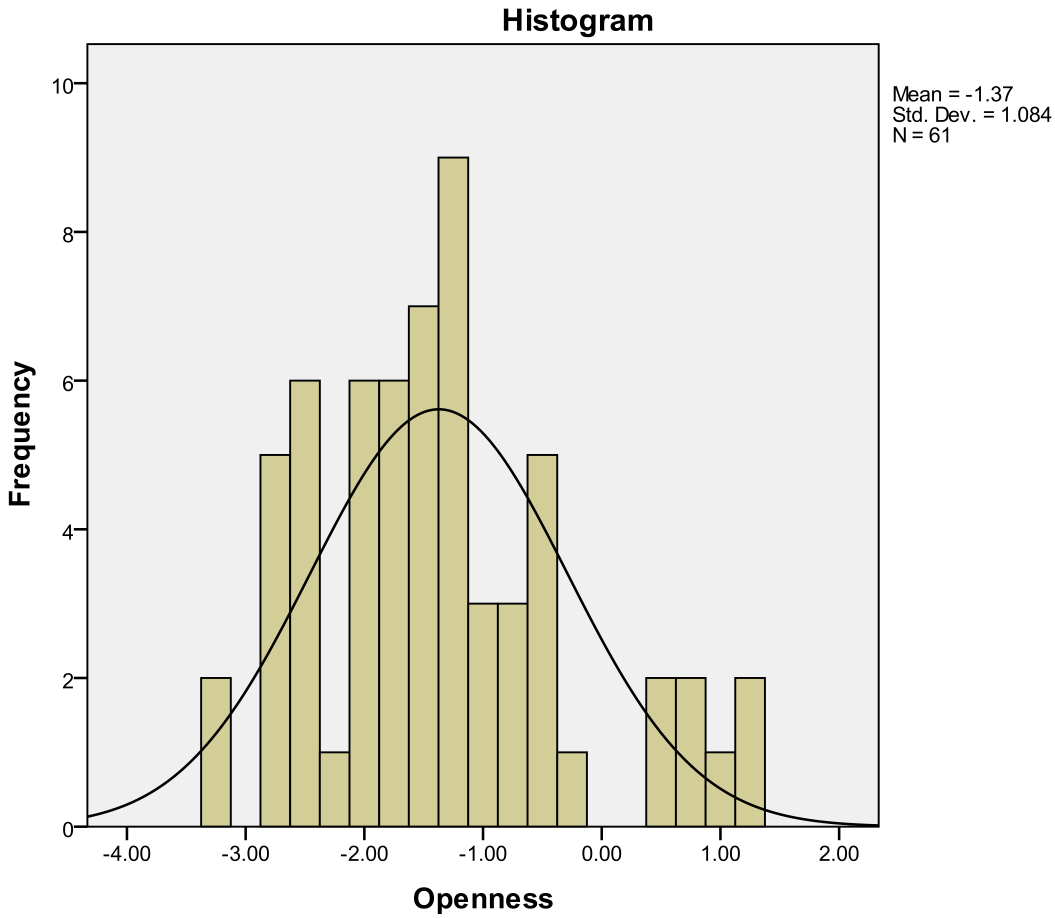



**Figure 8.8: Histogram of Openness Distribution for Observed Group**

### *8.1.2.4 Agreeableness*

The closeness of the mean and the median from Table 8.9 suggest a strong indication that the distribution was symmetrical. The values of the skewness and kurtosis were low thus bringing the distribution closer to normality. The negative value of the skewness suggests that the variable was slightly shifted to the left of the centre of the symmetry and the data was slightly more at the left side of the centre of the symmetry. However, this was considered not significant and the Agreeableness variable was therefore assumed to have the properties of normality.

The histogram in Figure 8.9 and Table 8.9 presents the visual summary of the distribution of the Agreeableness and the summary statistics of variable respectively, for the observed group.

**Table 8.9: Statistics for Agreeableness variable for Observed Group**

**Statistics**

Aggreableness

| | | |
|---|---|---|
| N | Valid | 61 |
| | Missing | 0 |
| Mean | | 2.8279 |
| Median | | 2.7500 |
| Mode | | 2.50 |
| Std. Deviation | | 1.30667 |
| Skewness | | -.179 |
| Std. Error of Skewness | | .306 |
| Kurtosis | | -.407 |
| Std. Error of Kurtosis | | .604 |
| Minimum | | -.50 |
| Maximum | | 5.00 |
| Percentiles | 25 | 1.7500 |
| | 50 | 2.7500 |
| | 75 | 3.7500 |

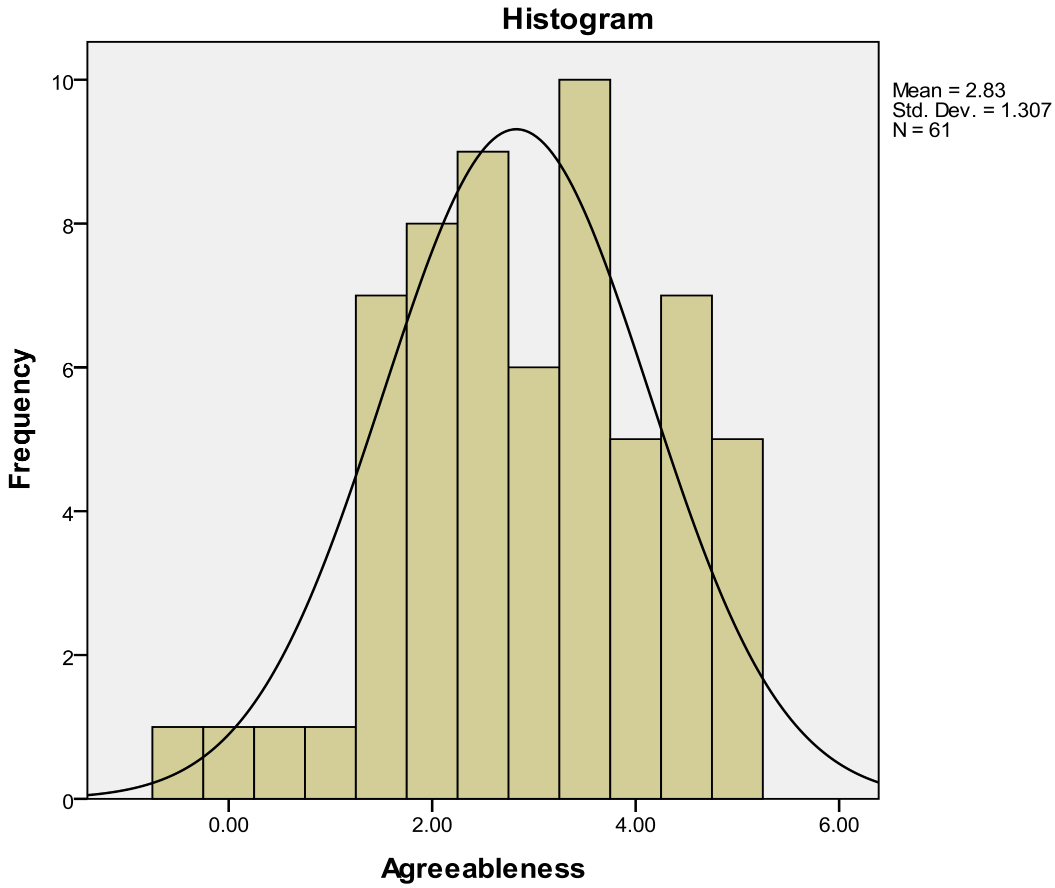



**Figure 8.9: Histogram of Agreeableness Distribution for Observed Group**

### *8.1.2.5 Neuroticism*

From Table 8.10, the mean and the median are reasonably close to each other. This was the property of variable with normal distributions. Therefore, the closeness of the mean and the median suggest that the distribution was symmetrical. However, the negative values were an indication that the variable was slightly shifted to the left of the centre of the symmetry and the data were slightly more at the left side of the centre of the symmetry. The values of the skewness and kurtosis were low thus bringing the distribution closer to normality. Therefore, the variable Neuroticism was considered to exhibit normality in its distribution.

The histogram in Figure 8.10 and Table 8.10 presents the visual summary of the distribution of the Neuroticism and the summary statistics of variable respectively, for the observed group.

**Table 8.10: Statistics for Neuroticism variable for Observed Group**

**Statistics**

Neurotism

| | | |
|---|---|---|
| N | Valid | 61 |
| | Missing | 0 |
| Mean | | -1.7869 |
| Median | | -1.5000 |
| Mode | | -1.25 |
| Std. Deviation | | 1.26560 |
| Skewness | | -.086 |
| Std. Error of Skewness | | .306 |
| Kurtosis | | -.292 |
| Std. Error of Kurtosis | | .604 |
| Minimum | | -4.50 |
| Maximum | | 1.25 |
| Percentiles | 25 | -2.7500 |
| | 50 | -1.5000 |
| | 75 | -1.0000 |

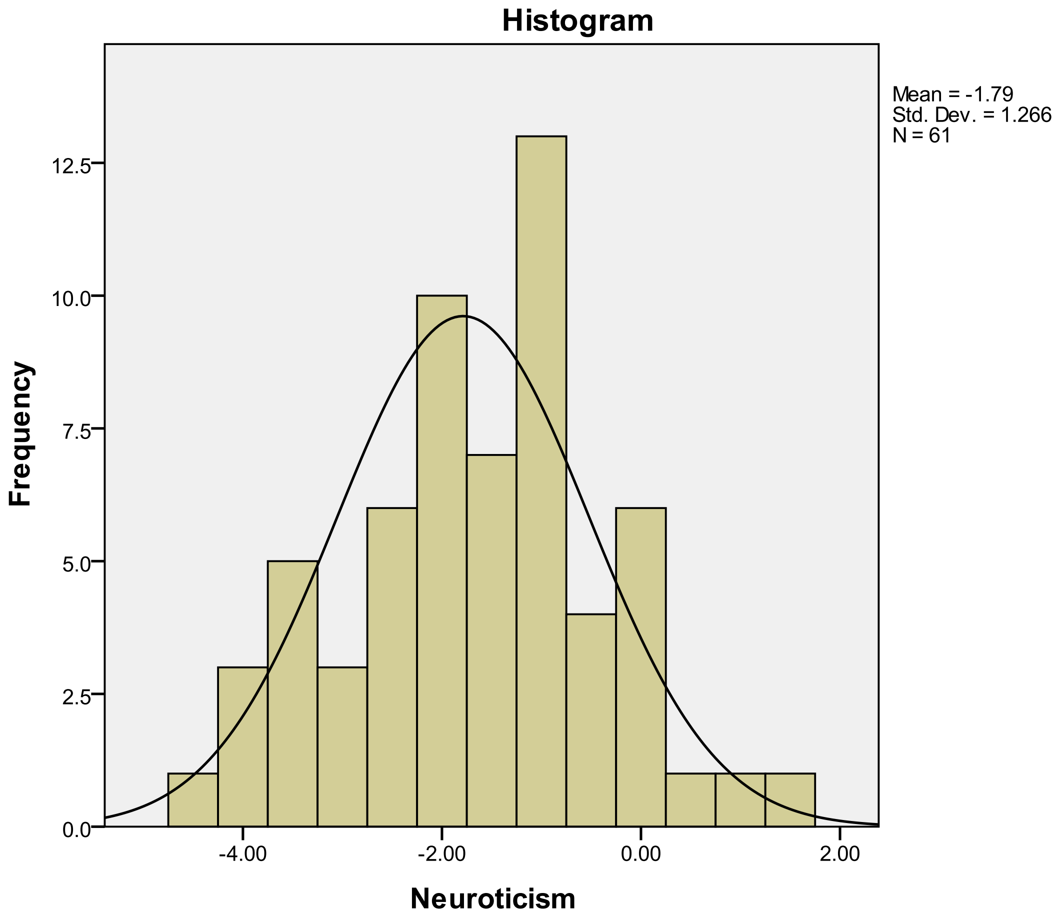



**Figure 8.10: Histogram of Neuroticism Distribution for Observed Group**

## 8.2 RESULTS OF ANALYSIS OF VARIANCE

This research was an attempt to provide a context for understanding the preferred personality instrument and desirable estimator traits necessary for a reliable project estimates. The purpose of this study was to demonstrate the value of knowing and understanding the personality traits of estimators and the traits' influence on the reliability of project estimates. In addition, the study was to demonstrate the influence of qualification and experienced on reliability of project estimates. The study was also to ascertain the main traits that have significant influence on reliability of project estimates. In so doing the study aimed to prove that traits have direct influence on reliability of project estimates.

The results obtained from the analyses of the influence of qualification, experience and personality archetype on reliability are presented in the subsequent sections.

### 8.2.1 Influence of Qualification on Reliability

Table 8.11 show the results from the analyses of the data in Table 7.7 of Chapter 7 on qualifications of the estimators and Appendix F of standardised scores of the cost estimates prepared by the estimators.

**Table 8.11: Influence of Qualification on Reliability.**

**Tests of Between-Subjects Effects**

Dependent Variable:StReliability

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | .186[a] | 2 | .093 | .725 | .489 | .024 |
| Intercept | .051 | 1 | .051 | .394 | .532 | .007 |
| Qualification | .186 | 2 | .093 | .725 | .489 | .024 |
| Error | 7.458 | 58 | .129 | | | |
| Total | 8.162 | 61 | | | | |
| Corrected Total | 7.644 | 60 | | | | |

a. R Squared = .024 (Adjusted R Squared = -.009)

The results in Table 8.11 show low F-statistics which was a strong indication for the rejection of the Null Hypothesis and the acceptance of the Alternate hypothesis. There is therefore a strong relationship between qualification and reliability of project cost estimates.

## 8.2.2 Influence of Experience on Reliability

The hypothesis for influence of experience on reliability was tested using ANOVA and the results are presented in Table 8.12. Table 8.12 show the results from the analyses of the data in Table 7.7 on experience of the estimators and Appendix F of standardised scores of the cost estimates prepared by the estimators.

**Table 8.12: Influence of Experience on Reliability**

**Tests of Between-Subjects Effects**

Dependent Variable:StReliability

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | .295[a] | 3 | .098 | .763 | .519 | .039 |
| Intercept | .613 | 1 | .613 | 4.757 | .033 | .077 |
| Experience | .295 | 3 | .098 | .763 | .519 | .039 |
| Error | 7.349 | 57 | .129 | | | |
| Total | 8.162 | 61 | | | | |
| Corrected Total | 7.644 | 60 | | | | |

a. R Squared = .039 (Adjusted R Squared = -.012)

The results show a strong relationship between experience and reliability. However, the F-statistic of 4.757 for the intercept shows that experience at some point has no relationship with reliability. The implications of the results are discussed in the next chapter.

## 8.2.3 Influence of Personality Archetype on Reliability

Personality traits namely Extraversion, Conscientiousness, Openness, Agreeableness and Neuroticism were analysed to ascertain their influence on reliability using One Way ANOVA statistical technique. The personality archetypes of the estimators in Table 7.10 and standardised scores of the cost estimates prepared by the estimators in Appendix F were used in the analyses. The results obtained are presented in Table 8.13.

**Table 8.13: Influence of Personality Archetype on Reliability**

**Tests of Between-Subjects Effects**

Dependent Variable:StdReliability

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | .845[a] | 4 | .211 | 1.740 | .154 |
| Intercept | .417 | 1 | .417 | 3.437 | .069 |
| PTrait | .845 | 4 | .211 | 1.740 | .154 |
| Error | 6.799 | 56 | .121 | | |
| Total | 8.162 | 61 | | | |
| Corrected Total | 7.644 | 60 | | | |

a. R Squared = .111 (Adjusted R Squared = .047)

The F-factor suggests a strong indication that the Null Hypothesis should be rejected and the Alternative Hypothesis that "there is systematic difference in reliability across various traits" should be accepted.

As explained in chapter seven, the various personality traits do not correlate with each other. This was due to the low value of Person's Coefficient of correlations presented in Table 7.8. Therefore, the various traits do not relate to each other and thus the results are consistent with the behaviour of the trait variable on reliability.

## 8.3 SUMMARY

The results from the summary statistics using frequency on the personality traits suggest normality for all the traits in both control and observed group of estimators. The variables therefore have characteristics that allowed them to be analysed using Analysis of Variance (ANOVA) to ascertain if there was correlation across the variables.

The F-statistics obtained from the analysis to ascertain the influence of qualification on reliability proved that qualification is directly proportional to reliability. The results of the experience however does not show conclusive evidence that experience is directly proportional to reliability. The F-statistics of the analysis of the personality archetype and reliability established that there is systematic difference in reliability across the various traits.

The results of these analyses as well as their implications are discussed in the next Chapter.

# CHAPTER NINE

# DISCUSSIONS

## 9.0 OVERVIEW

The aim of the study as stated in Chapter One was to present establish evidence that supports the assertion that personality traits influence reliability of project cost estimates. This chapter first discusses the findings from the trait analyses for transition of estimators from inexperience to experience. The significance of the findings also evaluated.

The chapter further provides a discussion of the results of the hypotheses tests on influence of qualification, experience and personality archetype on reliability of project cost estimates. The implications of the various statistics generated from the one-way analysis of variance on estimating are given attention within the chapter.

## 9.1 TRAIT TRANSITION

The percentage change in transition from inexperienced to experienced estimator obtained from the results of the study were 525%, 33,75%, -12,83%, 10.47% and -0.64% for Extraversion, Agreeableness, Neuroticism, Openness and Conscientiousness respectively. The findings were significant in planning targeted training needs in addressing the shortcomings of inexperienced estimators. The results indicate transition from inexperienced estimator to experienced estimator was more pronounced in Extraversion and Agreeableness traits than the other three. The effect was highest on Extraversion which was related to the estimator's level of consultation with other estimators and other professionals in the organisation and outside the organisation prior to making decisions, the level of agreement with comments on the work and the extent to which the individual estimator relies on owns ideas in making informed decision when estimating. The next influential trait for transition to experienced estimator was Agreeableness. This was also related to the ability of the estimator in tolerating criticism, and the extent to which the estimator consult views from others before making informed decisions in estimating among others.

The results have shown that the change from inexperienced to experienced estimator for Conscientiousness trait was very minimal. This was attributed to the fact that estimators are mindful of the public perception as demanded by the ethics of the profession. Also estimating is very critical work and estimators spend much time in analysing information prior to making informed decisions. These are attributes of estimators and therefore do not differ significantly between inexperienced and experienced estimators. This explained the low percentage figure obtained from the result for the transition in the conscientiousness trait. The results were thus consistent with previous studies on the classification of traits as common and unique traits (Cattell, 1965). The findings appear to suggest that the Conscientiousness trait is common to all estimators and the other traits are unique according to trait classification by Cattell (1965). Training targeted at estimators that make decisions without any factual basis, preference of the type of procedure in estimating other than the organisation's procedure and unreasonably long time in analysing information are identified to be negative in openness trait.

In Ghana, contingency sums on project cost estimates are normally set at 15%. Taking the level of contingency as the yardstick of the reliability, then deviations below 15% are considered as not responsive in the study. However, this should not be generalised since the contingency sum on projects in itself is dependent on the decision-making orientations of the estimator. It is therefore, advised that Openness and Neuroticism traits should also be given the necessary attention in transition from inexperienced to experience estimator.

## 9.2 INFLUENCE OF QUALIFICATION ON RELIABILITY

The F-statistic of the model, intercept and qualification were 0.725, 0.395 and 0.725 respectively. The low values of the F-statistic indicate a strong relationship between qualification and reliability. The implications are that the more the estimator's qualification the better the reliability of the cost estimates generated by that estimators. Therefore, qualification is directly proportional to reliability.

The review identified high workload to estimators in the road sector of Ghana due to inadequate number of estimators against the number of projects for which cost estimates are required. This situation is the same in most developing economies. This is against the backdrop of pressures from superiors for project cost estimates to be prepared within short period. The review identified that to become an estimator; one requires completing programs in estimating from tertiary institutions such as Universities and Polytechnics. The number of these institutions offering estimating programs is however few in Ghana.

To address the problem of lack of estimators requires a shift in the policies of the government in the educational sector with more emphasis on programs offering estimating modules. Furthermore, there is urgent need to increase the number of tertiary institutions that offer estimating programs. These are however, policy issues that are within the control of the government. However, the researcher could influence the implementation by explaining the benefits that would be derived from the programme if it is implemented to the government officials. Also, the researcher could use the media to propagate the benefits and the urgent need for the policy shift towards increasing number of tertiary institutions that offer estimating programs.

The results also indicate that the more qualification the better reliability. These brought to fore the issue of further studies in estimating programs. In Ghana, the highest level offered in the tertiary institutions is Bachelor of Science level. This could be addressed in two (2) fold. The first is to address the problem in the short term and in the long term. For the short term, the researcher advocated for the involvement of the private sector. The private sector could sponsor estimators for their masters' degrees at Universities abroad that offers master programmes in estimating and related programs. The amount spend on the estimator will become tax rebate for the private company. On the long term however, the issue of increasing the qualification level of estimators as exhibited in the results of the study has to involve government in reviewing its policies on tertiary education. In this regard, government has to initiate policies towards establishing master's degree programs in the country's universities in estimating and related programs.

The discussions on the results were issues that the developed economies have appreciable improved upon over the years. However, the results proved that the more the estimator's qualifications the better the reliability. It will therefore be important for developed economies to entreat their estimators for further causes since adequate number of tertiary institutions that offer masters and other higher degree programs in estimating and related subjects are already available. In this regard, developed economies could initiate programs towards carrier development in the organizations. The method of addressing the revelations from the findings therefore, might differ between developed and developing economies. The findings also provide an indication that training development produces value in terms of reliability of estimates and therefore, should form part of the policies for organizations and the national government.

The findings therefore justify the acceptance of the proposition on the influence of personality archetypes on reliability. This is because the source of the data used in the analysis was the same for the analysis of personality traits on reliability. The justification of the results of qualification on reliability is a further confirmation of the results in the analysis of influence of personality archetypes on reliability.

## 9.3 INFLUENCE OF EXPERIENCE ON RELIABILITY

The results from the analysis of influence of experience on reliability showed two (2) stets of results. The first set of results show the same F-statistics of 0.763 for experience and the model. The low value of the F-statistics is an indication of a strong relationship between experience and reliability. It could be deduced from the F-statistics that the more experience the more reliability. However, this deduction from the results could not be generalized that experience is directly proportional to reliability as in the case of qualification.

The results showed F-statistics of 4.757 for the intercept. The meaning of this is that the model has been shifted to the lower values at the intercept. The high F-statistics therefore indicate that after the point of interception the relationship between experience and reliability alters.

The literature review identified experience in the field of estimating as factors that influence reliability. The effect of knowledge of estimators in the area in which estimates are prepared is a prerequisite for a reliable estimate. Literature review also revealed that unreliable estimates are the results of estimators estimating in an area where the they have little knowledge. The estimator must have adequate knowledge in order to be able to interpret the design drawings and the related project information. Again, estimating involves making decisions on a number of issues on the project. The judgement of the estimator in such situations depends on the amount of knowledge the estimator has acquired from projects of similar nature and complexities. The first set of the results of F-statistic 0.763 is thus consistent with the review that the more experience the better the reliability.

In recent times, there have come estimating models such as Building Information Model (BIM) that estimates project cost faster than the traditional human generated estimates. However, the performance of the model is dependent on the estimator's knowledge in providing the right input information into the model, and also adequate experience in the running of the model to generate the expected results. Again, the review is consistent with the low F-statistics of 0.763 observed from the analysis.
Contingency allowances are established in order to compensate for the unfavourable that causes unreliable project estimates. The use of contingency in construction provides a clear and tacit acknowledgement of the perennial problem of unreliable project estimates. In particular, while the establishment of budget estimates for projects is often conducted

from first principles, the allocation of contingency to account for possible cost reliability is either a lump sum or a simple percentage. The review identified that the amount provided for contingency sums in project estimates is dependent on the experience of the estimator, and the individual estimators' behavioural characteristics in decision making orientations. Therefore from the first set of result of F-statistic 0.763, the more experience the more reliable the amount provided for contingency in project estimates and thus the more reliable the estimates.

The result is therefore consistent with the observations of factors that influence reliability in terms of experience from the literature review. In view of the revelations from the results that experience is directly proportional to reliability, adequate measures have to be put in place to increase the number of experience estimators and also to increase the experience level of estimators. This can be done through exposures to complex construction sites and through training. Training can be done within the organisation or abroad. These measures to address the problems associated with experience on reliability are within the control of the organisations.

However, experience could be acquired that is not related to the estimating know-how. In this case, the experience could be high but the reliability will be low. In other words, experience is inversely proportional to reliability in this case. This accounted for the high F-statistics of 4.757 observed in the analysis. The conclusion from the high F-statistics is that experience could be accumulation of wrong practices. The finding is very important to the researcher because interactions with some number of estimators showed that they acquired considerable number of years of experience but this does not reflect in their output of work. The implications are that such an estimator will continue imparting wrong practices to adversely influence young estimators and perpetuate the cycle of negative practice. In addressing this problem, urgent and frequent refresher courses in estimating should be organised for all experience estimators. Also, it will be appropriate to sponsor experienced estimators for short courses abroad to introduce them to technological advancement and best practices in estimating. This will influence positively their experience in estimating, and contribute to their attainment of improved reliability.

## 9.4 INFLUENCE OF PERSONALITY ARCHETYPE ON RELIABILITY

The analysis of the research data compared to the principal objectives of the study provided significant proof that personality traits of estimators influence the decisions that estimators make in the performance of their roles in estimating. The F-factors from the ANOVA results provided strong justification for the rejection of the Null Hypothesis that "there is no systematic difference in the reliability across the various traits" and the acceptance of the Alternate Hypothesis that "there is systematic difference in the reliability across the various traits". The results therefore showed traits influence the individual estimators differently. This is therefore, a strong evidence that trait has an influence on the reliability of estimates. The results also show strong evidence that error in variations are unequal. If they are unequal, then the individual estimator's trait in personality has an influence in the ability to estimate. How much the influence is should become the subject of further research.

It is critical for the success of any organisation that the employees enjoy what they do in their various organisations. This specific philosophy was supported by a comprehensive study by Eysenck and Eysenck that was published in 1985. In that study, Eysenck and Eysenck (1985) concluded that there are some specific occupations where the relevance of personality is very significant. In estimating profession the employees have little control on the decisions that estimators make in estimating. It is therefore important that in such professions, the individual personality archetype of the estimator meets the constraints of the job. It will therefore be of high interest that this specific research on estimators combined with the findings of the study could be use as the basis of developing targeted training programs towards achieving the desired reliability in project estimates. The implications of this research will therefore be beneficial to the construction industry as a whole and the road sector in particular.

This calls for short and long term measures to address the problem. The statistical analyses results on ANOVA are a strong indication that each individual is unique in personality traits. Therefore the training to be design to address this problem must not be on adhoc basis but must be tailored towards each estimator's need. This is where the research personality instrument for personality test could be used to first classify the estimators and targeted training programs organised accordingly in line with the needs identified from the test.

The long-term measures are beyond the control of the researcher. This will involve restructuring government's policies and programs on the education sector. Earlier section in this chapter discussed some of the measures to address the problem of inadequate number of experienced estimators in Ghana. In addition, government could offer incentives for people enrolled in the estimating programs. These incentives could be in a form of guaranteed employment after the program or subsidising the fee for students enrolled for estimating programs or granting scholarships to people enrolled for estimating programs. These measures in addition to those contained in the earlier sections of this chapter will induce interest of the youth in enrolment in to estimating programs. If this is accepted and implemented by the government, then the number of estimators will increase thus eliminating the stressors identified in the literature review among others that influence reliability of project cost estimates. The long term program is expected to spread over a period of ten years.

Although the government has the influence on this long term measures, the ministers responsible for education and the construction related sectors of any economy could be contacted and the benefits of the program explained to them. The benefits will include but not limited to producing of reliable estimates on projects, project budget at initiation compares reasonably with the final cost at completion thus abandonment of project due to shortage of funds experienced currently will be eliminated. Other benefits include the following points. The policies and programmes of the government will not be disrupted by the perennial reallocation of funds from other sectors of the economy for the completion of projects as is done currently. Equally, donor funded projects that operate on tight funding could now be completed without extra funding from the government as is currently experienced on most projects as the benefits to be derived if the program is implemented.

On the private sector, aggressive education would have to commence immediately to explain the need and benefits that would be achieved if the individual contractors in developing economies commence the preparation of their own cost data. This in addition with organisation of workshops to explain the interpretation of the cost data will minimise the unreliable cost estimates on construction projects in developing economies. The problem of cost data is already addressed in the developed economy. The literature review has revealed that in UK for example, Code of Estimating Practice issued by Chartered Institute of Building (CIOB) documents all the estimating functions. Those functions that have to be followed in estimating, and those that have to be followed by other departments of the construction company are well documented. This therefore facilitates contractor's estimating practices in UK. On the other hand, there is no guide to be followed by contractors in Ghana and most developing economies. In addition, the review identified cost data that is being used in Ghana was prepared in 1975. This again needs to be address in both the short and long term. As the result of the revelation from the literature review on the unreliable cost data being used in Ghana, the researcher has already commenced a program towards preparing a new cost data. In this regards the researcher explained the benefits to the Minister responsible of Roads and Highways in Ghana and the urgent need to update the cost data through work study. Due to the acceptance of the explanation, two workshops were held already to make awareness to estimators and other professionals to be use for the study. Also explained at the workshop was how the study is to be conducted with regard to timing of various activities. This is where the personality trait of the individual plays a major role in the reliability of the data. The decision point in such studies is the time to decide to start the timing. The findings from the study are very significant for reasons that it is now known that the traits of the individual timers differ and are not related to each other. Again the findings from the research has revealed that realisation of the reliability of the work study will heavily depend on the behavioural characteristics of the individual time keepers in decision making orientations. The lessons leant from the findings of the research will be applied in the work study to develop new cost data for the construction sector in Ghana.

In the short-term, research personality instrument for personality testing has to be performed on all estimators with the aim of identifying their training needs. This is very important from the results of the research which showed that the training needs of individual estimators are directly related to that estimator's personality trait. A comprehensive targeted training program will then be drawn and discussed with management for implementation. The benefits to the organisation will be shown as the basis of investing in the training program. Two types of training will be organised. These are on the job training and training through workshops. The type of training suitable for any estimator will be determined from the personality instrument on that particular individual. Appropriate training program could then be drawn, that is tailored to address the shortfalls identified in the estimators from the results obtained through the personality instrument. The short term programme is expected to spread over a period of two years

## 9.4 SUMMARY

In summary, the research primarily focused on the influence of personality traits on project estimate reliability. The chapter discussed the factors that influence reliability of project estimates as external and internal. The measures to address the influence of external factors on reliability desired in construction were discussed.

The findings on influence of qualification on reliability suggest a strong relationship between qualification and reliability. The implications are that the more qualification the more reliability. On the other hand, there is no conclusive evidence that the more experience the more reliability. This could be attributed to the fact that estimators might gain considerable experience but in the wrong estimating practices. The findings on the influence of personality archetype on reliability proved a strong justification for the rejection of the Null Hypothesis that "there is no systematic difference in the reliability across the various traits" and the acceptance of the Alternate Hypothesis that "there is systematic difference in the reliability across the various traits". The findings therefore showed traits influence the individual estimators differently. How much the influence is can become the subject of further research.

There is therefore a strong evidence that trait has an influence on the reliability of estimates and hence established the fact that error in variations are unequal which is attributed to the differences in the individual estimator's trait. The chapter also discussed the changes in trait in transition from inexperienced to experienced estimators. The findings revealed that extraversion accounted for the highest change followed by agreeableness. The least was conscientiousness and the reasons attributed for this was discussed in the chapter.

The significance of the research in terms of measures to bring the inexperienced estimators towards the level of experienced estimators was discussed in this chapter. Long-term and short-term measures were discussed in this chapter aimed at addressing the influence of trait on reliability of project cost estimates. The long term measures however required a shift in the government's policy on education which is beyond the control of the researcher. The researcher's role in advocating for the change was discussed in this chapter.

The significance of the findings of the research to both the public and the private sector were discussed. The conclusions and recommendations from the research are discussed in the next chapter.

# CHAPTER TEN

# CONCLUSIONS AND RECOMMENDATIONS

## 10.0 OVERVIEW

This chapter presents the conclusions and the recommendations that are drawn from the research. The chapter commences with a brief discussion on the justification for the research. It then progresses on to the aims and objectives of the study and how the results from the research address these aims and objectives. The chapter further provides the wider application of the results of the study to practitioners in the construction industry and also its significant to the programs and policies of governments. The wider benefits of the results of the study to the wider community were presented in this chapter. The chapter made recommendations for the full realisation of the benefits from the study. The chapter concluded by stating further research works on the subject matter.

## 10.1 CONCLUSION

This research was an attempt to provide a context for appreciating and understanding the personality traits and desirable estimator behaviours essential for reliability of project cost estimates. The aim of the research was formulated to provide answers to the research questions in Section 1.1 of chapter 1 as follows:

i. What are the theories and practices of estimating that account for the trend of unreliable project cost estimates?
ii. What are the estimating practices and constraints that inhibit the desired reliability in project cost estimates in Ghana?

iii. What are the internal factors that influence reliability and how are they measured?
iv. Does the individual estimator's personality attributes have an influence on reliability of project cost estimates?
v. Are there other estimator attributes that influence reliability of project estimates?

In finding answers to the research questions, specific objectives were set out in Section 1.2 of chapter 1 as follows:

i. Conducting a comprehensive review of literature to establish the state-of-the-art on estimating theories and practices
ii. Accomplishing a wide-ranging review of estimating practices for the study environment along with the constraints that attend to those practices
iii. Completing a thorough assessment of personality attributes along with the tools, systems and developments that have transpired in other fields of study, with the hope of identifying appropriate methods and tolls for addressing the internal factors associated with estimators.
iv. To establish whether estimator experience and qualification have an influence on the reliability of project estimates.
v. To investigate whether personality archetypes have different reliability attainments for estimators

The specific tasks performed in achieving the objectives set out have been discussed in the subsequent sections.

**Objective 1: Conduct a comprehensive review of literature to establish the state-of-the-art on estimating theories and practices**

Estimating practice is in transition. Especially changes from parametric source to computerisation. This transition has brought about improvement in estimating but not necessary reliable hence the existence of unreliable project budget and cost.

Much of the improvement in estimating effort has drawn on factors that are exogenous to the estimator. The conditions of achieving improvement in those types of factors are well known and documented.

More recent developments such as Building Information Model (BIM) and parametric influences estimating improvement for generating of more accurate estimate but not necessary reliable.

**Objective 2: Accomplishing a wide-ranging review of estimating practices for the study environment along with the constraints that attend to those practices**

Estimating practice in the road sector of Ghana is elementary. Thus the practice is quite basic with little reliance on many of the available facilities to support the establishment of cost and budget such as the use of IT software packages. Much of the estimating work is therefore dependent on the input from the estimator.

Cost data availability and reliability is a major constraint in the road sector of Ghana. The quantity standards prepared in 1975 are still being used in Ghana despite the technological advancement in the construction equipments.

There is high workload to experienced estimators ratio in Ghana. The road sector is experiencing inadequate number and calibre of experienced estimators. Estimators therefore do not have sufficient time in analysing project information before making decisions. Pressures are sometime mounted on estimators to produce project cost estimates within a limited time against the backdrop of estimating in the road sector from the “first principle. Projects are implemented without strict adherence to procurement plan.

**Objective 3: Completing a thorough assessment of personality attributes along with the tools, systems and developments that have transpired in other fields of study, with the hope of identifying appropriate methods and tolls for addressing the internal factors associated with estimators**

Theories on the uniqueness of personality traits to each individual were reviewed. These theories became the pivot upon which the research topic was formulated. The use of personality in various areas of work placement was discussed.

The review discussed the different tools for measuring personality archetypes. The discussions have informed the researcher in the design of the appropriate personality measurement tool for the research. Various self-reporting tools were reviewed and questionnaire form was adopted for elicitation of data for the research.

The review demonstrated of different personality types of general population. Evidence provided elsewhere indicates that different personality archetypes have influence on work performance and more significantly, with appropriate conditioning, there can be shift in personality orientations to accommodate the nature and demand of work.

**Objective 4: To establish whether estimator experience and qualification have an influence on the reliability of project estimates**

**i. QUALIFICATION**

The test of the influence of qualification on reliability was to provide justifications for the results of the trait influence on reliability. This is because from a logical stance it can be argued that the more qualified an estimator is; the better will be their performance. The study established that there was no sufficient ground to rule out formal qualification as an influencing factor in achieving estimating reliability.

**ii. EXPERIENCE**

There is no conclusive evidence that the more experience you gain the more reliability. This is consistent to the fact that the type of experience you acquired must be relevant to estimating practice before it can influence reliability variance.

**Objective 5: To investigate whether personality archetypes have different reliability attainments for estimators**

There is evidence to suggest that estimator's personality archetypes influence their estimating reliability. This particular finding goes to explain why different estimators with similar experience and qualification exposed to the same set of information deliver different levels of reliabilities of estimates and probable account for the "missing link" in estimating.

The research was aimed at exploring the influence of individual estimator's personality traits on reliability of project cost estimates. The results of the research have proven that there is systematic difference in reliability across the various traits. The research has also proved that the transition of inexperience estimators to experienced estimators were not the same across the various traits. The change from inexperienced to experience was more pronounced in extraversion and agreeableness traits than in openness and neuroticism trait with the minimum change in conscientiousness trait.

## 10.2 RECOMMENDATION

Data suggest that there is need of value to be gained to develop estimators to a high level particularly a place like Ghana. The practical applications of the findings from the study to government and practitioners in the construction industry for the achievement of the desired reliability in project cost estimate in Ghana are discussed as follows:

1. **Actions to be taken by Government.**

The number and calibre of estimators is lacking in Ghana. In the short term, the Government to have continues carrier development programs for estimators. This could be done by sponsoring estimators to abroad for causes in technological advancement in estimating practices. Thus, updating estimating knowledge with best practices would be a useful step.

For the long term, Government should aim at increasing number of estimators in Ghana. Government can implement this program in two ways. First, it will involve a change in Government's policies on education. This requires introducing estimating programs in most of the country's tertiary institutions. The next is the review of the estimating modules in the tertiary institutions to conform to recent best practices. Government should ensure that both industry and academic are involve for the design of the new modules for estimating programs. In this way, the modules will address practical problems in estimating practice in Ghana for the desired reliability.

The Government should provide some incentive to generate the interest of the youth to enrol for the estimating programs. The incentives could be in any or all the forms listed below:

a. Provision of subsidy on tuition fees,
b. Provision of full scholarship
c. Invite private companies to sponsor students and the cost rebate from the companies tax returns, and
d. Guarantee employment after completion of estimating programs.

Government should review the guidelines on appointment and promotions in the Ghana Civil and Public Service, to include the post for Director of Training (Estimating). The new establish post will thus become fully responsible for only training for estimators whiles the already established post of training officers continue training staff in others areas. This will enhance the organisations roles towards achieving reliable estimates in Ghana.

Advancement in technology requires constant research into new ways of doing things aimed at continues improvement. In this regard, Government should provide resources to enable academic conduct researches in estimating procedures and processes towards the desired reliability in project cost estimate.

**2. Actions to be taken by public and private employers**

The private sector has to invest in improving estimating practices in Ghana. The private sector should provide funding for research to be conducted in estimating procedures and processes. Private sector should also sponsor students in estimating programs in the country's tertiary institutions and abroad for further studies and the cost rebated from the company’s tax returns as an incentive to the private sector. The private sector should also develop and implement continues carrier development programs for their estimators. However, personality measuring tool must be use to determine training needs for the estimators.

The organisations in the public sector should developed comprehensive continues carrier development programs. The training program must be based on the needs assessment from personality measurement tool test. The public sector should make provisions in their budgets for training in estimating programs both locally and abroad depending on the training need for each individual estimator identified from the personality text. In addition, the public sector must also implement on-the-job training for targeted estimators. The training should be based on the needs assessments obtain from the personality test. The public sector will do well to have programs that will enable estimators to develop their full potentials if the benefits of having estimators are to be gained.

3. **Development of Cost Information**

Cost information is inadequate in Ghana. As the result of the review, the researcher has already commenced programs towards producing quantity standards from work study. There is therefore the urgent need to continue with this program for the realisation of reliable and adequate cost information in Ghana similar to Building Cost Information Services (BCIS) and Spon’s Price Books among others. Government and private sector should provide funding for the development of the cost information in Ghana. Public sector organisations must drive the development of the cost information.

## 10.3 LIMITATIONS OF THE STUDY

Data for the research was obtained from Ghana, a developing economy. The review has brought to fore differences in the environmental factors such as inflation, method and processes from developing economy and developed economy. These factors influence estimating reliability differently in both economies. Therefore the findings of this research are limited to countries that share the same economy like Ghana.

## 10.4 SUGGESTIONS FOR FURTHER RESEARCH

The study which formed the basis of this thesis has unearthed important developments that can influence the level of reliability which estimators can achieve. To bring the benefits of attaining such reliability, it would be useful to address the following aspects of research.

1. The level of reliability of project estimates for various categories of qualification. This will enable estimating task to be given based on the ability to perform that task for the desired reliability in project estimates.
2. The point at which experience becomes inversely proportional to reliability. It will be appropriate to identify this point in order to prepare carrier development policies that will ensure that estimators experience are proportional to reliability.
3. To develop the magnitude of the influence for different personality archetypes so that it serves as a moderating factor for checking estimates produce by different staff. This is necessary since the study has established strong evidence that personality archetypes of individual estimators influence reliability.
4. To replicate the study to see the interaction between estimating reliability and personality archetypes in other economic environments. This is necessary since data for the research was obtained from Ghana, a developing economy.

## REFERENCES


1. Aaltio-Marjosola, Irish, J. Lehtinen (1998). "Male Managers as Fathers: Contrasting Management, Fatherhood and Masculinity." *Human Relations* 51(2), pp. 121-137
2. Abd. Majid, M.Z and McCafer R. (1997). "Discussion of Assessment of work performance of maintenance construction in Saudi Arabia." *Journal of Management in Engineering*, ASCE, Vol. 13, No. 5, pp. 91.
3. Abernathy, W.J., (1971) "Subjective Estimates and Scheduling Decisions" *Management Science*, Vol. 18, No. 2, pp.B80-B88.
4. Abubakar A. (1992), A quantitative approach to cost monitoring and control of construction projects. *PhD. Thesis, Department of Civil and Building Engineering, Loughborough University* UK.
5. Adams, J.R., and Swanson, L.A., (1976). "Information Processing Behaviour and estimating Accuracy in Operations Management" *The academy of Management Journal,* Vol. 18, No.1, pp.98-110. Published by Academy of Management.
6. Adamu, T., (2003). "Increasing Road project cost and time certainty." *M.Sc. thesis, Civil and Building Engineering Department, Loughborough University*, UK.
7. Afetornu, C., and Edum-Fotwe, F.T. (2005) Characterising project contingency budget in construction. *In:* Khosrowshahi, F. (Ed), *21st Annual ARCOM Conference,* 7-9 September 2005, SOAS, University of London. Association of Researchers in Construction Management, Vol. 1, pp. 259-268.
8. Afetornu, C., Edum-Fotwe, F., McCaffer, R., Twumasi-Boakye, A., Fugar, F.D.K., (2009). Exploring Estimator Behaviour in Pricing Road Projects. *Fifth International Conference on Construction in the 21st Century (CITC-V) "Collaboration and Integration in Engineering, Management and Technology"* Ma 20-22, 2009, Istanbul, Turkey.
9. Afetornu, C., Edum-Fotwe, F.T., and McCaffer, R., (2006). Estimating budget variability for road projects. *In:* Boyd, D (Ed) *Procs 22nd Annual Conference,*

*ARCOM, 4-6 September, 2006, Birmingham, U.K.,* Association of Researchers in Construction Management, Vol. 2, pp. 563-571.

10. Ahmed, A.S., Aminah, R.F., and AbouRizk, S.M., (2007). Fuxxy Numbers in Cost Range Estimating, *Journal of Construction Engineering and Management,* April 2007 ed. pp.325-334.
11. Ahuja, H. N., Dozzi, S. P., and AbouRizk, S. M., (1994). *Project Management Techniques in planning and controlling construction project,* 2nd edition, Wiley, New York.
12. Akintoye, A., and Fitzgerald, E., (2000) A survey of current cost estimating practices in the UK. *Construction Management and Economics,* Vol. 18, pp. 161-172, 2000*.*
13. Akpan, E.O.P, and Odinaka, I., (2001), Methodology for determining price variation in project execution, *Journal for Construction Engineering and Management*, pages 367-373.
14. Akpan, E.O.P. (1987), stochastic network schedule system for optimum resource utilisation. *PhD thesis, University of Bradford*, Bradford, England.
15. Ali, T., and Ramon, L., (2006). Modelling Cost Escalation in Large Infrastructure Projects, *Journal of Construction Engineering and Management,* August 2006 ed. pp.853-860.. .
16. Allport, G.W. (1937). *Personality: A Psychological interpretation.* New York: Holt, Rinehart and Winston.
17. Amsel, A., and Roussel, J.S. (1952). Motivational properties of frustration: I. Effect of running report on the addition of frustration to the motivational complex. *Journal of Experimental Psychology*. **43,** pp. 363-368.
18. Archibald, R.D., and Villoria, R. L., (1967). "*Network-Based Management System (PERT/CPM)"* pg. 87, N. Y. John Wiley, New York*.*
19. Arditi, D. and Patel, B.K. (1989) Impact analysis of owner-directyed acceleration. *Journal of Construction Engineering and Management, ASCE* 115(1), PP. 144-157.
20. Asendorpf, J.B. (2006). Typeness of Personality Profiles: A Continuous Person-centred Approach to Personality Data*. European Journal of Personality*, 2006, **20**, pp. 83-106.

*21.* Ashley, D.B., and Bonner, J.J., (1987) Political risk in international construction. *ASCE Journal for Construction Engineering and Management,* 113(3), pp. 447-467, 1987.

22. Assaf, S.A; Al-Khalil, M; and Al-Hazmi, M (1995), Causesof delay in large buildings construction projects. *Journal of Management in Engineering*, ASCE, **11**(2), pp. 45-50.

23. Barney, J. B., 1986. Organisational Culture: Can It Be a Source of Sustained Competitive Advantage? *Academy of Management Review,* 11, 656-665.

24. Barrett, P., and Stanley, C., (1999), *Better Construction Briefing*. Oxford, Blackwell Science.

25. Barrick, M. R., and Mount M. K., (1991). The big five personality dimensions and job performance: a meta-analysis. *Personnel Psychology*, **44**, pp. 1-26.

*26.* Beeston, S.T., (1983) Statistical Method for Building Price Data. E. & F.N. Spon, London.

27. Bentz, V.M. (1998). *Mindful inquiry in social research*. Sage Publication, London

28. Block, J. (1961). *The Q-sort method in personality assessment and psychiatric research*. Spring-field. Ill.: Charles C Thomas.

29. Boyle, P., Broadie, M., and Glasserman, P.., (1995). Recent advances in simulation for security pricing. *In Proceedings of the 1995 Winter Simulation Conference,* ed. C .Alexopoulos, K.Kang, W. Lilegdon, and D. Goldsman. Pp. 212-219. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers.

30. Boyle, P., Broadie, M., and Glasserman, P.., (1997). Monte Carlo method for security pricing. *Journal of Economic Dynamics and Control,* Vol 21, pp. 1267-1321

31. Boyle, P.P. (1977). Options. A Monte Carlo approach, *Journal of Financial Economics,* Vol. 4: pp. 322-338

32. Bramble, B.B. and Collaham, M.T. (1992), *Construction delay claims*, Wiley Law publication, New York.

33. Breakwell, G.M., Hammond, S., Fife-Schaw, C., and Smith, J.A. (2006). *Research Methods in Psychology*. , London: Sages Publications.

34. Brewerton, P. and Lynne, M., (2001). Organisational Research Methods, Sage Publication, London.

35. Bromilow, F.J. and Henderson, J.A. (1976) Procedures for reckoning and valuing the performance of building contracts in: *CSIRO Division of Building Research Special Report B3*, 1-4, 2. 2nd edition, Melbourne, Australia.

36. Bryman, A and Cramer, D. (2009) *Quantitative Data Analysis with SPSS 14, 15 and 16. A Guide for Social Scientists*. TJ International Limited, Padstow, Cornwall, Great Britain.

37. Bryman, A. (1989). "*Research methods and organisation studies*." Unwin Hyman,Ltd. London

38. Bryman, A. (2004). *Social Research Methods*, 2nd edition. Oxford University Press, Oxford.

39. Bryman, A. and Bell, E. (2007). *Business Research Methods*, 2nd edition, Oxford University Press, Oxford.

40. Burke, R. (2003) *Project Management Planning and Control*, 4ed. J. Wiley & Sons, Chichester.

41. Butler, J.M., and Haigh, G.V. (1954). Changes in the relationship between self-concepts and ideal concepts consequent upon client-centered counselling. In C.R. Rogers and R.F. Dymond (Eds). *Psychotherapy and personality change: Co-ordinated studies in the client-centered approach*. Pp.55-67. Chicago: University of Chicago Press.

42. Caflisch, R.E., Morokoff, W., and Owen, A.B. (1997). Valuation of mortgage-backed securities using Brownian bridges to reduce effective dimension. *Journal of Computational Finance,* 1(1), pp. 27-46

43. Carlson, J., (1985). "Recent Assessment of the Myers-Briggs Type Indicator." *Journal of Personality Assessment*; Vol.49, 1985; pp.356-365.

*44.* Carr, R.I., (1989) Cost Estimating Principles. *Journal for Construction Engineering and Management,* 115(4), pp. 545-551.

*45.* CASLE, 2000. *Strategy 2000 - Commonwealth Association of Surveying and Land Economy*, CASLE, Bristol.

46. Cattell, R.B. (1950). *A systematic theoretical and factual study*. New York: McGraw-Hill.

47. Cattell, R.B. (1965). *The scientific analysis of personality*. Baltimore: Penguin Books.

48. Chalabi, F., and Camp, .D. (1984). “Causes of delays and overruns of construction projects in developing countries.” *Fourth International Symposium on Organisation and management of Construction, Vol. 3: Developing Countries, Waterloo, Ontario, Canada*, pp. 723-724.

49. Chalkley, R. (1990). Professional Conduct: a handbook for chartered surveyors. London, Surveyors, 1990.

*50.* Chen, C., and Messner, J.J, (2003) An investigation of entry-remain-exit patterns in international construction markets. *Proceedings of the Joint International Symposium of CIB Working Commissions*, Singapore, 22-24 October, Vol. 2, National University of Singapore, pp. 329-340.

51. Chester, G. and Bing, M., (2005). “Neural Network Modelling of Highway Construction Costs.” *Journal of Construction Engineering and Management*, ASCE, Vol. 131, No. 7, pp. 765 - 771, July/August 2005.

52. Chou, J.S. (2010). Cost simulation in an item-based project involving construction engineering and management, Int. J. *Proj. Mana*g, (2010), doi: 10, 1016/j.ijproman. 2010.07.010.

53. Christensen, R. (1996) *Analysis of Variance, Design and Regression: Applied statistical methods.* Chapman & Hall, 2-6 Boundary Row, London SE1 8HN, UK.

54. Chua, D. and Shen J. (2005). “Key Constraints Analysis with Integrated Production Scheduler.” Journal of Construction Engineering and Management, ASCE, Vol. 131, No. 7, pp.753 - 764, July/August 2005.

55. Ciminero, A.R., Calhoun, K.S., and Adams, H.E., (1977). “*Handbook of Behavioural Assessment”*. New York: Wiley.

*56.* CIOB (1997) Code of Estimating Practice, 5th Edition. *The Chartered Institute of Building. Ascot.*

57. Cohen, J., Cohen, P., West, S.T., and Aiken, L.S. (2003). *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences, third edition*: Lawrence Erlbaum Associates, Inc., Mahwah, New Jersey.

58. Colmer, G. Dunkley, M. Gray, K. Pugh, P. and Williamson, A., (1999) Estimating the cost of new technology products. *International Journal of Technology Management,* 17(7/8), pp. 840-846.

59. Cone, J.D., and Hawkins, R.P., (1977) "*Behavioural Assessment: New Directions in Clinical Psychology".* New York: Brunner/Mazel.

60. Cooper, C.L. and Sutherland V., (2006) Stress and the changing nature of work, in Clements-Croome D, (ed.), *Creating the Productive Workplace*, Abingdon, Taylor and Francis.

*61.* Daschbach, J.M., and Apgar, H., (1988) Design analysis through techniques of parametric cost estimating. *Engineering Cost and Production Economics,* 14, pp. 87-93.

*62.* Davey, K. (2000) Preventing project cost escalation, *Engineering Management Journal,* **10**(4), pp. 174-181.

63. De-Marco, (1994). "Computer Aided Parametric Estimating for Business process Re-Engineering" *Price Newsletter, October, 1994.*.

*64.* Dickmen, I., and Birgonul, M.T., (2006) A review of international construction research: Ranko Bon's contribution. *Construction Management and Economics*, Vol. 24, pp. 725-733, July 2006

65. Dormbusch, R., and Fisher, S. (1993), Moderate Inflation. *World Bank Economic* Rev., 7(1), 1

66. Dowdy, S., Wearden, S., and Chiko, D. (2004) *Statistics for Research, third edition*. John Wiley & Sons, Inc., Hoboken, New Jersey.

67. Dyer, J. H., and Chu, W., (2003). "The role of trust worthiness in reducing transaction cost and improving performance: empirical evidence from the United States, Japan, and Korea." *Organisation Science,* 14(1), pp. 57-68.

68. Easterby-Smith, M. Thorpe, R, and Lowe, A. (2002) *Management Research: An Introduction*, Sage Publication, London

69. Eastman, C.M. (2008). *BIM handbook: a guide to building information modelling for owners, managers, designers, engineers, and contractors*. Hoboken, Wiley.

70. Easton, A., and Emery, N.J. (2005). *The Cognitive Neuroscience of Social Behaviour*. New York: Psychological Press.

71. Edmonds, G.A., (1979). The Construction Industry in Developing Countries, *International Labour Review*, Vol. 118, No. 3, May-June, 1979, pp. 357-360.

72. Edwards, P. J., and Bowen, P. A., (1998). Practice, barriers and benefits of risk management process in building service costs estimation: comment. *Construction Management and Economics,* Vol.16, pp.105-108.

73. Edwards, P. J., and Bowen, P. A., (2005). *Risk Management in construction projects*, UNSW Press, University of New Sought Wales, Sydney.

74. Egan, Sir J., (1998) *Rethinking Construction*, Report of the construction task force to the deputy prime minister, John Prescott, on the scope for improving the quality and efficiency of uk construction, London: DTI.

75. Egglestone, K., Posner, E.A., Zeckhauser, R. (2000). The design and interpretation of contract: why complexity matters. *Northwestern University Law Review.* 95(1): pp.91-132.

76. Elcin, T., and Hakan, Y. (2005), "A building cost estimating model based on cost significant work packages", *Engineering, Construction and Architectural Management,* Vol. 12 No. 3, pp. 251-263

77. Eysenck, H.J. (1961). The effects of psychotherapy. In H.J. Eyenck (Ed.), *Handbook for abnormal psychology: An experimental approach*. Pp. 697-725. New York: Basic Books.

78. Eysenck, H.J., and Eysenck, M.W. (1985). *Personality and Individual difference: a natural science approach*. New York: London: Plenum

79. Fan, C.N.L., Ho, M.H.C., and Ng, V. (2001b) Effect of professional socialization on quantity surveyors' ethical perception in Hong Kong. *Engineering, Construction, Construction and Architectural Management*, Vol. 8, pp. 304-312

80. Fan, L., Ho, C., and Ng, V. (2001a). A Study of Quantity Surveyor's Ethical Behaviour. *Construction Management and Economics*, Vol. 19, pp. 19-36

81. Fellow, R., and Liu, A., (2002) *Research Methods for Construction*, 2nd edition, Blackwell Science Limited, Oxford

*82.* Fine, B., (1974) Tendering strategy, *Building*, 25 October, pp. 115-121

83. Fitzgerald, B. Howcroft, D. (1998). Towards dissolution of IS research debates: from polarisation to polarity, Journal for Information Technology, 13(4), pp. 313-326.

84. Frank, J. (1994). *Contract Administration and Practice,* B.T. Batsford Ltd., London

*85.* Franks, J. (1998) *Building Procurement Systems- A Clients Guide*. 3ed 1998, CIOB, Ascot

*86.* Fraser, (Lord) (2004). The Holyrood Enquiry, A report by The Rt Hon Lord Fraser in September, 2004, SP Paper 205, Blackwell's Publications, Edinburgh

87. Frechtling, J. and Sharp, L. (1997). Introduction the handbook, In: J. Frechtling and L. Sharp (eds). Use-Friendly handbook for mixed method evaluations, Westat Inc., Washington DC.

88. Fu, M.C., Laprise, S.B., Madan, D.B., Su, Y., and Wu, R., (1999). Pricing American options: A comparison of Monte Carlo simulation approaches. Technical report, University of Maryland, College Park, Maryland..

89. Furnham A. (1992). "*Personality at Work: The role of individual Differences in the Workplace*". Routledge, New York

90. Gardner, W.L., and Martinko, M.J., (1996). "Using the Myers-Briggs Type Indicator to Study Managers: A Literature Review and Research Agenda." *Journal of Management*, Vol.22, pp.45-83.

91. GCSGA, (2001). *Guidelines on Appointment and Promotions in the Ghana Civil Service*, Second Edition, August, 2001. Office of the Head of Civil Service, Accra, Ghana.

92. GhIS (2007). *The Ghana Institution of Surveyors Code of Ethics*, Amended Edition December, 1996, Further Amended December 14th 2007, GhIS, Accra.

93. Gilchrist, W., (1986), *Statistical Modelling*, John Wiley & Sons, Chichester, New York.

94. Glasserman, P., and Zhao, X., (1999). Fst greeks by simulation in forward LIBOR models. *Journal of Computational Finance.* 3 (1), pp. 5-39

95. Goldberg, L. R. (1990). An alternative description of personality: The big-five factor structure. *Journal of Personality and Social Psychology*, **59**, pp. 1216-1229

96. Goodstein, L.D., and Lanyon, R.I., (1971). "*Reading in Personality Assessment"* John Wiley & Sons, Inc.: New York; London; Sydney; Toronto.

97. Gould, F. E., and Nancy, E.J., (2000), Construction project management.

98. Grant, D., Vora, G., and Weeks, D., (1997). Path-dependent options: Extending the Monte Carlo simulation approach. Management Science 43 (110, pp.1589-1602

99. Graves, A., Rowe, D., Sheath, D. (1998). *Constructing the Government client,* London: HMSO.

100. Gray, C., and Hughes, W. (2001) *Building Design Management,* MPG Book Ltd., Bodmin, Cornwall.

101. Green, S. D. (1998) The technocratic totalitarianism of construction process improvement: a critical perspective, *Engineering, Construction and Architectural Management*, **5**(4), pp 376-386.

102. Greenwood, D, Walker, P. and Walker, A. (2008). The World turned upside-down: architects as subcontractors in design-and-build contracts. In: Dainty, A.R.J. (Ed), *Proceedings of 24th ARCOM Conference,* 1-3 September 2008, Leeds, UK, *Association of Researchers in Construction Management*, Vol. 1, pp.507-516.

103. Gross, M.L., (1962). *The brainwatchers.* New York: Random House.

104. Guilford, J.P. (1959). *Personality*. New York: McGraw-Hill.

105. Hackway, J.W., and Humphrey, K., (1992). “Control and Management of Capital projects.” (Second Edition). *American Society of Cost Engineers*

106. Hall, C.S., and Lindzey, G. (1978). *“Theories of personality” Third Edition, New York: Wiley.*

107. Hammer and Allen, L. (1996). MBTI Applications: Decade of Research on the Myers-Briggs Type Indicator. *Palo Alto: Consulting Psychologists* Press, Inc. 1996.

108. Hamza, N. and Greenwood, D. (2007). The impact of procurement methods on delivery environmentally sensitive buildings. In: Boyd, D. (Ed) *Proceedings of 23rd Annual Conference*, 3-5 September 2007, Belfast, UK, Association of Researchers in Construction Management, pp.723-732.

*109.* Han, S. Diekmann, J.E., (2001) Approaches for making risk-based go/on-go decision for international projects. *ASCE Journal for Construction Engineering and Management,* 130(3), pp. 346-356.

110. Harris, F., McCaffer, R., and Edum-Fotwe, F., (2006). *Modern Construction Management,* 6th edition, Blackwell Publishing, Oxford, United Kingdom.

111. Hartley, H.O. (1950) The maximum *F*- ratio as a short-cut test for heterogeneity of variance, *Biometrika*, **37**, pp.308-312

*112.* Hasrak, M., and Shaked, A., (2000) ICRAM-1: Model for international construction risk assessment. *ASCE Journal of Management in Engineering,* 16(1), pp. 59-69, 2000.

113. Haynes, S.N., (1978). "*Principles of Behavioural Assessment"* New York: Halstead Press.

114. Haynes, S.N., and Wilson, C.C., (1979). "*Behavioural Assessment: Recent Advances in Methods, Concepts, and Applications"*. Jossey-Bass Publishers: San Francisco, Washington, London.

*115.* Hegazy, T., and Moselhi, O., (1995) Elements of cost estimating: a survey in Canada and the United Sates*. Cost engineering*, 37(5), pp. 27-31

116. Hersen, M., and Bellack, A.S., (1976). "*Behavioural Assessment: A Practical Handbook*". Elmsford, N.Y.: Pergamon Press.

117. Herzberg, F. (1968). One more time: How do you motivate employees? *Harvard Business Revi*ew. 46 (1), p53-62.

118. Hillebrandt, P.M. (1985). *Economic Theory and the Construction Industry*. 2nd ed. Basingstoke: Macmillan Press Ltd

119. HMSO, (1984). Central Statistics Office, Monthly Digest of Statistics, No. 461, May 1984 Table 3.2

120. Hogan, A. (1998). *Women of faith in Victorian culture: reassessing the 'angel in the house'*. Basingstoke: Macmillan.

121. Hogan, R., Gordon, J.C., Hogan, J., (1994). "What We Know About Leadership." *American School Board Journal*, November, 1999, pp. 42-44.

122. Holland, J. L., and Richards, J. M., Jr. (1965). Academic and non-academic accomplishment: Correlated or Uncorrelated? *Journal of Education Psychology*, **56**, pp. 165-174.

123. Honderich, T. (1995) *The Oxford Companion to Philosophy*, Oxford University Press, Oxford

124. Honzik, M. P. (1972). Intellectual abilities at age 40 years in relation to the early family environment. In F. J. Monks, W. W. Hartup, and J. deWit (Eds.), *Determinants of Behavioural Development*. New York: Academic Press.

125. Horner, R.M.V. and Zakieh, R. (1993), "Beyond BRIDGET-an integrated model for estimating and controlling reinforced concrete bridge construction costs and durations" , *Highways and Transport,* Vol. 40 No. 11, pp. 11-14

126. Horner, R.M.V. and Zakieh, R. (1995), "Characteristic items-a new approach to pricing and controlling construction projects", *Construction Management and Economics,* Vol. 14 No. 3, pp. 241-252

127. Howard, A. and Bray, D.W. (1987). *Managerial lives in transition: advancing age and changing times*. Guilfird Press, New York.

128. Huitt and William, G., (1992). "Problem Solving and Decision Making: Consideration of Individual Differences Using Myers-Briggs Type Indicator." *Journal of Psychological Type*, Vol. 24, pp.33-34.

*129.* Ibbs, W.JR. (1984) Key Elements of construction specification. J. American Waterworks Association, 76(2), pp. 48-55.

130. Ibrahim, A.D., Price, A.D.F. and Dainty, A.R.J. (2006). The analysis of allocation of risks in public private partnerships in infrastructure projects in Nigeria. *Journal of Financial Management of Property and Construction*, Vol.11, No. 3, pp.149-163.

131. Ireland, V. (1980) The role of managerial actions in the cost, time and quality performance of high rise commercial building projects, PhD thesis, University of Sydney, Australia.

132. I-Tung, Y., (2008). Distribution-Free Monte Carlo simulation: Premise and Refinement, *Journal of Construction Engineering and Management,* May, 2008 ed. pp.352-360

133. Jankowicz, A.D. (2000) *Business Research Projects*, Thomson Learning.

*134.* Jaselskis, E.J., and Talukhaba, A., (1998) Bidding considerations in developing countries. *ASCE Journal for Construction Engineering and Management,* 124(3), pp. 185-193, 1998.

135. Johansen D.E. and Greenwood D.J. (1999). Hard, Soft or Lean? Planning on Medium-Sized construction projects. *15th Annual ARCOM Conference*, Vol. 2, pp. 385-394.
136. Jung, C.G. (1971). *Psychological Types*. Princeton: Princeton University Press.
137. Kagan, J. (2007). A trio of concern. Perspectives of Psychological Science, Vol. 85, pp. 361-376.
138. Kahn, Robert L., (1964). Organisational stress: studies in role conflict and ambiguity. New York: Wiley, 1964.
*139.* Kalidindi, S.N., and Thomas, A.V., (2002) Identification of critical risks in Indian road projects through Build, Operate and Transfer (BOT) procurement approach, *in Proceedings of Symposium on Procurement System (CIB W92), Trinidad and Tobago*, January, 2002, pp. 339-354.
140. Kaming, P.F., Olomolaiye, P.O, Holt, G.D., and Harris, F.C., (1997), Factors influencing construction time and cost overruns on high rise buildings in Indonesia, *Construction Management and Economics Journal*, Vol. 15, pages 83-94.
141. Kang, B. (2007). Construction ethics management: a comparative study in UK and Korea. *PhD Thesis*, Loughborough University, 2007.
*142.* Kapila, P. and Hendrickson, C., (2001) Exchange rate risk management in international construction ventures. *ASCE Journal of Management in Engineering,* 11(4), pp. 186-191, 2001.
143. Kayode, M. O., (1979). *The art of project evaluation*, University Press, Ibadan, Nigeria.
144. Killingsworth, R. (1988), *Cost Control in Building Design,* R.S. Means Company Inc., Kingston, MA.
145. Kirby and Linda, K., (1997). “Introduction: Psychological Type and Myers-Briggs Type Indicator.” *Palo-Alto: Davies-Black*, pp.3-33.
146. Kishk, M. and Al-Hajj, A. (2000). A Fuzzy Model and Algorithm to Handle Subjective In Life Cycle Costing Based Decision-making. *Journal of Financial Management of property and Construction*, 5(1-2), pp.93-104.
147. Koenigseker, N.A., (1982) Parametric estimating of buildings. *Cost Engineering,* 24(6), pp. 327-332.

148. Koushki, P.A., Al-Rashid, Karton, N., (2005). “Delays and Cost increases in the Construction of private residential projects in Kuwait.” *Journal of Construction Management and Economics,* Vol. 23, No. 3, pp. 285 – 294, March 2005
149. Kouskoulas, V. and Koehn, E., (1974) Predesign cost estimation function for buildings. *Journal of the Construction Division*, 100(CO4), PP. 589-604
150. Krosnick, J.A. and Schuman, H. (1988). Attitude intensity, importance and certainty and susceptibility to response effects. *Journal of Personality and Social Psychology*, 54, pp.940-952.
151. Kululanga, G.K. and Price, A.D.F. (2005). Measuring Quality of Writing of Construction Specifications. *Journal of Construction Engineering and Management*, Vol. 131, No.8, pp. 859-865.
152. Kwak, Y. H. and Watson, R. J. (2005). Conceptual estimating tool for technology-driven projects: exploring parametric estimating technique. *Technovation*, Vol. 25, Is. 12, pp. 1430-1436.
153. Latham, Sir, M. (1994). *Constructing the team - The Latham report*, Final report of the government/industry review of procurement and contractual arrangements in the UK construction industry, London, HMSO.
154. Levy, S.M., (2002) *Project Management in Construction*, fourth edition.
155. Lewis, S.J and Greenwood D.J. (2002). The treatment of Risk in Construction Contracts under PFI/PPP, In. Greenwood, D (Ed), *18$^{th}$ Annual ARCOM Conference*, 2-4 September 2002, University of Northumbria. Association of Researchers in Construction Management, Vol. 1, pp. 415-423.
156. Lindsay, P.H., and Norman, D.A. (1977). *Human information processing: An introduction to psychology* (2$^{nd}$ ed.) New York: Academic Press.
157. M4I, 2000. *A commitment to people-our Bigger Asset,* A report from the Movement for Innovation’s working group on Respect for People, November, 200. M4I, London
158. Maanen, J.V. (1983). “Qualitative Methodology.” SAGE publications, Ltd., London
159. Macaulay, S., (1963). Non-contractual relations in business: a preliminary study. *American Sociology Review*. 28(1), pp.55-67.

160. Mactavish and Marie, (1992). “Examining Correctional Manager’s Leadership Styles.” *Corrections Today,* April, 1992; pp.162-166.
161. Maher, B.A. (1966). *Principles of Psychotherapy: An experimental approach*. New York: McGraw-Hill.
162. Malmo, R.B. (1957). Anxiety and behavioural arousal. *Psychological Review*, 64, PP. 276-287.
163. Mandler, G. and Watson, D.L. (1966). Anxiety and the interruption of behaviour. In. C.D. Spiel-berger (Ed.), *Anxiety and Behaviour*, pp. 263-288. New York: Academic Press.
164. Martin, B. (2005). “Soaped up Safety.” *Journal for Construction Manager*, June 2005 edition, pp. 17
165. Maslow, A. (1943). A theory of human motivation. *Psychological Review*, 50, 370-396.
166. May, R. (1950). *The meaning of anxiety*. New York: Ronald
167. Mbugua, L.M., Holt, G.D., and Olomolaiye, P.O. (2000) Business performaqnce measurement in construction companies, *Proceedings of the 2nd International Conference on Performance Measurement*, Cranfield, UK, pp.371-378
168. McCaffer, R. (1976), Contractor’s Bidding Behaviour and Tender Price Prediction. PhD thesis, Department of Civil Engineering, Loughborough University of Technology, UK.
169. McCaffer, R. and Bainbridge, A.B., (1978). Can computers aid the estimator? *Chartered Institute of Building,* Estimating Information Service, No. 29, Summer 1978
170. McCaffer, R. and Edum-Fotwe, F.T., 2003. Construction in transition: where are we, and where could we be?, Second International Conference on Construction in the 21st Century (CITC-II) *Sustainability and innovation in Management and Technology,* 10-12 December, 2003, Hong Kong.
171. McCaffer, R., and Edum-Fotwe, F.T. (2005) Managing Intangibles-The Latent Dimension for Competitiveness in Construction. *In:* Pantouvakis, JP (ed) Advancing Engineering, Management and Technology, *Proceedings of the 3rd International Conference on Construction in the 21st Century ( CITC-III),* 15-17 September 2005, Athens.

172. McCauley and Mary, H., (1994). Research on the MBTI and Leadership: Taking the Critical First Step" The Myers-Briggs Type Indicator and Leadership: *An International Research Conference*, January, 1994, pp.12-14 at College Park, National Leadership Institute bat University of Maryland University College.

173. McCauley, Cynthia, D., Russ, S., Moxley, Velsor, E.V., (1998). The Centre for Creative Leadership Handbook of Leadership Development. San Francisco: *Jossey-Bass Publishers.*

174. McClelland, D. C. (1971). Assessing Human motivation. *General Learning P*., 1971

175. McClelland, D.C. (1951). Personality. New York: Holt, Rinehart and Winston.

176. McCrae, R.R. and Costa, P.T. Jr. (1999). A five factor theory of personality. In L.A. Pervin & O.P. John (Eds.), *Handbook of personality*: Theory and research (2nd ed., pp. 139-153). New York/London: Guilford Press.

177. McDonald, J.D. (2008). Measuring Personality Constructs: The Advantages and Disadvantages of Self-Reports, Informant Reports and Behavioural Assessments. *ENQUIRE*, Vol. 1, Issue1, and June, 2008.

178. McGregor D (1960) *The Human Side of Enterprise*, New York McGraw-Hill

179. McQueen, R., and Knussen, C., (2002) *Research Methods for Social Science. An Introduction.* Pearson Education Limited, Edinburgh Gate, Harlow, Essex.

180. McRae, R., and Costa, P., (1988). "Reinterpreting the Myers-Briggs Type Indicator From the Perspective of the Five-Factor Model of Personality." *Journal of Personality* Vol.57, 1998; pp.17-40.

181. Mei-Yung, L., Thomas, S., Skitmore, M., and Sal-On, C. (2005). "Critical stressors influencing construction estimators in Hong Kong." *Journal of Construction Management and Economics*, Vol. 23, No. 1, pp. 33 – 34, January, 2005.

182. Min, W. and Pheng, L.S., (2005). "Economic Order Quantity (EOQ) versus Just –In – Time (JIT) purchasing, an alternative analysis in the ready mixed concrete industry." *Journal of Construction Management and Economics,* Vol. 23, No. 4, pp. 409 – 422, May 2005

183. Mischel, W. (1986). *Introduction to Personality*. New York: Holt, Rinehart and Winston.

184. Misumi, J. (1985)."*The Behavioural Science of Leadership: An interdisciplinary Japanese Research Program,* Ann Arbor: The University of Michigan Press

185. Mohr, L.B., (1982). "Explaining Organisational Behaviour: The Limits and Possibilities of Theory and Research". *San Francisco, Jossey-Bass*

186. Morris, P.W.G., and Hough, G.H. (1989) *The anatomy of major projects*. J, Wiley & Sons, Chichester

187. MRH, (2010). *2010 Progress Report on Projects*, Ministry of Roads and Highways, Ghana.

188. Myers, Briggs I., McCaulley M.H., Quenk N.L., and Hammer A.L. (1998) "*MBTI Manual. A Guide to the Development and Use of the Myers-Briggs Type Indicator* "Third Edition, Consulting Psychologist Press, Palo Alto.

189. NASA, (1995). "Parametric Cost Estimating Handbook" Joint Government/Industry Initiative.

190. Naylor, J.C., Pritchard, R.D. and Ilgen, D.R. (1980) A *theory of Behaviour in Organisations*, Academic Press, New York.

191. Neisser, U. (1967). *Cognitive Psychology*. New York: Appleton-Century-Crofts.

192. Neuman, W.L. (2006) *Social Research Methods: Qualitative and Quantitative approaches*, 6$^{th}$ edition, Pearson Education, Boston

193. NTPG, (2005). "*National Transport Policy of Ghana*" Assembly Press, Accra Ghana.

194. Olomolaiye, P.Q., Jayawardane, A.K.W., and Harris, F. (1998). *Construction productivity management*. Harlow: London.

195. Oppenheim, A.A. (1992). *Questionnaire design, interviewing and attitude measurement*, London: Pinter.

196. Ostwald, P.F. (1992). *Engineering Cost Estimating*, 3rd Edition, New Jersey: Prentice Hall.

197. Oti, H.O. (1988). Construction financing in Nigeria; *A banking perspective. Financial* Rev., Lagos, Nigeria, 1(4), 12-13.

198. Ouchi, W. G. (1982). *Theory Z: How American business can meet the Japanese challenge*. New York: Avon Books.

199. Pablo, F. Navarrete, and William, C.Cole, (2001). Planning, Estimating, and Control of chemical construction projects.

200. Paul, R. (1993). Critical Thinking, Foundation for Critical Thinking, Santa Rosa, CA

201. Peters, J. and Howard, K. (2001). Looking for good research in management – a publisher's case study, *Management Decision*, 39(7), pp. 594-598.

*202.* Pheng, L.S., and Hongbin, J., (2003) Internalisation of Chinese construction enterprises. *ASCE Journal for Construction Engineering and Management,* 129(6), pp. 589-598, 2003.

203. Pohl, G., and Mihaljek, D. (1992), Project evaluation and uncertainty in practice: *A statistical analysis of rate of return divergences of 1015 World Bank projects. World Bank Economic* Rev., 6(2), 260-275.

204. Price, A.D.F and Newson, E. (2003). Strategic Management: Construction of Paradoxes, Processes, and Associated Concepts as Applied to Construction. *Journal of Management in Engineering*, Vol. 19, No.4, pp. 183-192.

205. Remenyi, D., Williams, B., Money, A. and Swatz, E. (1998). *Doing Research in Business and Management: An Introduction to Process and Methods*, SAGE Publications Ltd.

206. Render, N., Greenwood, D., and Edge, J. (2005). The other G.M.P.: Good Manufacturing Practice and its Importance in the Validation of Constructed Pharmaceutical Facilities. In: Khosrowshahi, F. (Ed.), *Proceedings of 21$^{st}$ Annual ARCOM Conference*, 7-9 September 2005, SOAS, University of London. Association of Researchers in Construction Management, Vol. 2, pp.917-925.

207. Rogge. D.F., and Tucker, R.L., (1984). "Foreman-delay survey: Work sampling and output." *Journal of the construction division*, ASCE, Vol. 108, No. CO4, 592-604.

208. Rosenhead, R. (2007) Project estimates, why are they so wrong? London Olympics 2012. Available: http://www.ronrosenhead.co.uk/archives/

209. Rouna, W.E.A. (2000) Should we define the profession of HRD? Views of leading scholars, In: Kuchinke, K.P.(ed), *Proceedings of Academy of Human*

*Resource Development 2000 Conference*, Baton Rouge, L.A: Academy of Human Resource Development.

210. Rush, C. and Roy, R., (2001). Capturing quantitative and qualitative knowledge for cost modelling within concurrent engineering environment, *8th ISPE International conference on .Concurrent Engineering Research and Applications,,* Anaheim, California, July 29th-August 1st, CETEAM International, USA, PP.209-218.
211. Rush, C. and Roy, R., (2001)."Knowledge in Cost Modelling" *The Cost Engineer: journal of the Association of Cost Engineers,* 39 (1), pp.10-12.
212. Sang-Hoon L., Stephen, R., Thomas, Turker, R.L., (2005). "The Relative impacts of selected practices on project cost and schedule." *Journal of Construction Management and Economics,* Vol. 23, No. 5, pp. 545 – 553, June 2005.
213. Seeley, L.H. (1983), *Building Economics,* The Macmillan Press Ltd., Basingstoke.
214. Seymour, D., Crook, D. and Rooke, J. (1997) The role of theory in construction management: a call for debate, *Construction Management and Economics,* **15**(1), pp. 117-119.
215. Shash, A.A., and Al-Khaldi (1992) The production of reliable construction cost estimates on Saudi Arabia. *Cost Engineering*, 34(8), pp. 111-118
216. Sidney, M. Levy, (2002), Project management in construction, fourth edition.
217. Skeels, H. M. (1966). Adult status of children with contrasting early life experiences. *Mono-graphs of the Society for Research in Child Development*. 31, No. 3.
218. Skitmore, M. and Marston, V., (eds) (1999). *Cost modelling*, Spon, London.
219. Skitmore, M., and Thomas, S., (2002). Analytical and Approximate Variance of Total Project Cost. *Journal for Construction Engineering and Management,* Vol.5, pp.853-860.
220. Skitmore, M., Runeson, G., and Chang, X., (2006) Construction price formulation: full-cost pricing or neoclassical microeconomic theory? *Construction Management and Economics*, Vol. 24, pp. 773-783

221. Sohail, M. and Edum-Fotwe, F.T., (2000), Cost-duration tool for policy decision on micro and small projects. *Journal of Financial Management in Property and Construction*, **5**(3), pp. 71-84.
222. Stephenson, W. (1953). *The study of behaviour*. Chicago: University of Chicago Press.
223. Stevens, S.S. (1946) “On the theory of scales of measurement” *Science 103, pp. 677-680*.
224. Stogdill, R.M., (1948). “Personal Factors Associated with Leadership. A Survey of the Literature.” *Journal of Psychology;* Vol.25, 1948; pp.35-71.
225. Sudman, S. and Bradburn, N. M. (1992). *Asking questions: A practical guide to questionnaire design*. San Francisco: Jossey-Bass.
226. Sultan, M. (1999), Causes of delay in Civil Engineering Projects; M.Sc. Thesis, Loughborough University, UK.
227. Swee, C., and Moonseo, P., (2005). “Project Cost Estimation using principal component regression.” *Journal of Construction Management and Economics*, Vol. 23, No. 3, pp. 295-304, March 2005.
228. Tah, J.H., Thorpe, A., and McCaffer, R. (1993) Contractor project risks contingency allocation using linguistic approximation. *Computing Systems in Engineering. 4*(2/3), pp. 281-293.
229. Tarek M., and Halpin, W. (2004). “Process versus Data Oriented Techniques in Pile Construction Productivity assessment.” *Journal of Construction Engineering and Management,* ASCE, Vol. 130, No. 4, pp. 490-499, July/August 2004.
230. Tas, E. and Yaman, H., (2005). A building cost estimating model based on cost significant work packages. *Engineering, Construction and Architectural Management,* Vol.12, No.3, pp.251-263.
231. The Ghanaian Journal, (2011). Interest Rates are still high in Ghana, www.theghanaianjournal.com/2011/02/14interest-rates-still-high-in-ghana. Site accessed on 26th March, 2011.
232. The Quantity Surveyor, (2010). Official magazine of the Quantity Surveying Division of the Ghana Institution of Surveyors: December, 2010 issue Accra, Ghana

233. The Telegraph, (2011). Liam Fox: No system in place to control MoD costs. *The Telegraph,* www.telegraph.co.uk. Site accessed on 25th March, 2011.

*234.* Thomas, A.A., (2003) Identification, assessment, and allocation of critical risks in Indian BOT road project, *PhD thesis, Indian Institute of Technology, Madras.*

235. Thomas, A.V., Satyanarayana N., Kalidindi, and Ganesh, L.S. (2006) Modelling and assessment of critical risks in BOT road projects. *Construction Management and Economics*, Vol. 24, pp. 407-424, April 2006

236. Thommen, G. (1973) *"Is this your day? How biorhythm helps you determine your life cycle*, Revised Edition, Crown, New York.

237. Thompson, R. L., Higgins, C.A., and Howeh, J.A. (1994). Influence of experience on personal computer utilisation: testing a conceptual model. *Journal of Management Information Systems,* Vol. 11, issue1, pp.167-187.

238. Titus, H.E., and Hollander, E.P. (1957). The California *F* Scale in psychological research: 1950-1955.*Psychological Bulletin*, **54**, pp.47-64.

239. Touran, A. (2003) Probabilistic Model for Contingency, *Journal of Construction Engineering and Management,* **129**(3), pp. 280-284.

240. Touran, A., and Lopez, H., (2006). Modelling Cost Escalation in Large Infrastructure Projects. *Journal for Construction Engineering and Management,* Vol.132, issue8, pp.853-860.

241. Tukey, J.W. (1977). *Exploratory data analysis*. Reading, MA: Addison-Wesley.

242. Tupes, E. and Christal R., (1961). Recurrent Personality Factors based on Trait Ratings. *USAFASD Technical Report* (61-97). Lackland Air Force Base, Texas.

243. Turin, D.A. (1973). Construction and Development, *University College Environmental Research Group, Building Economics Research Unit*, 1973

*244.* Uman, D.M., (1990) Is a standard needed for estimating building design and construction cost? *Cost Engineering*, **32**(8), pp. 7-10.

245. Uzzi, B., (1997). Social structure and competition in interfirm networks; the paradox of embeddedness. *Administrative Science Quarterly,* Vol. 42, pp.35-67.

*246.* Vegara, A.J., and Boyer,L.T. (1974) Probabilistic approach to estimating and cost control. *Journal of Construction Division, ASCE*, 100, PP. 543-552.

247. Vianem V., Annelies E. M, and Kmieciak Y.M., (1998). “The Match Between Recruiters Perceptions of Organisational Climate and Personality of the Ideal Applicant for a Management Position.” *International Journal of Selection and Assessment,* Vol.6, July, 1998, pp.153-163.

248. Vose, D. (1996). *Quantitative risk analysis: a guide to Monte Carlo simulation modelling*. Chichester: Wiley.

249. Voster M.C. and DE LA Garza J.M.D., (1990). “Consequential Equipment cost associated with lack of availability and downtime.” *Journal of Construction Engineering and Management*, ASCE, Vol.116, No.4, pp. 656-669.

250. Walker, A., Greenwood, D. and Johansen, E. (2010). User engagement and quality in the design of UK schools. In. Egbu, C. (Ed) *Proceedings of 26th Annual ARCOM Conference,* 6-8 September 2010, Leeds, UK, Association of Researchers in Construction Management, pp.3-12.

251. Walker, D., and Hampson, K., (2003) *Procurement Strategies: A relationship based approach,* Blackwell since Ltd., Osney Mead, UK.

252. Wang, C.H., and Mei, Y.H. (1998) Model for forecasting construction cost indices min Taiwan. *Construction Management and Economics,* 16(2), pp. 147-157.

253. Watson, R and Kwak, Y. H. (2004) Parametric estimating in the knowledge age: capitalizing on technological advances. *IAMOT 2004 - 13th International Conference on Management of Technology,* Washington, DC, April 3-7, 2004.

254. Wen-Der, Y. (2006) PIREM: a new model for conceptual cost estimation. *Construction Management and Economics,* Vol. 24, pp. 259-270, March, 2006.

255. Wickens, A. (2005). *Foundations of Biopsychology*. England: Pearson Education Limited, Edinburgh Gate, Harlow.

256. Wiggins, J.S. (1979). *A Psychological taxonomy of trait-descriptive terms*: The interpersonal domain. Journal of Personality and Social Psychology, **37**, pp.395-412

257. Williams, T.P., (2003). Predicting final cost of competitive bid construction projects using regression models. *International Journal of Project Management,* Vol. 21, pp.593-599.

258. Wilmot, C.G., and Cheng, G., (2003) Estimating future highway construction cost. *Journal of Construction Engineering and Management,* **129**(3), pp. 272-279.

259. Wong, J. T. Y., and Hui, E. C. M., (2006). Construction project risks: further considerations for contractors' pricing in Hong Kong. *Construction Management and Economics,* Vol.24, pp.425-438.

260. Yates, J.K., (1992). "A computerised inquiry-feedback knowledge engineering system." *American Association Cost Engineers* (AACE) Vol. 2. pp. R.1.1-R.1.7.

261. Yin, R. K. (2003). *Case study research: Design and methods*, 3rd edition. Sage Publications, Thousand Oaks, CA.

262. Yu, W.D., and Lai, C.C., (2003) WICE: a Web-based Intelligent Cost Estimator for real-time decision support, *Proceedings of the 2003 IEEE/WIC International Conference on Weh Intelligence*, Halifax, Canada, Session 10B, IEEE/WIC, 13-17 October.

263. Zaheer, A., McEvily, B., Perrone, V., (1998). Does trust matter? Exploring the effects of inter organisational and interpersonal trust on performance. *Organisation Science,* 9(2) pp. 141-159.

# APPENDICES

# APPENDIX A

## APPENDIX A: SAMPLE FORM OF LETTER SENT TO RESPONDENTS

Department of Civil and Building Engineering
Loughborough University, Leicestershire, LE11 3TU, UK
Switchboard: +44(0)1509 263171 | Department: +44(0)1509 222884 | Direct: +44(0)1059 223776

Loughborough University

To whom it may concern

Direct Line: +44(0)1509 223776
Fax: +44(0)1509 223981
E-mail: c.afetornu@lboro.ac.uk
http://www.lboro.ac.uk/departments/cv/

22nd December 2009

Dear Sir/Madam

**Achieving Reliable Estimates**

I am writing to request your assistance and support for a major research into how **Cost Estimates** can be improved to yield more reliable forecast of project cost.

The importance of achieving reliable estimates in the delivery of projects is recognised and shared by all the stakeholders. Notwithstanding considerable effort made by practitioners and researchers over the years, the problem of unreliable estimates continues to reflect in projects; a situation that is shared by the construction industry in Ghana. Much of the efforts made in the past to address the problem of reliable estimates have focused on the contribution of factors outside the control of the estimator, such as the amount of information. The current study takes a different approach and sees the estimator as pivotal to achieving improvements in accuracy and reliability for estimates that they produce. The study is aimed at exploring the effect of factors such as individual preferences and choices made by estimators have on the level of reliability and accuracy.

The exercise involved in the study requires the completion of two tasks for which your involvement would contribute to a better understanding of how to improve the reliability of estimates. The tasks comprise completing an **Evaluation Instrument**, and performing a **Simple Estimating Task**. In appreciation of your input, a feedback session will be provided on the key aspects of the study that can contribute to achieving improvement in estimating reliability. Please indicate on the Evaluation Instrument whether you would want to participate in the feedback session.

Naturally, all responses provided will be treated with the strictest of confidence, and any feedback will only employ data that has been aggregated and rendered anonymous.

Thank you in anticipation of your effort, support and time.

Yours sincerely

Charles Afetornu

# APPENDIX B

# OBSERVED GROUP QUESTIONNAIR

## Research on Achieving Reliable Estimates

ESTIMATOR EVALUATION INSTRUMENT

This instrument is aimed at collecting basic information on the factors that influence the reliability of estimates produced by practitioners.
It forms part of a research study directed at exploring how project cost estimates can be improved.
The completion of the instrument is not a test, and there are no right or wrong answers.

*Please complete all sections of the instrument.*

**Section A Personal and Organisational Details**

| | | | | | |
|---|---|---|---|---|---|
| Please state your full name | **1** | | | | |
| What is your educational qualification | CTC | HND | BSc | PG Dip | MSc |
| Please indicate your working experience (*years*) | 0-2 | 3-4 | 5-6 | 7-10 | >10 |
| State the name of your current employer | INSTRY OF ROADS AND HIGHWAYS/ DEPT. OF FEEDER ROAD | | | | |
| How long have you been with your current employer (*years*) | 0-2 | 3-4 | 5-6 | 7-10 | >10 |
| What is your current position with your present employer | Tech Off. | Ass. QS | QS | Snr QS | ≥Prin QS |
| | Other | ASSISTANT ENGINEER | | | |
| How long have you been in this position (*years*) | 0-2 | 3-4 | 5-6 | 7-10 | >10 |
| What was your previous position | Tech Off. | Ass. QS | QS | Snr QS | ≥Prin QS |
| | Other | ASSISTANT ENGINEER | | | |
| Please indicate which of the following typify your current job role | Valuation | Estimating | Admin Work | Advisory | Document |
| | Other | PROJECTION SUPERVISION AND MONITORING | | | |
| On average, how may projects do you estimate per annum | 0 - 5 | 6 - 10 | 11 - 15 | 16 - 20 | >20 |
| State the value of the largest project you prepared an estimate for (*NB: Cost in GHC 10000.00*) | 0-20 | 20-50 | 50-100 | 100-500 | □500 |

**Section B Influences on estmating ability**

The following questions explore which factors influence your estimating proficiency and the extent to which such influence exists

*Please indicate for each question the degree to which it reflects your estimating practice*

| | Never | Only when required | Sometimes | Often | Always |
|---|---|---|---|---|---|
| **In generating an estimate:** | 0% | 25% | 50% | 75% | 100% |
| I consult other estimators in my organisation | | x | | | |
| I consult engineers in my organisation | | x | | | |
| I seek approval for my estimate from my peers and superiors | | x | | | |
| I consult other estimators outside my organisation | | x | | | |
| I discuss with others who is prepared to listen | | x | | | |
| | 0 | 5 | 0 | 0 | 0 |
| I work on the priniciple of *'the end justifies the means'* | | x | | | |
| I do not consider what the public expects from my work | | | x | | |
| I confront others who criticise my work | x | | | | |
| I analyse documents very quickly | | | | x | |
| I make decision very quickly | | | x | | |
| | 1 | 1 | 2 | 1 | 0 |
| I feel a lot of tension during the whole task | | x | | | |
| I am sensitive to comments on my estimates | | | | x | |
| I feel nervous when my work is being reviewed | | x | | | |
| I change decisions when others criticise my work | | x | | | |
| I change my decisions when my peers comment on my work | | x | | | |
| | 0 | 4 | 0 | 1 | 0 |

**Section B** **Influences on estmating ability** *(continued)*

| In generating an estimate: | Never 0% | Only when required 25% | Sometimes 50% | Often 75% | Always 100% |
|---|---|---|---|---|---|
| I rely only on my thoughts in making decisions | | | x | | |
| I consider the output of my work to be superior to that of others | | x | | | |
| I have an obdurate character | | x | | | |
| I disagree with any negative comments on my work | | x | | | |
| I consider myself unyielding to suggestions from others | | x | | | |
| | 0 | 4 | 1 | 0 | 0 |
| I take at face value any available information | | x | | | |
| I base my decisions on what I feel at the time | | x | | | |
| I accept unproven new ideas in preparing my estimate | | | x | | |
| I change my decisions everytime a different option is presented | | | x | | |
| I look for new ways of performing the same task | | | | | x |
| | 0 | 2 | 2 | 0 | 1 |
| I make all decisions by myself with no input from engineers | | x | | | |
| I make all decisions by myself with no input from other estimators | | x | | | |
| I see myself as the approving person | | | | x | |
| I consider the work as confidential to others in my organisation | | | x | | |
| I consider the work as confidential to others outside my organisation | | | | x | |
| | 0 | 2 | 1 | 2 | 0 |
| I am happy to agree with the view of others on my work | | | | x | |
| I tolerate criticism of my work | | x | | | |
| I am happy to listen to views from my peers | | x | | | |
| I lend support to the work of my subordinates | | | | x | |
| I share any new insights and knowledge I gain with peers | | | | x | |
| | 0 | 2 | 0 | 3 | 0 |
| I am calm in making key decisions | | | | | x |
| I am definitive on any decision I make | | | | x | |
| I am unperturbed by comments from others on my work | | | | x | |
| I consider myself to be able to work well under pressure | | | | x | |
| I defend my decisions against negative comments from others | | | | x | |
| | 0 | 0 | 0 | 4 | 1 |
| I keep at a task until it is completed | | | | | x |
| I take time to analyse all available project information | | | | x | |
| I prefer detailed costing as against PC sums for M&E | | | | x | |
| I am mindful of what the public expects of me | | | | | x |
| I am always ready for a new assignment | | | | x | |
| | 0 | 0 | 0 | 3 | 2 |
| I base my decisions on proven and justifiable evidence | | | | x | |
| I prefer the established procedure to a proposed new one | | | | x | |
| I consider the outcome to be more important than the procedure | | | | x | |
| Advent of new and proven methods do not sway my decisions | | | | x | |
| I arrive at a decision only after considering all available evidences | | | | x | |
| | 0 | 0 | 0 | 5 | 0 |

**Additional Comments and Suggestions**

Participate in Feedback Session Yes No

Please return your completed instrument to: Charles Afetornu
Department of Civil and Building Engineering, Loughborough University
Loughborough, Leicestershire, LE11 3TU, United Kingdom

**Thank you for your help**

# APPENDIX C

# CONTROL GROUP QUESTIONNAIR

## Research on Achieving Reliable Estimates

ESTIMATOR EVALUATION INSTRUMENT

This instrument is aimed at collecting basic information on the factors that influence the reliability of estimates produced by practitioners.
It forms part of a research study directed at exploring how project cost estimates can be improved.
The completion of the instrument is not a test, and there are no right or w rong answ ers.

*Please complete all sections of the instrument.*

**Section A Personal and Organisational Details**

| | | | | | |
|---|---|---|---|---|---|
| Please state your full name | 1 | | | | |
| What is your educational qualification | CTC | HND | BSc | PG Dip | M Sc |
| Please indicate your working experience (*years*) | 0-2 | 3-4 | 5-6 | 7-10 | >10 |
| State the name of your current employer | DEPARTMENT OF URBAN ROADS | | | | |
| How long have you been with your current employer (*years*) | 0-2 | 3-4 | 5-6 | 7-10 | >10 |
| What is your current position with your present employer | Tech Off. | Ass. QS | QS | Snr QS | ≥Prin QS |
| | Other | | | | |
| How long have you been in this position (*years*) | 0-2 | 3-4 | 5-6 | 7-10 | >10 |
| What was your previous position | Tech Off. | Ass. QS | QS | Snr QS | ≥Prin QS |
| | Other | | | | |
| Please indicate which of the following typify your current job role | Valuation | Estimating | Admin Work | Advisory | Document |
| | Other | | | | |
| On average, how may projects do you estimate per annum | 0 - 5 | 6 - 10 | 11 - 15 | 16 - 20 | >20 |
| State the value of the largest project you prepared an estimate for (*NB: Cost in GHC 10000.00*) | 0-20 | 20-50 | 50-100 | 100-500 | 500 |

**Section B Influences on estmating ability**

The follow ing questions explore w hich factors influence your estimating proficiency and the extent to w hich such influence exists

*Please indicate for each question the degree to which it reflects your estimating practice*

| | Never | Only when required | Sometimes | Often | Always |
|---|---|---|---|---|---|
| **In generating an estimate:** | 0% | 25% | 50% | 75% | 100% |
| I consult other estimators in my organisation | | | | x | |
| I consult engineers in my organisation | | x | | | |
| I seek approval for my estimate from my peers and superiors | | | | x | |
| I consult other estimators outside my organisation | | | x | | |
| I discuss with others who is prepared to listen | | | | x | |
| | 0 | 1 | 1 | 3 | 0 |
| I work on the priniciple of *'the end justifies the means'* | | | | x | |
| I do not consider what the public expects from my work | | x | | | |
| I confront others who criticise my work | | | | x | |
| I analyse documents very quickly | | | | | x |
| I make decision very quickly | | | | x | |
| | 0 | 1 | 0 | 3 | 1 |
| I feel a lot of tension during the whole task | | x | | | |
| I am sensitive to comments on my estimates | | | | x | |
| I feel nervous when my work is being reviewed | x | | | | |
| I change decisions when others criticise my work | | x | | | |
| I change my decisions when my peers comment on my work | | x | | | |
| | 1 | 3 | 0 | 1 | 0 |

| **Section B** | **Influences on estmating ability** | *(continued)* | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Never | Only when required | Sometimes | Often | Always |
| **In generating an estimate:** | | | 0% | 25% | 50% | 75% | 100% |
| I rely only on my thoughts in making decisions | | | | x | | | |
| I consider the output of my work to be superior to that of others | | | x | | | | |
| I have an obdurate character | | | x | | | | |
| I disagree with any negative comments on my work | | | | x | | | |
| I consider myself unyielding to suggestions from others | | | | x | | | |
| | | | 2 | 3 | 0 | 0 | 0 |
| I take at face value any available information | | | x | | | | |
| I base my decisions on what I feel at the time | | | | x | | | |
| I accept unproven new ideas in preparing my estimate | | | x | | | | |
| I change my decisions everytime a different option is presented | | | | x | | | |
| I look for new ways of performing the same task | | | | | | | x |
| | | | 2 | 2 | 0 | 0 | 1 |
| I make all decisions by myself with no input from engineers | | | x | | | | |
| I make all decisions by myself with no input from other estimators | | | x | | | | |
| I see myself as the approving person | | | x | | | | |
| I consider the work as confidential to others in my organisation | | | x | | | | |
| I consider the work as confidential to others outside my organisation | | | | x | | | |
| | | | 4 | 1 | 0 | 0 | 0 |
| I am happy to agree with the view of others on my work | | | | | | | x |
| I tolerate criticism of my work | | | | | | | x |
| I am happy to listen to views from my peers | | | | | | | x |
| I lend support to the work of my subordinates | | | | | | | x |
| I share any new insights and knowledge I gain with peers | | | | | | | x |
| | | | 0 | 0 | 0 | 0 | 5 |
| I am calm in making key decisions | | | | | | x | |
| I am definitive on any decision I make | | | | | | | x |
| I am unperturbed by comments from others on my work | | | | x | | | |
| I consider myself to be able to work well under pressure | | | | | | x | |
| I defend my decisions against negative comments from others | | | | | | | x |
| | | | 0 | 1 | 0 | 2 | 2 |
| I keep at a task until it is completed | | | | | | | x |
| I take time to analyse all available project information | | | | | | | x |
| I prefer detailed costing as against PC sums for M&E | | | | | | x | |
| I am mindful of what the public expects of me | | | | | | x | |
| I am always ready for a new assignment | | | | | | x | |
| | | | 0 | 0 | 0 | 3 | 2 |
| I base my decisions on proven and justifiable evidence | | | | | | | x |
| I prefer the established procedure to a proposed new one | | | | | | | x |
| I consider the outcome to be more important than the procedure | | | | x | | | |
| Advent of new and proven methods do not sway my decisions | | | | x | | | |
| I arrive at a decision only after considering all available evidences | | | | | | | |
| | | | 0 | 2 | 0 | 0 | 2 |

**Additional Comments and Suggestions**

Participate in Feedback Session | Yes | No

Please return your completed instrument to: Charles Afetornu
Department of Civil and Building Engineering, Loughborough University
Loughborough, Leicestershire, LE11 3TU, United Kingdom

**Thank you for your help**

# APPENDIX D

# SAMPLE ESTIMATING TASK

| | | | | | | |
|---|---|---|---|---|---|---|
| ESTIMATING TASK | | | | | | |
| ESTIMATING COST OF ONE METRE STREACH OF PROPOSED SPEED RAMP | | | | | | |
| | | | | | | |
| | RESOURCE DETAILS | | | | | |
| **Resource** | **Unit** | **Unit Price** | **Resource Qty.** | **Assume % for waste** | **Total Qty.** | **TOTAL COST** |
| ***Materials*** | | | | | | |
| 20mm Course Aggregates | cu.m | 200.00 | 0.76 | | | |
| Sand | cu.m | 15.00 | 0.48 | | | |
| Cement | bag of 50kg | 12.00 | 6.5 | | | |
| Haulage of Cement | bag of 50kg per Km | 0.20 | 1 | | | |
| **Materials Cost to Summary** | | | | | | |
| | | | | | | |
| ***Equipment*** | | | | | | |
| 14/10 Conc. Mixer | Equip-hr | 10 | 1.3 | | | |
| Small Tools | Assume lump sum | | | | | |
| **Equipment/ Small tools Cost to Summary** | | | | | | |
| | | | | | | |
| ***Labour*** | | | | | | |
| Labour | Man-hr | *****0.6x Mult. Factor | 3.5 | | | |
| **Labour Cost to Summary** | | | | | | |
| | | | | | | |
| **SUMMARY** | | | | | | |
| *Material Cost* | | | | | | |
| *Equipment/ Small tools Cost to Summary* | | | | | | |
| *Labour Cost to Summary* | | | | | | |
| ***Sub-Total (A)*** | | | | | | |
| | | | | | | |
| Add Assumed % on A for overheads | | | | | | |
| ***Sub-Total (B)*** | | | | | | |
| | | | | | | |
| Add. Assume % on B for profit | | | | | | |
| | | | | | | |
| **GRAND TOTAL: ESTIMATED COST** | | | | | | |
| | | | | | | |
| ***0.6 = Basic wage** | | | | | | |
| *** Assume Multiplying Factor for all provisions in Labour Act, Act 652 for ALL-IN-RATE** | | | | | | |

# APPENDIX E

# COST ESTIMATES

| Estimator | Estimated Cost (GHS) | Estimator | Estimated Cost (GHS) |
|---|---|---|---|
| **1** | 339.16 | **32** | 434.08 |
| **2** | 357.55 | **33** | 378.10 |
| **3** | 359.48 | **34** | 297.50 |
| **4** | 331.69 | **35** | 373.43 |
| **5** | 347.67 | **36** | 377.24 |
| **6** | 362.66 | **37** | 555.61 |
| **7** | 339.91 | **38** | 329.40 |
| **8** | 503.75 | **39** | 340.15 |
| **9** | 594.88 | **40** | 40.79 |
| **10** | 410.44 | **41** | 374.05 |
| **11** | 420.20 | **42** | 471.30 |
| **12** | 336.91 | **43** | 214.48 |
| **13** | 333.42 | **44** | 399.40 |
| **14** | 573.91 | **45** | 341.69 |
| **15** | 344.04 | **46** | 350.16 |
| **16** | 425.71 | **47** | 583.22 |
| **17** | 445.08 | **48** | 299.74 |
| **18** | 419.49 | **49** | 357.78 |
| **19** | 400.28 | **50** | 373.22 |
| **20** | 346.22 | **51** | 326.06 |
| **21** | 330.44 | **52** | 505.50 |
| **22** | 336.92 | **53** | 351.76 |
| **23** | 606.28 | **54** | 272.32 |
| **24** | 333.63 | **55** | 368.78 |
| **25** | 432.96 | **56** | 375.05 |
| **26** | 462.89 | **57** | 449.49 |
| **27** | 345.43 | **58** | 316.21 |
| **28** | 1,084.26 | **59** | 323.07 |
| **29** | 364.75 | **60** | 329.67 |
| **30** | 384.94 | **61** | 302.00 |
| **31** | 496.71 | | |

# APPENDIX F

## STANDARDISED Z-SCORES OF COST ESTIMATES

| Estimator | Standardised Z-Scores | Estimator | Standardised Z-Scores |
|---|---|---|---|
| 1 | -0.0579 | 32 | 0.2058 |
| 2 | -0.0068 | 33 | 0.0503 |
| 3 | -0.0014 | 34 | -0.1736 |
| 4 | -0.0786 | 35 | 0.0373 |
| 5 | -0.0343 | 36 | 0.0479 |
| 6 | 0.0074 | 37 | 0.5434 |
| 7 | -0.0558 | 38 | -0.0850 |
| 8 | 0.3993 | 39 | -0.0551 |
| 9 | 0.6524 | 40 | -0.8867 |
| 10 | 0.1401 | 41 | 0.0390 |
| 11 | 0.1672 | 42 | 0.3092 |
| 12 | -0.0641 | 43 | -0.4042 |
| 13 | -0.0738 | 44 | 0.1094 |
| 14 | 0.5942 | 45 | -0.0509 |
| 15 | -0.0443 | 46 | -0.0273 |
| 16 | 0.1825 | 47 | 0.6201 |
| 17 | 0.2363 | 48 | -0.1674 |
| 18 | 0.1653 | 49 | -0.0062 |
| 19 | 0.1119 | 50 | 0.0367 |
| 20 | -0.0383 | 51 | -0.0943 |
| 21 | -0.0821 | 52 | 0.4042 |
| 22 | -0.0641 | 53 | -0.0229 |
| 23 | 0.6841 | 54 | -0.2436 |
| 24 | -0.0733 | 55 | 0.0244 |
| 25 | 0.2027 | 56 | 0.0418 |
| 26 | 0.2858 | 57 | 0.2486 |
| 27 | -0.0405 | 58 | -0.1216 |
| 28 | 2.0118 | 59 | -0.1026 |
| 29 | 0.0132 | 60 | -0.0842 |
| 30 | 0.0693 | 61 | -0.1611 |
| 31 | 0.3798 | | |

# APPENDIX G

# CORRELATIONS OF TRAITS

**Correlations**

| | | Openness | Neuroticism |
|---|---|---|---|
| Openness | Pearson Correlation | 1 | .300* |
| | Sig. (2-tailed) | | .019 |
| | N | 61 | 61 |
| Neuroticism | Pearson Correlation | .300* | 1 |
| | Sig. (2-tailed) | .019 | |
| | N | 61 | 61 |

*. Correlation is significant at the 0.05 level (2-tailed).

**Figure G1: Correlation of Openness and Neuroticism**

**Correlations**

| | | Neuroticism | Extraversion |
|---|---|---|---|
| Neuroticism | Pearson Correlation | 1 | .072 |
| | Sig. (2-tailed) | | .582 |
| | N | 61 | 61 |
| Extraversion | Pearson Correlation | .072 | 1 |
| | Sig. (2-tailed) | .582 | |
| | N | 61 | 61 |

**Figure G2: Correlation of Neuroticism and Extraversion**

**Correlations**

| | | Extraversion | Openness |
|---|---|---|---|
| Extraversion | Pearson Correlation | 1 | -.332** |
| | Sig. (2-tailed) | | .009 |
| | N | 61 | 61 |
| Openness | Pearson Correlation | -.332** | 1 |
| | Sig. (2-tailed) | .009 | |
| | N | 61 | 61 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Figure G3: Correlation of Extraversion and Openness**

# APPENDIX G (CONT'D)

**Correlations**

| | | Extraversion | Conscientiousness |
|---|---|---|---|
| Extraversion | Pearson Correlation | 1 | .165 |
| | Sig. (2-tailed) | | .203 |
| | N | 61 | 61 |
| Conscientiousness | Pearson Correlation | .165 | 1 |
| | Sig. (2-tailed) | .203 | |
| | N | 61 | 61 |

**Figure G4: Correlation of Extraversion Conscientiousness**

**Correlations**

| | | Extraversion | Agreeableness |
|---|---|---|---|
| Extraversion | Pearson Correlation | 1 | .435** |
| | Sig. (2-tailed) | | .000 |
| | N | 61 | 61 |
| Agreeableness | Pearson Correlation | .435** | 1 |
| | Sig. (2-tailed) | .000 | |
| | N | 61 | 61 |

**. Correlation is significant at the 0.01 level (2-tailed).

**Figure G5: Correlation of Extraversion and Agreeableness**

**Correlations**

| | | Agreeableness | Conscientiousness |
|---|---|---|---|
| Agreeableness | Pearson Correlation | 1 | .263* |
| | Sig. (2-tailed) | | .041 |
| | N | 61 | 61 |
| Conscientiousness | Pearson Correlation | .263* | 1 |
| | Sig. (2-tailed) | .041 | |
| | N | 61 | 61 |

*. Correlation is significant at the 0.05 level (2-tailed).

**Figure G6: Correlation of Agreeableness and Conscientiousness**

# APPENDIX G (CONT'D)

**Correlations**

| | | Agreeableness | Openness |
|---|---|---|---|
| Agreeableness | Pearson Correlation | 1 | -.120 |
| | Sig. (2-tailed) | | .358 |
| | N | 61 | 61 |
| Openness | Pearson Correlation | -.120 | 1 |
| | Sig. (2-tailed) | .358 | |
| | N | 61 | 61 |

**Figure G7: Correlation of Agreeableness and Openness**

**Correlations**

| | | Agreeableness | Neuroticism |
|---|---|---|---|
| Agreeableness | Pearson Correlation | 1 | -.112 |
| | Sig. (2-tailed) | | .392 |
| | N | 61 | 61 |
| Neuroticism | Pearson Correlation | -.112 | 1 |
| | Sig. (2-tailed) | .392 | |
| | N | 61 | 61 |

**Figure G8: Correlation of Agreeableness and Neuroticism**

**Correlations**

| | | Neuroticism | Openness |
|---|---|---|---|
| Neuroticism | Pearson Correlation | 1 | .300* |
| | Sig. (2-tailed) | | .019 |
| | N | 61 | 61 |
| Openness | Pearson Correlation | .300* | 1 |
| | Sig. (2-tailed) | .019 | |
| | N | 61 | 61 |

*. Correlation is significant at the 0.05 level (2-tailed).

**Figure G9: Correlation of Neuroticism and Openness**

# APPENDIX G (CONT'D)

**Correlations**

| | | Neuroticism | Agreeablenes s |
|---|---|---|---|
| Neuroticism | Pearson Correlation | 1 | -.112 |
| | Sig. (2-tailed) | | .392 |
| | N | 61 | 61 |
| Agreeableness | Pearson Correlation | -.112 | 1 |
| | Sig. (2-tailed) | .392 | |
| | N | 61 | 61 |

**Figure G10: Correlation of Neuroticism and Agreeableness**