TECHNOLOGY, ITS APPLICATION AND PRODUCTIVITY OPTIMISATION IN GHANA: A CASE STUDY

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Technology has two major components, hardware (the tool that embodies the technology as a material or physical object), and software (the knowledge base for the tool)" (Rogers, 2003). Information technology has become pervasive in many Ghanaian organizations. Many view information technology innovations as strategic organizational tools. Researchers suggest that technology applications for example, computers, telecommunication services and software are the goals of most organizations. Others contend that the use of the technology application services can enable organizations to reduce its inefficiencies and errors in the job processes thus improving organizational performance.

In the increasingly global business environment, there is a growing need to accept and utilize technology to achieve efficiencies, coordination, and communication (Laudon and Laudon, 2006; Porter and Miller, 1985). Technology acceptance and its application, is the demonstrable willingness within a user group to employ the technology and also use it for the tasks it is designed to support, and is a crucial factor for deriving benefits in multinational and transnational organizations (Dillon and Morris, 1996). Usability of technology can be defined as "a measure of the ease with which a technology can be learned or used, its safety, effectiveness and efficiency, and attitude of its users towards it" (Preece et al., 1994), while acceptability is one which appropriately satisfies the requirements of its users for utility, usability, and cost.

Businesses have become more international in today's society. Despite significant investments in technology by businesses in both developed and developing countries over recent decades, concern still exists over the extent to which such expenditures have produced the intended benefits. Concern is

therefore raised on the issue of whether any of such technology in Ghana is accepted and to what extent it is being used by its intended users.

Given the pace of information technology (IT) change, the issues of information technology implementation and employee acceptance and usability of IT have become increasingly important in most Ghanaian organizations. The questions that one asks are: Are employees ready to accept technology? Are they ready to use the technology? How could application of Information technology benefit the organization? How could technology and its application bring about organizational productivity optimization if it is not accepted and then utilized? These are issues that must be fully examined prior to the introduction of any technologies in our organizations.

People vary in their orientation towards using technology. Some organizations like Quality Company Limited (QCC) face resistance or lack of confidence in new technology or computer systems which affect the investment in technology and prevent or impair performance improvement. As an information systems' expert, it is necessary to spend time investigating how users accept technology, or variables affecting the users' decisions in using such technology and then the impact of technology application on productivity optimization.

Understanding and predicting how new technologies would be received by their potential users in organizations is one of the crucial topics when planning design processes and during the actual design activity. In order to understand both the users' mindsets and their activity contexts towards new technologies, successful predictions of acceptance and utilization are important. Just allocating the systems does not return always efficient results. Information technologies are introduced in organizations because it is anticipated that high utilization of these technologies bring out efficient results when accepted and then at the same time also used. Businesses have become more

international in today's society. Despite significant investments in technology by businesses in both developed and developing countries over recent decades, concern still exists over the extent to which such expenditures have produced the intended benefits. Concern is therefore raised on the issue as to whether any of such technology is accepted and to what extent it is being used by its intended users.

Although technology acceptance, its application and productivity optimization has been a key component of information technology research, little has been done to determine the association between technology acceptance and its application in respect to productivity.

Specifically the relationship between technology acceptance and its application with respect to productivity has not been comprehensively examined especially in the developing countries like Ghana. Shackel (1991) is one of the few researchers who made an explicit study on the association between technology acceptability and its usability. It is important for Ghanaians organizations to note that, ability to deploy any technology is obviously necessary, it is not sufficient to ensure acceptability, and that many technologies that are demonstrably usable are never accepted or the vice versa, by the target users.

Ghanaian companies, heavily invest resources toward enhancing the productivity of their workers by providing access to various technology applications. Unfortunately, as numerous managers have discovered in the past, mere investment in these systems does not guarantee enhanced productivity of the user base. There is a general belief that technology and its usage eases and contributes significantly to many aspects of our life (Nunn and Quinet, 2002). New technologies have changed drastically our ways of thinking, perceptions, attitudes, symbols, and even our community. In particular, technology application has transformed our big world into a small village by creating communication channels all around the globe (Chan, 2001). The returns reaped from technological investments are

largely a function of the relationship of knowledge workers' acceptance and actual utilization of these systems.

Information technology (IT) acceptance and its application has been a key area of information systems research for the last two decades, because information technology represents a substantial investment for most organizations and constitutes a significant standpoint of their work. The characteristics of users in organization and the features of tasks affect the process of technology acceptance and the effective use of a particular technology, thus inhibiting productivity optimization, . Resistance to acceptance and usage of information technology is a common problem for our organizations especially in the developing countries of which Ghana is no exception. However, if a technology is accepted and at the same time utilized by the organizations' intended users, then that technology would bring success to the organizations at the managerial, professional, and operational levels. Thus organizational productivity would increase significantly. For instance, organization should not just allocate or implement information technologies because it has the resources but should investigate if the users' mindsets are prepared for their acceptance and usage as well.

Information technology has become pervasive in almost all industry. Again, many view information technology innovations specifically, the Internet and others as strategic tools. Most strategists suggest that technology applications for example, electronic health records, e-prescribing, Internet services, computers and others are the goals of most organizations. Others say that the use of the technology enables organizations to reduce their inefficiencies and errors in the delivery job processes. As organizations become increasingly wired and workers face increasing workload demands, usage of numerous technology applications could assist to accomplish their work. Despite the purported advantages of IT investments in companies many individuals do not widely use computer-based applications in their operational practices.

Studies of information technology (IT) adoption have focused on numerous antecedents to behavioral intent to use. Although some antecedents (such as subjective norms) reflect aspects of the organizational environment, most antecedents reflect beliefs or attitudes about the technology itself. Study also posits that general beliefs about the organizational environment can influence employee adoption of information technology used on the job. In particular, it is also said that effective commitment, perceived usefulness, ease of use, team member trust, subjective norms and others, influence behavioral intent to accept usage of a technology. Research can therefore provide valuable insights into the nature of processes, obstacles, and opportunities present in technological environments and that, it can also enhance our understanding of technological acceptance, its application and productivity optimization.

Many researchers have studied and proposed theories and models of technology in order to predict and explain user behaviour towards technology application and its productivity optimization. Each theory or model has been proposed with different sets of determinants and moderators and most of them have been developed in the U.S. For instance, even TAM that posits the influence of perceived usefulness, Ease of use and attitude towards technology acceptance and usage, were tried in the developed countries. It is therefore questioned whether these theories and models of technology acceptance, developed, modified, and extended in the U.S. could be used in other countries, especially in the developing ones like Ghana. It is also questioned whether other determinants and moderators of technology acceptance, its application, enhancing productivity optimization could also play a more important influential roles in other environment than others.

Again, most of the proposed theories tried to establish the influence of the determinants towards technology acceptance and usage. But it appears technology acceptance does not necessarily mean its usage or that technology as a whole does not breed productivity optimization if not accepted and at same time utilized. If Organizations like Quality Control Company Limited of COCOBOD has to make

maximum benefits from technological investments, then the people really have to accept and at the same time apply the technology deployed. Integration of the two is very necessary for systems' benefits. All the theories (TAM, TRA, etc) did not delve into the actual linkage of acceptance and usage of information technology which is also relevant for productivity. Are there instances where acceptance does not mean usage? Thus, if technology acceptance does not really mean its application, then there would be a blurring benefit of productivity.

It is against these grounds that the current study tries to investigate more thoroughly, organizational variables and determinants that influence technology acceptance and its application in relation to productivity optimization. In this regard, the purpose of the study is to provide and continue with a perspective which seeks to understand the linkage of technology acceptance, its application and productivity optimization in organizations. It also sought to test the significance and influence of the determinants of perceived usefulness, perceived ease of use and attitude (PU, PEOU and Attitude) of technology acceptance, its application and productivity optimization in Ghana.

Furthermore it would broaden our knowledge and understanding on technology acceptance and the necessary conditions sufficient for the preparation of technology usage and then the subsequent productivity optimization. Another relevant aspect of the study would imply that when introducing technology, managers or the appropriate authorities must pay attention not only to technology-related issues, but also the broader organizational environment in which the technology would be used as well as the willingness of the individuals to its usage.

1.2 The Problem Statement

Little research has been carried out on technology acceptance, its application and productivity optimization especially in the developing countries like Ghana. Though theories have focused on the influence of either technology acceptance or technology usage, they were developed and tried in the

developed countries. It is also not certain whether the influence of these determinants (e.g. usefulness, ease of use and attitude) would work on technology acceptance, its application and productivity optimization in the least developed nations. Furthermore, the relationship between technology acceptance and its application has received little attention, despite the great potentials technology offers; for improving the quality of services provided. Many researchers in the field of Information Systems (IS) have focused principally on how potential users' perceptions on information technology (IT) innovation influence its adoption and usage (Davis, 1989). Added to this, user acceptance of information technology (IT) has been a primary focus in the management information system (MIS) implementation research for the past decade, though in the developed countries.

Most research on innovation adoption and diffusion, especially in the rapid growing area of Information Technology, focuses on developed countries (Mathieson et al., 2001; Staub, 1994; Gallivan, 2001). Furthermore technology adoption research presumes that technology acceptance necessarily implies technology usage and productivity optimization (Davis, 1989, Afari-Kumah and Akwasi Kyere, 2009). These assumptions may fall short of realities in the least developed countries. In filling this void or correcting this deficiency, the current research seeks to examine the influence of the determinants (PU, PEOU and Attitude) of technology acceptance and its usage in the Ghanaian context and then establishes its relationship in the context of productivity optimization.

The research project addresses these questions: Why do users accept or reject information technology? Why do users use or reject Information Technology? If users accept a technology and applies it, does it really lead to productivity optimization? If users use a technology, does it really mean they have accepted it? Is there any linkage between technology acceptance and its usage? These are issues relevant to the researcher so as to establish clearly whether technology acceptance is a necessary condition for technology usage and that technology acceptance and its application is also a sufficient condition for productivity optimization.

According to Agarwal (1999) "...Acquiring appropriate Information Technology (IT) is a necessary but not sufficient condition for utilizing it effectively". The mere physical access to technology is not enough in itself to promote utilization which brings productivity increase. Therefore, understanding individual determinants to acceptance of Information Technology (IT) and also relating it to its usage is an important issue (Igbaria, 1990, Melone, 1990, Davis, 1989).

Understanding human factors which are significant in promoting acceptance and usage of information technology would ensure that new designs are built and implemented in such way so as to minimize user resistance in the organizations.

1.3 Objectives

The objective of this study was to use the method of regression analysis as follows:

- To examine the influence of PU, PEOU and A on technology
- To investigate the relationship between Technology when subjected to Age and 'Years of Experience'. How technology reacts to Age and years of experience in technology.
- To examine the relationship between technology and Productivity. How production values response to technology usage.

It was to further establish the relationship between technology and productivity with reference to computer technology in Quality Control Company of Ghana Cocoa Board (COCOBOD).

1.4 Methodology

We used Regression analysis approaches to study the effect of Technology acceptance, its usage and productivity optimization on the measures of explained variation. Regression analysis is a statistical tool that utilizes the relation between two or more quantitative variables so that one variable can be predicted from another. The variable we are trying to predict is called the response or dependent variable. The variable predicting this is called the explanatory or independent variable. Relationships

between variables can be either functional or statistical. A functional relationship is exact, while a statistical relationship has error associated with it. Regression analysis is utilized to develop an accurate mathematical formulation of the regression analysis. The simple linear regression function is;

$Y_i = \beta_0 + \beta_1 \times_1 + \varepsilon_i$ ***(1.1)***

In this model β_0, β_1, and ε_i are parameters and Y_i and X_i are measured values. For every level of X, there is a probability distribution for Y having mean $E(Y|\times) = \beta_0 + \beta_1 \times_1$ and variance $\sigma^2 (Y_i) = \sigma^2$ where σ^2 is the variance of the entire population. β_0 is called the intercept and β_1 is called the slope of the regression line.

The estimated regression function is

$Y_i = b_0 + b_1 X_i$: ***(1.2)***

We calculate b_0 and b_1 using the methods of least squares.

The researcher also used modified questionnaire from his Master's in Business Administration (MBA) program to solicit responses for the regression analysis.

1.5 Justification of the Study

This present study intends to examine the determinants influencing technology acceptance and usage and to also establish the relationship between technology application and productivity optimization. Understanding the influence of usefulness, ease of use and attitude will provide added leverage to enhance acceptance and application of computers and related technology in Quality Control Company (QCC) in order to boost operational performance and productivity. It is hoped that this research will provide education to QCC management, policy makers, and those interested in the use of computers and related technologies in Ghana with an understanding of how computers and related technologies become accepted and utilized by the end-users.

Most organizations quickly acquire the best technology but the extent to which it is accepted and put to use is a matter of concern. However, the main question that arises is whether these organizations, for

instance, end-users in Quality Control Company Ltd of COCOBOD are willing to accept and at the same time use the technology (computers, Internet services, E-mail services and application software packages) in performing their tasks. Despite huge information technology investments by COCOBOD, technologies are still not fully utilized by end- users for which increased in productivity is not realized.

With regards to the issues mentioned, the results of the study would be significant to Quality Control Company Limited (QCC) of COCOBOD as to whether computer technology/ information systems such as computers, application software and others which the Company introduces would be accepted and used by its intended users. Importantly, Quality Control Company Ltd could then predict accurately to ascertain that computer resources, allocated and implemented would be utilized by its intended users. The study is intended to provide assistance to Quality Control Company LTD, to better organize, deploy and manage information technology resources in order to enhance overall effectiveness and achieve productivity payoffs from information systems' investment.

The results from this study would again be used by management in charge of systems to either improve the system or utilize the information to find ways to attract new users to utilize technologies in the company.

Furthermore, the study is also intended to provide useful assistance to QCC of COCOBOD in the deployment of information systems' resources which the Company would efficiently utilize so as to derive maximum benefits from both existing as well as subsequent information technologies in the Company when adopted.

Researchers and Academia would also find the study useful as it lays bare where further research work on the topic can be carried out. It will again add up to the store of knowledge on technology acceptance, its application and productivity optimization. Findings would also serve as useful academic

materials for researchers and other academia in their field of study. Thus output would be used as a reference point for students.

To the General Public, the findings and facts of the investigation would increase the knowledge of the public on the relationship between technology acceptance and usage. To the public, it would increase their knowledge and understanding on how perceived usefulness, ease of use, attitude, behavior and other determinants influence individual's decisions on technologies in organizations.

It is again to aid the understanding and also educate policy makers that in introducing technologies, it is necessary to pay attention not only to technological-related issues, but also the broader organizational environment in which the technologies would be used as well as the willingness of the individuals who would be using such technologies. It would also enable policy makers to ensure that new systems which are designed, built and implemented, is done in such a way as to minimize users' resistance in the appropriate places.

1.6 Scope and Limitation of the Study

In every research there is the need to define clearly the areas of research to be conducted. This is because as a scientific discipline, those who would like to verify for the authenticity of the research findings could easily do that. It also gives the researchers the opportunity for comparing and replicating information elsewhere.

The actual study covered the Accra main office of Quality Control Company Ltd of COCOBOD – Ghana. The study was limited to Ghana as there is little literature on this subject in relation to the Ghanaian situation. This is to enable the researcher undertake an in-depth study on the problem.

The study area covered principally, perceived usefulness, perceived ease of use and behavioural attitude towards Information technologies such as computers, and others which have been deployed for the operations of Quality Control Company Ltd of COCOBOD for the past four years. The study also

covered users' perceptions regarding technology acceptance, its application and productivity optimization. It again intended to cover and examine the factors which could motivate Quality Control Company's staff to accept or reject, use or abandon a technology. It expanded to cover the relationship between technology acceptance, usage and productivity optimization. It further sought to investigate, why staff perceptions towards various technologies in Quality Control Company Ltd, might differ.

QCC, being a big organization, time was therefore the major limitation in completing this study. Another limitation was the issue of time on the part of the tester(s) group as well as their availability. Most of the focus groups, with high education, are the Directors, Managers, Officers, core users and others who had little time due to their tight schedule of work. Added to this, the large number of staff, intended to be examined, was inconvenient for the collection of the completed questionnaires. Other limitations encountered were access to accurate responses, answers and information from the respondents.

Regarding the above limitations, however, the researcher's position in QCC, and in-depth experience, brought to bear on this research and this also catered for any limitation that could detract the quality of work done.

1.7 Research Questions

The research study sought to address the following research questions:

- To what extent does perceived usefulness influence technology?
- Would perceived ease of use of computers influence acceptance?
- To what extent will perceived ease of use of a technology influence usage decision?
- Does attitude influence computer acceptance and usage decisions?
- How would usefulness and ease of use of computers influence attitude?
- Would technology acceptance and its application, in Quality Control Company Ltd improve job performance and productivity?

- Does acceptance or usage of a technology influence each other?
- To what extent is technology related to productivity optimization?

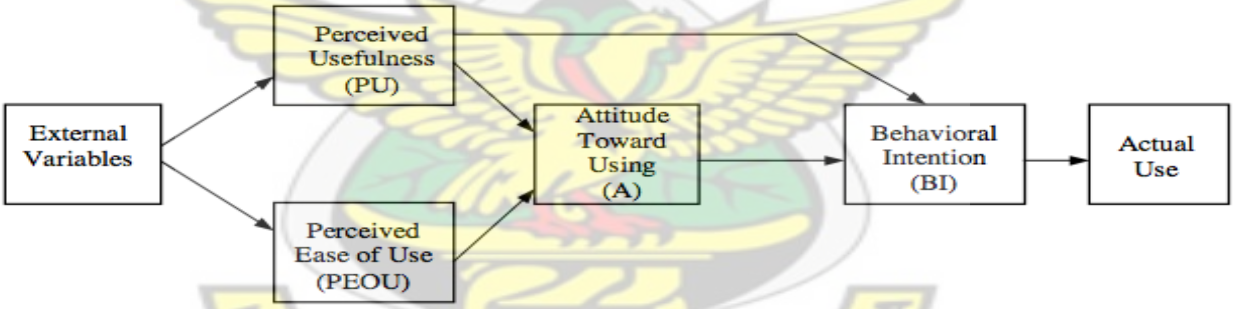
1.8 Theoretical Framework

In an attempt to predict the influence of the external variables on user acceptance and usage and also to establish the relationship between technology acceptance, its application and productivity optimization, it is useful to consider the assistance of Technology Acceptance Model (Davis, 1989, Davis *et al.*, 1989) in this research. Pursuing this extension of the Technology Acceptance Model (TAM) framework, the current research focuses on first, the influence of three principal variables; perceived usefulness (PU), perceived ease of use (PEOU) and attitude on technology acceptance and usage (refer figure 1.0) with regards to situations prevalent in the Ghanaian context and then its payoffs in terms of productivity. TAM is to provide a means for predicting technology acceptance and discretionary use of information systems and technologies (Davis, 1989; Davis et al., 1989). TAM is developed to study the decision-making processes of users as to whether or not to adopt information technology in giving settings. As a result of its practicability, it has gained a lot of popularity. It is a widely used approach for predicting user acceptance of information systems, and has produced consistently reliable research results over time in the developed nations (Davis, 1996). The model allows researchers not to only predict, but also explain why a particular system may or may not be acceptable to users (Davis et al., 1989). TAM is a model derived from a theory that addresses the issue of how users come to accept and use technology. The model suggests that when users are presented with, for instance, a new technology such as software application, Internet services, computers, a number of variables influence their decisions about how and when they would accept it. Accordingly, the two specific external variables, mentioned earlier, are hypothesized to be fundamental determinants of user acceptance to technology (Davis and Arbor, 1989). Perceived usefulness (PU) was defined as "the degree to which a person believes that using a particular system would enhance his or her job

performance" (Davis, Bagozzi, and Warsaw, 1989). Perceived ease-of-use (PEOU) was also defined as "the degree to which a person believes that using a particular system would be free from effort "(Davis, Bagozzi, and Warsaw, 1989, p.320). These two notions, particularly when translated into, "is this any use to me" and "can I make this work easily", are a common-sensical way of approaching the issue.

Based on the similarities, the current research therefore investigates the influence of these external variable; perceived usefulness, perceived ease of use and attitude, using the Technology Acceptance Model (in figure 1.0) as a reference mode, in the Ghanaian situation. TAM, considered appropriate to this research because technology payoffs is only realized if the technology is accepted and then applied in the organization.

Figure 1.0 TAM



Source: Davis, et al., (1989).

1.9 Definition of key Terms

Attitude (A): Attitude was defined in 1901 as "readiness for attention or action of a definite sort" (Baldwin, 1901).

Attitude Toward Using –one's feelings of favorableness or unfavorableness towards using the technology

Attitude toward the behavior is defined as the individual's positive or negative feelings about performing a behavior.

Acceptable system-is one that appropriately satisfies the requirements of its users for utility, usability, and cost.

Behavioral intention – is the extent to which an individual intends to perform a specific behavior. (Davis et al., 1989) or is the strength on one's intentions to use the technology in the future.

Belief-refers to a person's subjective probability judgment concerning some discriminable aspect of his world

Behavioral control is defined as one's perception of the difficulty of performing a behavior.

Diffusion: "The process by which an innovation (new idea) is communicated through certain channels over time among the members of a social system" (Rogers, 2003).

Innovation: "An idea, practice, or object perceived as new by an individual or other unit of adoption" (Rogers, 2003).

Perceived ease of use (PEOU) – defined as the degree to which a person believes that using a particular system would be free of effort. (Davis, 1989)

Perceived usefulness (PU) - is defined as "the degree to which a person believes that using a particular system would enhance his/her job performance" (Davis; 1989).

Technology: "Technologies have two components, including hardware (the tool that embodies the technology as a material or physical object), and software (the knowledge base for the tool)" (Rogers, 2003).

Usage -the amount of usage over a fixed unit of time.

Usability can be defined as "a measure of the ease with which a system can be learned or used, its safety, effectiveness and efficiency, and attitude of its users towards it" (Preece et al., 1994).

Subjective norm is defined as an individual's perception of whether people important to the individual think the behavior should be performed.

1.10 Organisation of the Study

The study is made up of five main chapters. Chapter 1 deals with the background of the study, statement of the problem, objectives, methodology, justification scope and limitation of the study, Research questions, Theoretical framework, Recommendation and definition of key terms.

Chapter 2 deals with the related literature relevant to the study.

Chapter 3 discusses the methodology used for the study.

Chapter 4 presents the results of data analysis and the discussion of the case study.

Chapter 5 deals with the Summary of results, conclusion and recommendation of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

As Information technologies infiltrate into our organizations, research on user acceptance, its usage and productivity optimization has started to receive much attention from professional as well as academic researchers. Even developers and software industries are beginning to realize that lack of user acceptance of a technology and its usage does not promote productivity in organizations and thus, leads to loss of money and resources. Various literatures from scholars were reviewed on the subject of Technology acceptance, its application and productivity optimization among users' organisations in particular. It reviews literature on the research topic with a view of identifying the gap in literature of which the study is intended to fill. One of the reasons of reviewing the literature is that a large number of works studying user acceptance or usage in using Information Systems (IS) was based on the developed countries. Most of these researchers have studied and proposed theories or models of technology acceptance in order to predict and explain user behaviour with regards to technology acceptance, its application and productivity optimization, to account for the rapid change in both technologies and their environments. Each theory or model has been proposed with different sets of determinants and moderators and most of them have been developed in the U.S. It is therefore questioned whether the theories and models of technology acceptance, its application and productivity optimization that have been developed, modified, and extended in the U.S. can be used in other countries, especially in the developing countries such as Ghana. On reviewing the literature, the researcher identifies that, most of theories and models on the influence of the determinants of technology acceptance and usage which promotes operational performance focus on the developed countries (Mathieson et al., 2001; Straub, 1994, Gallivan, 2001), and did not even adequately establish any relationship of technology acceptance, usage and productivity optimization. This chapter focuses on bridging this gap by discussing the relationship between technology and productivity optimization,

technology acceptance, technology usage, acceptance & usage relationship in Ghana and then summarizes and conclusion.

2.2 Technology Acceptance

Technology acceptance is described as "the demonstrable willingness within a user group to employ the technology for the tasks it is designed to support" (Dillon and Morris, 1996). Most of the Information systems researchers have spent time investigating how users accept technology, and which variables affect the users' decisions in using such technology especially in the developed countries. Assessing user acceptance is one method of evaluating organizational information systems (Aydin, 1994), and a variety of disciplines contribute to information system evaluation. Most research on technology adoption especially in the rapidly growing area of Information Technology focuses on acceptance. Probably they assume, when the technology is accepted, the purpose for which it was introduced is achieved. Moreover, most of these theories and models focus on developed countries especially in the U.S (Davis, 1989, Mathieson et al., 2001; Staub, 1994; Gallivan, 2001). Even the determinants and moderators for the determination of these models were of typical characteristics of the developed countries. Several researchers also report that the existing technology acceptance or adoption models, for instance, TAM, deny variables that may also be important predictors (Davis, 1989, Mathieson et al., 2001; Staub, 1994; Gallivan, 2001, Galletta, 1999). Let us not also deny that most of the technology acceptance research presumes that technology was readily available, and that the responsibility for accepting or rejecting resided with the end user (Davis, 1989, Mathieson et al., 2001; Staub, 1994; Gallivan, 2001, Galletta, 1999. Accepting a technology especially within a short period of time might not necessarily mean the individual would continue accepting it forever.

Again, these assumptions may fall short of the realities in the context of the developing countries of the world such as Ghana. Ghana as a developing country lags behind the rest of the world in basic socio-economic factors which are pertinent to accept and use of technologies. To the potential users in the

developing countries, acceptance or adoption is not about choice but universal access and exposure to the technology which is not adequately available. It must also be indicated that maturity and longtime exposure to technology and the existence of appropriate technological infrastructure in Ghana coupled with sound environmental setup helps users to ascertain a perception toward acceptance. Since the previous researches were mostly done in the context of developed economies, it is therefore not certain whether the same influence of these determinants and moderators on acceptance and usage would yield same results in Ghana as those tested in the developed countries. Also since technologies are not artifacts, it would seem reasonable that we cannot simply extrapolate the findings and experiences from the developed nations to technology adoption/acceptance in the developing countries such as Ghana. It seems to the current research that consensus building among stakeholders breeds commitment and understanding and could change the user perception towards technology acceptance especially in Ghana. The setup, in the Ghanaian context within which most technologies are introduced by imposition might not justifiably support the conclusion that the influence on the determinants of TAM such as ease of use (PEOU) and perceived usefulness of the system (PU) and the others which are valid for the developed countries also do for us in Ghana.

2.3 Perceived Usefulness of a Technology

Perceived usefulness is defined as the degree to which a person believes that using a particular technology would enhance his or her job performance and efficiency. People may use an application to the extent that they believe it would help them perform their job better – (Davis et al., 1989). Perceived usefulness explains user's perception to the extent that the technology would improve the user's workplace performance (Davis et al. 1989). It can be said that if the user conceives a perception of how useful the technology would be in performing his or her job then the technology is worth accepting. Thus if the technology is seen to decrease the time spent for doing the job, or increase efficiency or ensures accuracy of the user's work, then it's worth embracing it .Even if potential users believe that a given application is useful, they might, at the same time be convinced that the Systems are not too hard

to be used and that the performance benefits of usage are outweighed by the effort of using the application. Sheridan (1988) places perceived usefulness as a characteristic of automation trust, as individuals can rely on or trust that a useful system is beneficial. Thus, users with usefulness technology trusting expectations would anticipate the business information technology would benefit them in their work. Similarly, usefulness of a technology means the technology can help one accomplish one's job-related task. Because usefulness is an attribute of the technology, and because the trustee in our context is the technology, usefulness belongs in the trusting expectation category.

Davis et al. (1989) further defined perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance". Within the organizational context, people are generally reinforced for good performance by raises, promotions, bonuses, and other rewards .A system high in perceived usefulness, in turn, is one that a user believes would lead to a positive use performance relationship.

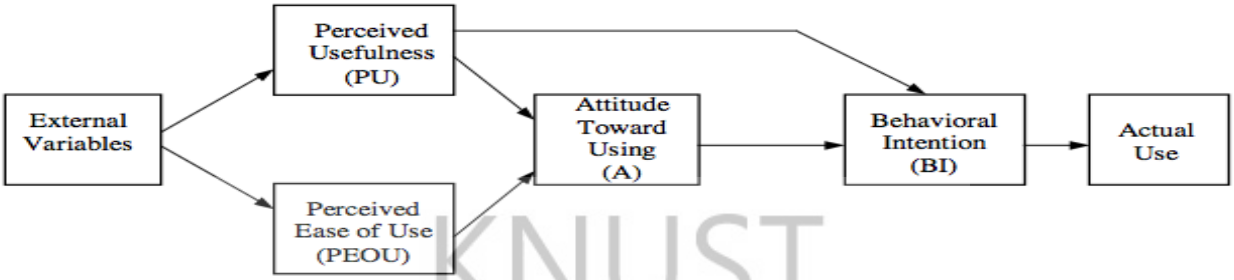
2.4 Perceived Ease of Use of a Technology

Perceived ease of use, in contrast, refers to "the degree to which a person believes that using a particular system would be free of effort". This follows from the definition of "ease": "freedom from difficulty or great effort." Ease of use has its roots in TAM (Davis et al. 1989), and is explained as the degree to which the technology will require little mental effort to use.

These factors of perceived usefulness and perceived ease of use as determinants play a crucial role in understanding individual response to information technology (Agarwal and karahanna, 2000; Chau, 2001; Hong, Thong, Wong and Tam, 2001). According to TAM, Usefulness (U) and Ease of Use (EOU) have a significant impact on a user's attitude (A) toward using a system (ie the feeling of favorableness or unfavorableness) as in Figure **2.1**. In spite of its relevance and practicality, the original TAM model is potentially limited when it comes to Africa- Ghana.

Criticism of TAM, claim the elements such as perceived usefulness, perceived ease of use and attitude were tried in the developed countries.

Figure 2.1: Technology Acceptance Model (TAM)



Source: Davis et al. (1989)

2.5 Technology Application

Technology is a relatively new phenomenon and until very recently its use was limited, although now they have been pushed to the forefront. Although much effort have been put into integrating technology especially computers into the daily lives, the usage has not really caught on with us. Since users are imperative and have played a major role in the utilization of technology, factors affecting their technology use became an important concern for researchers. This is because merely the existence of technology does not guarantee its application or productivity optimization. It is commonly accepted that today's organizations may benefit from technology to a great extent. Therefore, failure in its application or acceptance, especially in our Ghanaian organizations is an important issue which needs consideration. Observers note that in most cases, organizations fail to recognize that in order to reap these benefits; members of the organization must actually use the technology (Lucas, 1999). Technology adoption at the organizational level does not guarantee diffusion (defined in this instance as the actual use of the technology) by individuals whose work it is intended to facilitate. The problem for organizations is how to get end-users to accept new information technologies, and to integrate these technologies into current work processes.

Again it must be pointed out that research on technology usage and job performance focuses on the developed countries which have access and exposure of technological environment. Again the technology usage research assumes that the technology is readily available and that the usage depends on the choice of the end-user. Furthermore, the determining factors (ie ease of use, usefulness, attitude, etc) of technology usage by the previous researchers were tried with end-users in the developed nations', which might not necessarily work for the developing countries like Ghana since individual perceptions differ with different situations. These assumptions run short of realities in the developing countries such as Ghana. The researcher is of the view that even if adequate technologies exist in our Ghanaian organizations, the way and manner these are introduced into our organizations might change users' perception towards technology usage. If an individual is involved in a technological innovation decision making, his/her perception with regards to the determining factors might be slightly different from one who would not be involved. Organization needs to determine if end-users will have a positive mind towards technology usage so that the benefits would be realised. Most researchers even purported that technology usage models, developed in the developed nations, omits variables considered important predictors of usage (Mathieson et al., 2001; de Vreede et al., 1999; Malhotra and Galletta, 1999).

Afari-Kumah and Akwasi Kyere; (2009) like Venkatesh and Davis (2000) purports that technology usage is predominantly by experience. The Afari-Kumah and Akwasi Kyere; (2009), outcome of their research was based on inputs from students in the tertiary institutions of Ghana. Technology is taught in the schools for the acquired knowledge to be imparted into organizations for actual technology usage in order to enhance productivity. Furthermore, findings based on only students might be a fallacy for justifying the validity of the influence on the determinants of technology usage in Ghana. This assertion again is partially invalid since without access one cannot acquire the needed prior experience as indicated.

The current research again tries to investigate technology usage characteristics in Ghana by using end-users of Quality Control Company Ltd who have equal exposure to technology. Reviewing the literature on technology acceptance, the most referenced models in this research stream is the Technology Acceptance Model (TAM) and the Theory of Reasoned Action (TRA), [Davis, et al., 1989, Fishbein and Ajzen, 1975].

2.6 Technology and productivity

Only in the 1990s empirical evidence was found that computers had a substantial effect on firms' productivity levels. In their studies of the effect of information technology on productivity, Brynjolfsson and Hitt (1995) observed that alongside firm effects, ICT capital contributes positively and significantly to output and productivity for large US firms. Similar results are also found when examining the effects the use of various ICTs has on productivity. These results were consolidated even further in a more recent study (Brynjolfsson and Hitt 2000), which underscores the importance of complementary factors such as restructuring the enterprise and improving the skills level of the personnel to get productivity growth as a result of investment in ICT. They also take into account the reverse causality that successful firms might spend their windfall on ICT equipment. Information also has become in recent years an important feature in promoting and facilitating the conduction of trade. Contact or exchange of information between producers, exporters and consumers helps to improve trade performance by creating mutual awareness of products, quality and market conditions. Therefore, access to information is an important determinant to create competitiveness by effectively reducing transaction costs. The applications of the new information and communication technologies, especially the Internet, offer increased effectiveness, for they encourage and facilitate direct contacting between trade partners. However, usage of advanced ICTs presupposes as a necessary condition reliable technical equipment and infrastructure.

There are many who believe that the most single important factor promoting the growth of organizational sector is Information Technology. Flanagin (2002), states that technology changes the dynamics of organizations by optimizing productivity and also by creating effective communication tools which allow more interpersonal relationships. Hinds and Kiesler (1995), claims that information technology provides an environment in which a variety of people can join the organizational decision-making process thus eliminating organizational inefficiencies (as cited in Flanagin, 2002). Similarly, Flanagin (2002) points out that Pinsonneault and Kaemer (1990) also finds that information technology has an impact on reaching group consensus and increasing the confidence and satisfaction of its members. It is believed that information technology has enhanced vertical and horizontal relationships within organizations by removing physical interaction problems (as cited in Flanagin, 2002). These assumptions seem to fall short of realities in the developing countries. To the researcher, a mere physical access to technology is not enough in itself in changing the dynamics of organizations nor eliminates organizational inefficiencies if not truly accepted and same time utilized by the people in the organizations. While technology acceptance and usage improve organizational performance, reduce process errors; provide links to knowledge and decision support systems, simultaneous access to information, greater security, improved legibility, communication and more complete documentation, end-users resistance continues to be a barrier to widespread adoption and use of technology (Anderson, 1997; Dick & Steen, 1991; Dick et al., 1997; Rippen & Yasnoff, 2004; Thompson & Brailer, 2004). Nearly 30% of all EHR technology implementations fail (Gater, 2005). Information technology is introduced in organizations merely because it is anticipated that utilization of the technology brings out efficient results if and only if there is a high user acceptance and usage. Just allocating the technology does not always return efficient results. For instance just allocating computes to Quality Control Company Ltd would not improve the dynamics and efficiency of work quality, speed of operations and job performance if the system owners and users do not accept and again use them.

Information technology systems significantly depend on the individual users' capacities for acceptance and usage. The characteristics of users in Quality Control Company Ltd and the features of tasks will affect the process of technology acceptance and effective usage of a particular technology. Resistance to acceptance and the application of information technology is a common problem for most organizations especially in the developing countries of which Ghana is no exception. However, acceptance and then usage of information technology can bring success to organizations at the managerial, professional, and operational levels. When organizational users (for instance QCC users) are presented with a new technology, a number of factors influence their decision as to whether to accept the technology or not. If their decision is to accept, the decision is as to whether to use the technology or not. The users are therefore confronted with the challenge about how and when they will use this new technology. In Ghana, technology is introduced in organizations because it is anticipated that high utilization of it brings out efficient results in job performance which leads to productivity increase. Egan (1988) states that in a system design, individual differences play an important role because they influence whether or not people would accept the system or can use the system to perform their tasks well. Williams and Aasheim (2005) points out that if the user needs cannot be understood properly and user resistance occurs, an unwanted situation would be created which would undermine system usage, thus, leading to a defeat in the purpose of the technology.

In most Ghanaian organizations, for instance, with Quality Control Company, some users might perceive Information Technology as creating a greater workload and heavy burden for them. Even some users question the value of the system when they encounter some deficiencies and limitations of the technology. If all workers of QCC fall into the said group, how could technology then change the dynamics of the organizations? However, it is known that adoption and usage of technology creates opportunities which are convenient for organizations, though it may generate some difficulties and strain for other people. It can be said that, it is rather lack of technological acceptance and utilization in

organizations that serves as an important obstacle for improving job performance and efficiencies.It is good, Information technology (IT), represents a substantial investment for most Ghanaian organizations, however, technological payoff is most significant if organizational stakeholders' technology acceptance matches its utilization.

2.7 Technology Acceptance Model (TAM)

TAM proposes that successful adoption (acceptance) of technology is dependent on its usefulness and its ease-of-use (Davis, 1989; Davis et al., 1989). Technology Acceptance Model (TAM) was to provide a means for predicting acceptance and discretionary use of information systems and technologies (Davis, 1989; Davis et al., 1989). TAM was also developed to study the decision-making processes of users as to whether or not to adopt information technology in giving settings. A major reason for TAM's popularity is its practicality .It is a widely cited and a validated approach for predicting user acceptance of information systems, and has produced consistently reliable research results over time in the developed nations (Legris et al., 2003; Venkatesh & Davis, 1996). The model allows researchers not to only predict, but also explain why a particular system may or may not be acceptable to users (Davis et al., 1989). It is important to note that the TAM is useful in determining pre-implementation attitudes toward information systems in environments where system use is discretionary, rather than mandated. TAM is a model derived from a theory that addresses the issue of how users come to accept and use technology. The movcdel suggests that when users are presented with, for instance, a new software package, Internet services, computers, a number of variables influence their decisions about how and when they would accept it (see figure 2.0). Technology Acceptance Model (TAM) is tailored for information systems (IS) contexts, and is designed to predict user's acceptance on the job. According to TAM there are two specific external variables, perceived usefulness and perceived ease of use, which are hypothesized to be fundamental determinants of user acceptance to technology (Davis and Arbor, 1989) which leads to technology application and productivity. TAM explains that if users perceive the technology would be useful and easy to handle, an attitude of positive impression stimulates the

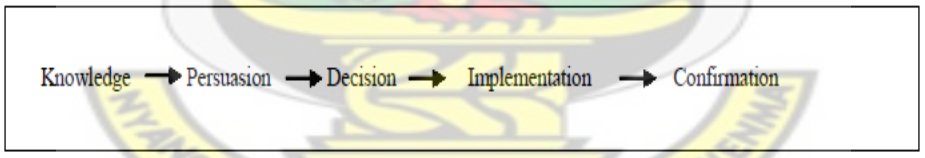
users' to accept the technology and then its subsequent application. TAM, again attempts to test and predict why people are motivated to use or reject a technology. From **(figure 2.1),** model again explains that when users' are confronted with a technology, their intended behaviors which are conceived from their attitude, predict their actual system use (Davis, 1989; Davis et al., 1989). In addition to usefulness, usage is theorized to be influenced by the perceived ease of use. The technology acceptance model purports that if users' perceived ease of use in technology, they are motivated to its usage. Usage was also studied as a phenomenon of interest in its own right (Davis, 1989, 1993; Davis et al., 1989, 1992; Mathieson, 1991; Moore & Benbasat, 1993; Thompson et al., 1991; Hartwick & Barki, 1994). Technology usage is also of increasing practical importance, as the usage of information technology becomes more pervasive. Technology Usage is a necessary condition for ensuring productivity payoffs from information systems investments (Davis, 1989; Mathieson, 1991). According to Straub et al. (1997), Technology acceptance model is widely regarded as a relatively robust theoretical model for explaining information technology usage. From a practitioner perspective, TAM is useful for predicting whether users will adopt new information technologies. Acceptance is a key to a successful technology choice and subsequent use of the technology (Borthick, 1988).Two determinants that are crucial to understanding user acceptance and subsequent usage of technology are the perceived usefulness and ease of use. Again according to Davis et al. (1989) he contended that perceived usefulness and ease of use stimulates people in believing information technology would help them perform their jobs better. At this stage the end user's decision would be to use the organizational technology.

2.8 The theory of Innovation Diffusion (IDT-Rogers 1995)

Although not being specific to information technology, also examines the processes surrounding changes that occur when an innovation or technology is introduced into an organization. Diffusion of Innovation research examines which social characteristics impact an individual's decision to adopt or reject a new innovation and classifies adopters into categories based upon these. With this theory, similar relationships between the two constructs, relative advantage and compatibility, and information

technology adoption were discovered. Innovation diffusion theory (IDT) previously was mostly applied in anthropology, sociology, education, communication, marketing, etc. (Rogers, 1962, 1983, 1995). Diffusion is defined as "the process by which an innovation is communicated through certain channels over time among the members of social systems" (Rogers, 1995). An innovation is "an idea, practice, or object that is perceived as new by an individual or another unit of adoption" (Rogers, 1995). According to Rogers (1995), there are five stages that are linked to innovation decision processes **(see Figure 2.2).** Each stage represents systems acceptance among users. In the knowledge stage, users are introduced to the innovation and gained an initial understanding of the innovation. Thus if users are confronted with technology, users must be educated on the technology to have fair idea of it. If this is done, then they would be knowledgeable about the system and forms a positive impression of it. In the persuasion stage, the decision makers such as managers create the attitude toward the system or the innovation. They try as much as possible to create a positive impression about the system such that users would realize it would be beneficial to their jobs. At this stage, they are then motivated to make a decisive impression towards accepting the system.

***Figure 2.2**: Innovation Diffusion Process (Rogers, 1995)*



According to Rogers (1995), these five stages that are linked to innovation decision processes. The current research therefore sets out to investigate technology acceptance, its application in relation to productivity optimization by examining the influence on determinants of technology acceptance and then usage through the technology acceptance model and how it is related to the Ghanaian context, thus addressing the elements of the local problems in Ghana.

2.9 Technology Acceptance, its application and productivity optimization in Ghana

Computer Usage Intentions of Tertiary Students in the developing country through the Technology Acceptance Model (Afari-Kumah and Akwasi Kyere; 2009) focuses on students perceptions towards technology usage. Thus, Afari-Kumah and Akwasi Kyere, (2009) model also focuses on a narrower field of Ghanaians experiences as a contributory factor to explain the key factors affecting the decision to technology acceptance or usage. Samples size of the population was represented by the students of the university. This method of sampling would be convenient; however difference in explanatory power between students and organizations would be a potential setback. Most probably they presumed influence on those determines tried on technology acceptance with the developed countries, were sufficiently and equally valid for Ghana or that technology acceptance is same as usage though it was not investigated. One cannot simply rely on the model since this requires the user to have prior experience to the technology in order to formulate his/her perception. This stresses to the fact that other external variables, commitment, consensus building, personal interest and others which are peculiar to the Ghanaian context have to be looked at.

Hinson and Boateng (2007), therefore acknowledges the significance role technology plays in the Ghanaian organizations if and only if it is accepted and utilized. Hinson and Boateng (2007), states acceptance and usage of Information Technology has added value to the tourism services and products and supports the development of industry networks. It contends that IT is transforming the role played by the Ghanaian industries. Accordingly, it states that in the past few years, Ghanaian industries have been influenced by Information Technology. The study purports that technology has made the tourism industry proactive with regards to the adoption of new technologies and that the Internet service in particular has had the strongest impact on the tourism sector. Technology (computers, Internet services and others) is introduced into organizations because high utilization of it is said to increase performance and thus, bring efficient results. If technology is therefore not used by their intended users

it does not always encourage organizational performance. Performance output, realized from Information systems, such as computers and others, significantly depend on the individual users' capacities of usage.

Boateng A. (2007), in technology in education, purports the transformation in education with reference to technology adoption. Her study examines how computers and related technology were used in Ghana. It addressed issues on use or non-use of computers and related technology within the critical social theory framework in order to determine the underlying social, economic, and political factors that affected the use of the technology the school. It stresses the significance of information technology in education on grounds of its acceptance and utilization by all the stakeholders. The study says the integration of technology in education involves the actual process of using computers and related technologies for learning activities that support the curriculum. Often, this is confused with the infusion of technology which is merely the physical presence of computers. The emergence of the Internet and computerized smart systems has made interactivity through two way responses possible. Teachers and students are able to interact via video conferencing, instant messaging and chat rooms thereby boosting performance. Also, developments in the form of web cams have made interactions via video more interesting. The Internet is just one of the avenues for interactivity. It provides users with control that its predecessors did not offer. Despite these new capabilities, digital televisions are still used primarily for television and the Internet remains the top pick for interactive services. The advent of computers and the Internet is an indication of a new phase in instructional technology. The emergence of new technologies and the integration of such technologies in educational institutions is an important issue in the quest to bridge the developed and undeveloped digital divide in Ghana.

As a qualitative research, the findings of her study are limited to the extent that it reflects on issues regarding how computers and related technologies are used and integrated into the educational

curriculum. Her study does not extend into productivity in relation to Ghanaians organizations. Thus, this study cannot be generalized as a true reflective of all schools in Ghana.

Shackel (1991) is one of the few researchers to make explicitly, association between usability and acceptability in relation to productivity optimisation. According to his formulation, an acceptable system is one that appropriately satisfies the requirements of its users for utility, usability, and cost. These attributes could be easily linked with Rogers's five characteristics showing a close overlap between two distinct perspectives. However, even this theory was tested with the developed countries where innovative decision making involves consensus building.

Despite the many models and studies that examine technology adoption in information systems (IS) research, the researcher did hardly find studies that examine technology acceptance and usage in the Ghanaian context. Irrespective of the many models and studies on technology acceptance and usage in the IS research, the research did not find studies that examine the actual relationship between acceptance and usage in the Ghanaian context. Most of the previous literature reviews, contributed to technology acceptance and usage but not their relationship or productivity optimisation. Again, even those developed in the Ghanaian context, focused only on either technology usage or acceptance, rather than establishing the relationship between acceptance, usage and productivity optimisation. If a technology is accepted by its end-users, does that really translate into usage? Aren't there instances where acceptance of technology not matching usage, thus, leading to no performance? For instance, in most Ghanaian organizations the very top management who call for the provision of technologies is the same people who might not even use them at all. Do organizations then have to implement technology just because the people have expressed willingness for acceptance or desirous for usage? The balance in the two is really fundamental if really; organizations have to make maximum benefits from technology investments. Thus organizational end users must first be willing to welcome the technology and also embrace its usage as well. It must be emphasized that technology is good but does not bring

development in itself, in organizations and institutions if it is not accepted and utilized. However, while ability to use any technology is obviously necessary, it is not sufficient to ensure acceptability, and many technologies that are demonstrably usable are never accepted by the target use. The researcher again posits that the relationship between technology acceptance and usage has to be established before any talk about acceptance meaning usage can be justifiable. The study would also serve as a relevant point especially to our organizations in the country by ensuring that a balanced needs to be reached between acceptance and usage or investment and technology usage. With the swift advent of technology in previous decades, Information and Communication Technologies (ICT) have pervaded the workplace. Organizations devote considerable resources to and spend considerable sums of money on improving their information technology infrastructure in the expectation that it will help improve organizational performance. However, in case after case, the anticipated benefits associated with these investments fail to be realized.

Unfortunately it is not certain if these theories would apply and work perfectly in the developing countries such as Ghana since individuals' perceptions about technology might differ in different situational context.

This serious deficiency needs to be corrected so that organizations would reap the benefits of their technological investments in Ghana. This current research investigates the relationship by examining the influence of determinants of acceptance and usage concurrently with same end-users in a Ghanaian organization of QCC. Most importantly, findings about the relationship between technology acceptance and its usage would probably redirect technology adoption research.

At least part of researchers concern is raised around the issue of whether any technology would be used by its intended users. An end user's perception informs his or her decision to either use or reject the usage of technology. It is interesting to know what conceives that perception in order to understand the determinants and human factors that are significant to the usage of technology. This is so important

because the determinants would ensure that new designs of information technology or information systems are built and implemented so as to minimize user resistance to their use in the organizations. Although usage is a necessary condition for ensuring productivity payoffs from Information Systems' investments, the extent to which it is linked to acceptance has to be established.

They attempted to predict factors which would influence individuals to accept information technology and the subsequent usage of the technology. If individuals are apparently approached with technology they have to make a decision as to whether to accept or use or reject it. The review contends that, perceived usefulness and ease of use are the principal ingredients, stimulating end users' decision on technology. The researcher adds to the discussion by gathering data from QCC to help understand the value of the linkage relationship between technology acceptance and usage in the region. It is believed that the new model presented here would be relevant to Ghanaian organizations especially Quality Control Company of COCOBOD where technology, considered the answer to everything and utilization of technology remains static.

The study builds on the works of other researchers that made notable contributions to technology acceptance, its application and productivity optimisation (Davis, 1989; Ajzen and Fishbein 1980; Fishbein and Ajzen 1975; Afari-Kumah and Akwasi Kyere, 2009; Hinson and Boateng, 2007; Boateng, 2007).

2.10 Summary and Conclusion

It is commonly accepted and undeniable that today's organizations benefit enormously from technological investments to a great extent. However, physical access to technology is not enough in itself in changing the dynamics of organizations nor eliminates organizational inefficiencies. It is not surprising that meaningful transfer and adoption of technology, with a focus on improving organizational development remains problematic and with unfulfilled dreams. While some people may rejoice over the recent increases in the number of technology in the organizations, they fail to realize that by and large,

these devices are not being used to enhance the socio-economic development of the companies, but for exhibiting a status symbol. It is also believed that, meaningful and sustainable developments would not be realized just by flooding the companies with even the best and latest technologies.

The infiltration of technologies into our organizations, calls for serious research on the influence of technology acceptance and usage in relation to organizational productivity especially in our local context. The determining factors on user acceptance and usage have received little attention from professional as well as academic researchers. Adequate user acceptance and usage of technology allows a company to realize the impact of technology. It is rather the technology application and its impact that is of most importance to our orgainsations. It can be argued that if the right strategies are pursued, the ingenuity, resilience, and desire to accept and use information technology fully, in Quality Control Company Ltd , could facilitate the Company to reach acceptable living standards sooner than later. To this regard, the current research presents an overview of what it believes to be some serious technology adoption problems such as; the influence of user technology acceptance and usage which hinders job performance. The research then looks into this deficiency by investigating the influence of these determinants toward technology acceptance and usage together with their relationship in the Ghanaian situation.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This section describes the exact steps that were taken to address the research questions in order to ensure accuracy of responses and findings. The scientific concern with Technology Acceptance and Technology usage traditionally is comparatively recent; developers and procurers of new technology could rely on authority to ensure that technology was used, at least in many industrial or organizational contexts. However, current working practices, as well as the large market for leisure and educational applications of information technology have enabled greater discretion among users thus increasing the need to determine the dynamics of Technology acceptance, its usage and productivity optimisation.

For a thorough investigative finding, mathematical models were explored and were used to analyze the data. Since the research seeks to examine Technology in the context of variables relationship, (perceived usefulness -PU, perceived ease of use -PEOU and attitude towards technology, it was prudent for the researcher to use **Regression analysis**. Thus, the Simple Linear, the Multiple and Logistic Regression which are so chosen is due to the fact that equations developed can be used to predict the variables relationship.

We shall therefore outline the necessary methodology used to arrive at the research findings. We used three different Regression approaches to study the effect of Technology acceptance, its usage and productivity optimization on the measures of explained variation discussed earlier. The methods and approaches are as enumerated; **Simple Linear Regression**, **Multiple Regression** and **Logistic Regression**

3.2 Regression Analysis

Regression analysis is a statistical tool that utilizes the relation between two or more quantitative variables so that one variable can be predicted from another. The variable we are trying to predict is called the response or dependent variable. The variable predicting this is called the explanatory or independent variable. Relationships between variables can be either functional or statistical. A functional relationship is exact, while a statistical relationship has error associated with it. Regression analysis is utilized to develop an accurate mathematical formulation of the regression analysis. The line of best fit is defined as a line for which minimizes the sum of squares of deviation of the various data points from the line. The regression line is also referred to as the least squares line. Regression methods have become an integral part of any data analysis concerned with describing the relationship between a response variable and one or more explanatory variables. When the outcome variable is continuous, linear regression methods are the standard tools to model this relationship. However, in many fields the outcome variable is discrete, and most often takes on only two possible values, e.g., diseased or not diseased. It is often of interest to produce an estimate of the probability a subject will have the response given some predictor characteristics. For example, in epidemiological studies researchers might be interested in predicting the probability of developing a disease after controlling for other associated risks or in exploring the type and strength of the relationships between the disease and associated risk factor(s). Over the years logistic regression has evolved, in many fields, as a standard method of analysis in such situations. From its original acceptance in epidemiological research logistic regression is now commonly employed in many fields including but not limited to biomedical research, education, criminology, business and finance, health policy, ecology and wildlife biology.

3.2.1 Simple Linear Regression

Simple Linear regression is a general method for estimating/describing association between a continuous outcome variable (dependent) and one or multiple predictors in one equation. The simple regression analysis seeks a relationship of a response variable with only one predictor.

3.2.1.1 Simple linear regression model

The simple linear regression function is;

$$Y_i = \beta_0 + \beta_1 \times_1 + \varepsilon_i \qquad (3.1)$$

In this model β_0, β_1, and ε_i are parameters and Y_i and X_i are measured values. For every level of X, there is a probability distribution for Y having mean $E(Y|\times) = \beta_0 + \beta_1 \times_1$ and variance $\sigma^2(Y_i) = \sigma^2$ where σ^2 is the variance of the entire population. β_0 is called the intercept and β_1 is called the slope of the regression line. Data for the regression analysis may be either observational or experimental. Observational data is simply recorded from naturally occurring phenomena while experimental data is the result of some manipulation by the experimenter.

3.2.1.2 Estimated regression model

The estimated regression function is

$$Y_i = b_0 + b_1 X_i: \qquad (3.2)$$

We calculate $b0$ and $b1$ using the methods of least squares. This chooses estimates that minimize the sum of squared errors. These estimates can be calculated as

$$b = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \qquad (3.3)$$

$$b = \frac{(\sum_{i=1}^{n} y_i \ \sum_{i=1}^{n} x_i^2) - (\sum_{i=1}^{n} x_i \ \sum_{i=1}^{n}(x_i y_i))}{n(\sum_{i=1}^{n} x_i^2) - (\sum_{i=1}^{n} x_i)^2} \qquad (3.4)$$

$$b_0 = \tilde{Y} - b_1 \dot{X} = 1/n \left(\sum Y_i - b_1 \sum X_i\right) \quad (3.5)$$

Under the conditions of the regression model given above, the least squares estimates are unbiased and have minimum variance among all unbiased linear estimators. This means that the estimates get as close to the true unknown parameter values as we can get. The least squares regression line always passes through the point $(\dot{X}, \tilde{Y})$.

The predicted or fitted values of the regression equation, is calculated as

$$\hat{Y} = b_0 + b_1 X_i \quad (3.6)$$

(1) Illustrated Example of Estimated Regression Model

Table 3.1 Association between Years of Experience in Technology and level of Technology Usage

PCs Users	Yrs of Experience (X)	Technology Usage (Y)	$(Xi - \dot{X})$	$(Yi - \dot{Y})$	$(Xi - \dot{X})(Yi - \dot{Y})$	$(Xi - \dot{X})^2$
1	1	10	-4.5	-10.1	45.45	20.25
2	2	15	-3.5	-5.1	17.85	12.25
3	3	14	-2.5	-6.1	15.25	6.25
4	4	10	-1.5	-10.1	15.15	2.25
5	5	14	-0.5	-6.1	3.05	0.25
6	6	19	0.5	-1.1	-0.55	0.25
7	7	24	1.5	3.9	5.85	2.25
8	8	24	2.5	3.9	9.75	6.25
9	9	28	3.5	7.9	27.65	12.25
10	10	43	4.5	22.9	103.05	20.25
SUM	**55**	**201**	**0**	**0**	**242.5**	**82.5**
AVG	**5.5**	**20.1**				

The Mathematical Computation of the Regression Coefficients for the ca+se of a single independent variable is given as in table above: The slope (regression coefficient) for the line of least squares is given by b_1, as in equations ***(3.3) and (3.4).*** Using the above formulae, the estimates of the parameters are calculated as:

Step 1: Compute, b_1. Using equations (***3.3 and 3.4)*** and the information from **Table 3.1**

$$b = \frac{\sum_{i=1}^{n}(x_i - \bar{x})\,(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} = 2.94$$ **{from equation (*3.3 and 3.4)}***

Step 2: Compute, $\mathbf{b_o}$;

$\mathbf{b_o} = \tilde{Y} - b_1\dot{X} = 1/n\,(\sum Y_i - b_1\sum X_i) = 3.94$ **{from equation (*3.5)}***

Step 3: formulate the model;

$Y_i = 3.94 + 2.94X_i$ **{from equation (*3.2)}***

once we have calculated a regression equation we can predict a new observation of Technology usage at *Xi* by substituting in this value and calculating $Y_i = 3.94 + 2.94X_i$

3.2.1.3 Graphical Explanation of Regression

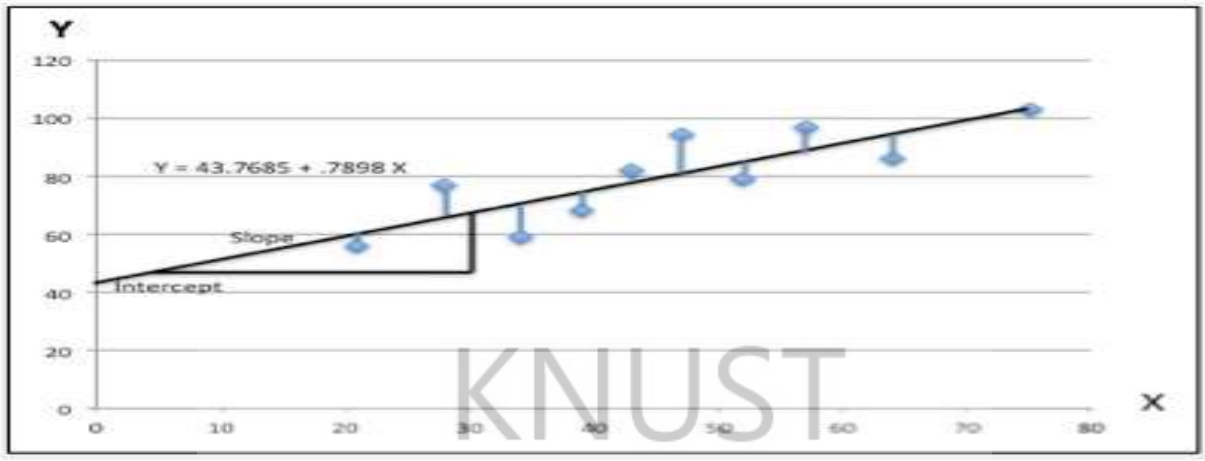
A simple approach to approximate a regression equation for a single variable is to plot the relationship between the variables. The task requires that we first plot the dependent variable against the independent variable. This type of plotting is called the scatter diagram. Next, identify the straight line that best represents the trend through the mid-point of the data. This line must be the one with the `best fit'. The regression analysis line identifies the trend or relationship between the independent and dependent variables. The relationship, once identified, is used to predict the various values of the dependent variable given specific values of the independent variable. This predicted relationship is always in the form of a linear trend. Table 3.2 illustrates the foregoing discussion. The Table below identifies a set of values for an independent (X) and dependent (Y) variable that are shown in the X-Y scatterplot.

Table; 3.2 Technology Usage and Productivity

X	39	43	21	64	57	47	28	75	34	52
Y	68	82	56	86	97	94	77	103	59	79

The scatter plot of the variables is given as in figure 3.1 below:

Figure 3.1 shows scatter plot of Technology Usage against productivity



β_0 is the intercept (the mean value of y at X = 0), β_1 (Slope, Regression coefficient) tells us that, on average, as X increases by 1 so y increases by β_1, and ε_i is the error term. The intercept and the slope are determined graphically and the values used to establish the regression equation as seen as part of the graph.

3.2.2 Multiple Regression Model

Multiple regression analysis relates the variation in our dependent variable to several different independent variables. Multiple regression analysis is used to test the effects of n independent (predictor) variables on a single dependent (criterion) variable. Regression tests the deviation about the means, and all variables must be at least interval scaled. Computationally, regression analysis may be conducted using either a raw data matrix (respondents by variables) or a correlation matrix. Regression analysis measures the degree of influence of the independent variables on a dependent variable. In the case of simple bivariate regression where there is a single independent variable, the dependent variable could be predicted from the independent variable by the simple equation. Let $\mathbf{X_1, X_2, \ldots X_k}$, denote k predictors to be investigated for their relationship with a response variable Y to study its distribution. A multiple linear regression model is a hypothetical relationship such as described below.

$$\mathbf{Y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \varepsilon_i}$$

In the equation β_0, β_1, β_2 , …., β_k, are called regression coefficients of predictors. The regression coefficient of a predictor quantifies the amount of linear trend in Y. It is the amount of change in Y corresponding to one unit change in a predictor while all other predictors are held fixed at some specified levels. If the scatter plot of Y with a predictor suggests a non-linear trend, then the predictor suitably transformed may preserve the linearity. The expression

$$\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \varepsilon_i$$

is hypothesized to be the mean of Y. As in the simple regression, ε_i captures the sampling error as well as the variation in Y values from its mean. It is assumed normally distributed with mean 0 and standard deviation s. The regression coefficients are estimated from a sample observed through designed experiments on a random sample of n units.

3.2.2.1 Estimated Multiple Regression Model

The estimated relationship can be expressed by

$$\hat{Y} = b_0 + b_1 X_1 + b_2 X_2 + \ldots\ldots + b_k X_k \qquad (3.7)$$

All the sample statistics referred to here are part of the computer **SPSS** print outs following the regression methodology. Therefore, no emphasis is placed here on formulas and their computations Let b_i denote an estimate of b_i obtained from observed sample with its standard error $_{bi}s$.

(2) Illustrated Example of Estimated Multiple Regression Model

Table 3.3: Association between Technology usage subject to Age and Level of Technology

Average Age (X_1)	Level of Technology Accept (X_2)	Level of Technology Usage (Y)
14.5	34	29
34.5	23	21
44.5	20	23
54.5	13	10
64.5	10	17

Table 3.3 presents values, used to illustrate how to arrive at the estimated parameters of a multiple regression model. The data was then inputted into **SPSS** to generate the output below. The estimated relationship can now be expressed by

$\hat{Y} = b_0 + b_1 X_1 + b_2 X_2$. ***(From 3.7)***

Table 3.4 presents values of these measures (computer printout) generated for the model. There is a straight forward interpretation of coefficients in regression analysis SPSS output. Using equation ***(3.7)*** and the information from Tables 3.4 and Table 3.5.The estimated relationship relating Level of technology and Age with level of technology acceptance can be expressed by

$\hat{Y} = -130.4 + 1.7 X_1 + 4.0 X_2$. ***(Equation 3.7)***

Table 3.4 SPSS output for variables in the Equation (Coefficients)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(b_0)	-130.362	45.483		-2.866	.103
	(b_1)	1.652	.546	4.494	3.026	.094
	(b_2)	4.007	1.116	5.331	3.589	.070

a. **Dependent Variable: Level Technology Usage**

Table 3.5 SPSS output for sum of squares (ANOVA)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	190.703	2	95.351	20.512	.046[a]
	Residual	9.297	2	4.649		
	Total	200.000	4			

a. Predictors: (**constant**), (**Level of Technology**), (**Age**)

b. Dependent Variable: Level of Technology Usage

3.2.3 Coefficient of Determinant

The coefficient of determinant is a measure of the goodness fit for the estimated regression equation. It can be interpreted as the proportion of the variability in the dependant variable that can be explained by the regression equation. The coefficient of determinant, denoted R^2, is computed as follows.

$$R^2 = SSR/SST \quad (3.8)$$

Where

(a) sum of squares Due to Regression **(SSR)** is computed as

$$SSR = \sum(\hat{Y} - \tilde{Y})^2. \quad (3.9)$$

SSR is a measure of how much the $\hat{Y}$ values on the estimated regression line deviate from $\tilde{Y}$.

(b) total sum of squares (SST) is computed as

$$SST = \sum(Yi - \tilde{Y})^2. \quad (3.10)$$

SST is a measure of how much the Yi values on the estimated regression equation deviate from $\tilde{Y}$

(c) Sum of squares Due to Error **(SSE)** is computed as

$$SSE = \sum(Yi - \hat{Y})^2. \quad (3.11)$$

The value SSE is a measure of the error in using the estimated regression equation to estimate the values of the dependant variables in the sample. The sample correlation coefficient as a descriptive measure of the strength of linear association between two variables, x and y, denoted r_{xy} *is given* by;

r_{xy} = (**Sign of b_1**) $\sqrt{coefficient\ of\ Determinant}$

= (**Sign of b_1**) $\sqrt{r2}$ **(3.12)**

Where

b_1= the slope of the estimated regression equation = $\hat{Y}$**= b_0+b_1x**

The correlation coefficient is a value between -1 and +1 and a value of +1 indicates the variables in question are perfectly related.

(3) Illustrated example

Table 3.6 Technology Usage and Technology Acceptance for 10 units in QCC

Dept	Tech Accept (Xi)	Tech Usage (Yi)	$(Xi - \dot{X})$	$(Yi - \dot{Y})$	$(Xi - \dot{X})(Yi - \dot{Y})$	$(Xi - \dot{X})^2$	$\hat{Y}=60+5Xi$	$Yi - \hat{Y}$	$(Yi - \hat{Y})^2$	$Yi - \tilde{Y}$	$(Yi - \tilde{Y})^2$
1	2	58	-12	-72	864	144	70	-12	144	-72	5184
2	6	105	-8	-25	200	64	90	15	225	-25	625
3	8	88	-6	-42	252	36	100	-12	144	-42	1764
4	8	118	-6	-12	72	36	100	18	324	-12	144
5	12	117	-2	-13	26	4	120	-3	9	-13	169
6	16	137	2	7	14	4	140	-3	9	7	49
7	20	157	6	27	162	36	160	-3	9	27	729
8	20	169	6	39	234	36	160	9	81	39	1521
9	22	149	8	19	152	64	170	-21	441	19	361
10	26	202	12	72	864	144	190	12	144	72	5184
TOTAL	**140**	**1300**	**0**	**0**	**2840**	**568**	**1300**	**0**	**1530**	**0**	**15730**

Using equations **(3.3)** and **(3.6)** and the information in Table **3.6**, we compute the slope and the intercept.

$b_1 = 2840/568$

$b_1 = 5$

Calculation of the y intercept b_0 follows.

$b_0 =$ $\tilde{Y} - b_1 \dot{X}$

$=130-5(14)$

$= 60$

The estimated equation is

$$\hat{Y} = 60 + 5x$$

Again using equations **(3.8),(3.9),(3.10),(3.11) and (3.12)**

$$SST = \sum(Yi - \tilde{Y})^2.$$

=15730

$SSE = \sum(Yi - \hat{Y})^2$.

=1530

SSR = SST-SSE

= 15730-1530

= 14200

$R^2 = SSR/SST$

= 14200/15730

=0.9027

r_{xy} = (**Sign of b_1**) $\sqrt{r2}$

=+√0.9027

=+0.9501

3.2.4 Logistic Regression

Logistic regression models the relationship between a binary or ordinal response variable and one or more explanatory variables. It is a mathematical modeling approach which can be used to describe the relationship of several Independent and dichotomous dependent variable. Thus it is suited for studying the relationship between a categorical or qualitative outcome variable and one or more predictor variable. In general, the data for logistic regression are *n* independence observations, each consisting of a value of the explanatory variable $(\times, level\ of\ technology)$ and either a success or a failure for that trial. For example, $\times$, the explanatory variable in technology determination may be the

usefulness of a technology, and "success" means that this technology is accepted to be used by the people. Every observation may have a different value of $\times$.

Odds are the ratio of the probability of occurrence of an event to that of nonoccurrence. The Odds determine the strength of association: **Strong (OR>3), moderate (OR=1.6-3.0), weak (OR=1.1-1.5)**. We illustrate by showing, in the simple case of two exposure groups how logistics regression models the association between binary outcomes (level of technology) and exposure variables (eg Technology Measure), in terms of odds ratios. It is always convenient to start with the special case in which the explanatory variable assumes values ***(X= 1 or X= 0***) variable. Thus the explanatory variable would then contain an outcome which is either (success or failures) for each of the two values of X. Now the Odds Ratio (OR) in terms of exposure is defined as:

$$\boldsymbol{Exposure\ odds\ ratio\ (Technology\ measure)} = \frac{\boldsymbol{odds\ in\ Exposed\ (accept\ group)}}{\boldsymbol{odds\ in\ unexposed\ (non\ accept\ group)}}$$

If we re-express this as:

$$\mathbf{Odds\ in\ Exposed\ (Technology\ usefulness)} = \boldsymbol{Odds\ in\ unexposed(non\ accept(0) * Exposure\ odds\ ratio\ (accept(1))}$$

Then, we have the model of the outcome, which expresses the odds in each group in terms of two model parameters. These are:

(1) The baseline Odds referring to the Exposure group (Technology measure) group against the other groups. When there are just two exposure groups, then the baseline Odds are the Odds in the unexposed group. Thus, we will use the parameter name "Baseline" to refer to the Odds in the baseline group.

(2) The exposure odds ratios, express the effect of the exposure on the odds of technology acceptance.

Table 3.7 odds of the outcome comparing two exposure groups.

Technology Group	Odds Outcome	Odds of Outcome in terms the parameter names
Technology PU (1)	Baseline Odds *Exposure Odds ratio	Baseline *Exposure
Technology non PU(0)	Baseline odds	Baseline

$\text{Odds} = Baseline * Exposure$. Assuming there are two exposures (***A, B***) the model would be; $\text{Odds} = Baseline * Exposure\ (A) * Exposure\ (B)$. Thus, if for example, the exposure ***A*** doubled the odds of technology acceptance and the exposure ***B*** trebled it; a person exposed to both would have six times greater odds of technology acceptance than a person in the baseline group exposed to neither.

Table 3.8 illustrated example of ODDS ratios

Technology Measure	***Technology Accept***	***Technology unaccept***	***Total***	***Odds of level of Technology***
	Yes (1)	***No (0)***		
Tech usefulness	*541(71.7%)*	*213(28.3%)*	*754*	*541/213 =2.540*
Tech non Usefulness (Baseline group)	*281(51.3%)*	*267(48.7%)*	*548*	*281/267=1.052*
Total	*822*	*480*	*1302*	

Odds in technology usefulness = ***541/213***

=2.540

Odds in technology non-usefulness = ***281/267***

= 1.052

Then Odds in technology measure = technology non-usefulness * technology usefulness

= 1.052 *2.540x

Thus, for the first row, labeled 'technology usefulness', this is the Odds (2.413) comparing the usefulness of technology to acceptance with the non-usefulness of technology. For the second row, labeled 'non-usefulness technology' this is the Odds of technology acceptance in the baseline group (1.052)

3.2.4.1 Logistic Regression Model

Currently, logistic models are more popular because the logistic function is an extremely flexible and easily used function and it lends itself to a clinically meaningful interpretation e.g., the exponentiated logistic coefficients can be interpreted as odds ratios. Another reason for the popularity of the logistic

model is probably the availability of more diagnostic tools in logistic regression. The model is designed to describe a probability, which is always some number between 0 and 1. Probability of the event is labeled as binary outcome [1, 0]. Event (Y = 1) represents the outcome of success, while no event (Y = 0) indicates failure.

The logistic Odds have the following form:

$$Odds = \frac{\pi(x)}{1-\pi(x)} = \frac{probability\ of\ event}{probability\ of\ no\ event} \qquad (3.13)$$

The logistic function has the following form:

$$\pi(x) = \frac{e^{\beta_0+\beta_1 X_1+\cdots+\beta_p X_p}}{1+e^{\beta_0+\beta_1 X_1+\cdots+\beta_p X_p}} \qquad (3.14)$$

The right hand side of equation (1.14) now ranges from 0 to 1. But the model is still nonlinear in the parameters. Logistic regression handles this problem of nonlinearity through a linearizing transformation, called the logit transformation, which is central to the study of logistic regression. The transformation process is convert P(Y = 1) as opposed to P(Y = 0) to an odds

$$\phi(x) = [\pi(x) / (1- \pi(x)] = e^{(\beta_0 + 1\beta'x1)} \qquad (3.15)$$

This transformation causes the dependent variable to range from zero to positive infinity. Another step in the transformation process is to convert the odds in (1.15), to the logit function, g(x), by taking the natural logarithms of ϕ(x):

$$g(x) = \ln\left[\frac{\pi(x)}{1-\pi(x)}\right] = \beta_0 + \beta_1 x + \cdots + \beta_p X_p \qquad (3.16)$$

The interpretation then becomes that the relationship is nonlinear in terms of its variables but linear in terms of its parameters. The logit transformation in (1.16) completes the resemblance of the logistic regression to the linear regression model. The logit function g(x) is linear in its parameters, may be

continuous, and may range from −1 to +1, depending on the range of x. Once this resemblance is established, the principles that guide an analysis in linear regression may also be used for analysis in logistic regression.

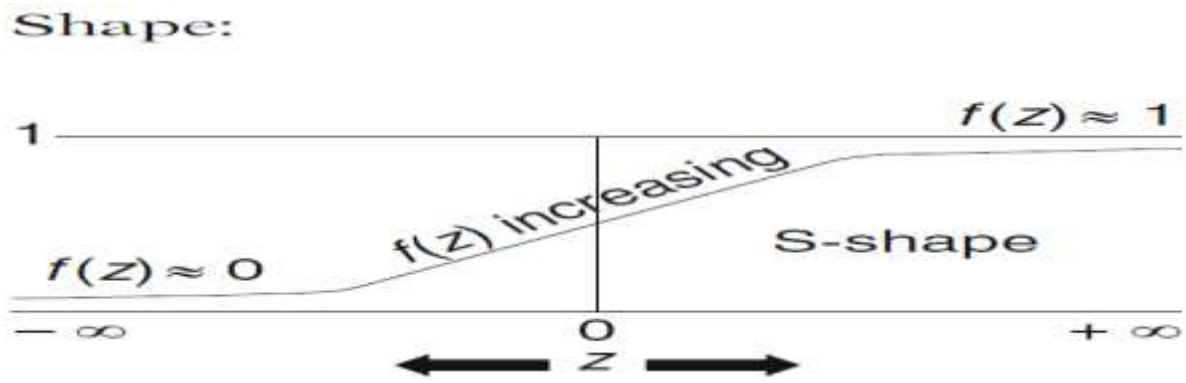
Since the current study is intended to investigate the level of technology (Acceptance (π) or Rejection $(\hat{\pi})$), subject to technology determinants-Y (Perceived Usefulness, Ease of Use or attitude), there are two outcomes of interest to the researcher (proportion of the event and the proportion of no event). If $\hat{\pi}$ is defines the proportion for technology acceptance which is the desirable outcome, then **1 −** $\hat{\pi}$ is the proportion for the second outcome: If $\hat{\pi}$ is the sample proportion, then the **odds** are $\hat{\pi}/(1-\hat{\pi})$, the ratio of the proportion of times the event happens to the proportion of times the event does not happen.

Generally, logistic regression is well suited for describing and testing hypotheses about relationships between a categorical outcome variable and one or more categorical or continuous predictor variables. The coefficient or **parameters** of the logistic model, $\beta_0, \beta_1 \ldots \beta_p$ determines the direction of the relationship between explanatory variable (*X)* and the logit . When **β** is greater than zero, larger (or smaller) *X* values are associated with larger (or smaller) logits. Conversely, if **β** is less than zero, larger (or smaller) *X*- values are associated with smaller (or larger) logits. The assumption is that the independent variables (Measure of technology) are linear in the logit which may contain interaction and power terms. The dependent variable is binary X=0 or 1 while the independent variables may be binary, categorical or continuous. The parameters of the model are βo, β1, β2 …βp while π is a binomial proportion and the x the explanatory variables.

3.2.4.2 Graphical representation of Logistic Regression

Another reason why the logistic model is popular derives from the shape of the logistic function. The result of the graphical output is always an elongated, S-shaped picture as illustrated in figure 3.2.

Figure 3.2: S-Shaped Logistic Function



3.2.4.3 Fitting and Interpreting the Logistic Regression Model with illustration

To communicate effectively, the basic principles of logistic regression models, which the researcher adopts and uses is detailed with a step by step approach and illustration.

- **Example 1**

Table 3.9 Association between age group and microfilaria infection in the onchocerciasis study

Age group	Microfilaria infection		Total
	Yes	No	
5-9	46	156	**202**
10-19	99	119	**218**
20-39	299	125	**424**
>= 40	378	80	**458**
Total	**822**	**480**	**1302**

Using the information from the table **3.9**, and also the formulae above, the application of the model is as follows:

$\pi(x)$ = the event occurred (infection) then;

For the Odds of age group (5-9);

; $\pi(x)$**=46/202 and**

1 − ˆ $\pi(X)$ **= 1-[46/202]**

$\gg ODDS(\pi(x)) = \pi(x)/[1 - \hat{}\pi(x)]$ *(from equation 3.13)*

=0.228/[1-0.228]

=0.228/0.772

=0.295

Odds of age group (10-19);

; πx=99/218

1 − ˆ π = 1-[99/218]

$\gg ODDS(\pi(x)) = \pi/[1 - \hat{}\,\pi(x)]$

=0.454/[1-0.454] *(from equation 3.13)*

=0.454/0.546

=0.832

Odds of age group (20-29);

; $\pi(x)$=299/424

1 − ˆ $\pi(x)$ = 1-[299/424]

$\gg ODDS(\pi(x)) = \pi(x)/[1 - \hat{}\,\pi(x)]$

=0.705/[1-0.705] *(from equation 3.13)*

=0.705/0.295

=2.392

Odds of age group (>=49);

; $\pi(x)$=378/458

1 − ˆ $\pi(x)$ = 1-[378/458]

$\gg ODDS(\pi(X)) = \pi(x)/[1 - \hat{}\,\pi(x)]$

=0.825/[1-0.825] *(from equation 3.13)*

=0.825/0.175

=4.725

- **Example 2**:

In determining the level of technology (accept or reject) in Ghana Cocoa Board, the Company observed that out of the total number of sample taken, 0.227 (22.7%) accepted to use technology while 0.170(17.0%) rejected the use of technology.

- **Solution**

The explanatory variable is level of technology, a categorical variable. To use the above Logistic regression Model to explain, we need to use a numeric code as an **indicator variable.** For our problem we will use an indicator of whether or not the staffs accept the technology:

$$\times = \begin{cases} 1 \text{ if staff accept technology} \\ 0 \text{ if staff reject technology} \end{cases}$$

First we convert to **ODDS.**

For staff accepting technology,

ODDS$=\hat{\pi}(x)/(1-\hat{\pi}(x))$

$= 0.227/(1-0.227)$

$=0.294$

Similarly, for staff rejecting technology

ODDS$=\hat{\pi}(x)/(1-\hat{\pi}(x))$

$=0.170/(1-0.170)$

$=0.205$

For staff accepting technology,

Log $[\hat{\pi}(X)/(1-\hat{\pi}(x))] = \beta_0 + \beta_1$ ***(from equation 3.16)***

Y=Log $[\hat{\pi}(x)/(1-\hat{\pi}(x))] = -1.23$

For staff rejecting technology,

Log $[\hat{\pi}(x)/(1-\hat{\pi}(x))] = \beta_0$

Y=Log $[\hat{\pi}(x)/(1-\hat{\pi}(x))] = -1.59$

Note that there is a β_1 term in the equation for accepting technology because **x=1**, but it is missing in the equation for rejecting technology because **x=0**.

To find the estimates of b_0 and b_1, we match the accepting technology and rejecting model equations with the corresponding data equations. Thus, we see that the estimate of the intercept b_0 is simply the log *(*ODDS*)* for the rejecting:

$b_0 = -1.59$

and the slope is the difference between the log*(*ODDS*)* for the accepting and the log*(*ODDS*)* for the rejecting:

$b_1 = -1.23 - (-1.59) = 0.36$

The fitted logistic regression model is

Log *(*ODDS*)* = −1.59 + 0.36*x* ***(from equation 3.16)***

The slope in this logistic regression model is the difference between the log *(*ODDS*)* for accepting and the log *(*ODDS*)* for rejecting. It can also be shown

$ODDS_{accept} / ODDS_{reject} = e^{0.36} = 1.43$ ***(from equation 3.16)***

$ODDS_{accept} = 1.43 \times ODDS_{reject}$

In this case, the probability for accepting to use technology in Ghana Cocoa Board when subjected to technology determinants such as (perceived usefulness, perceived ease of use or attitude) is 1.43 times rejecting the use of the technology.

CHAPTER FOUR
DATA ANALYSIS AND RESULTS

4.1 Introduction

This chapter presents results of our technology study addressing the research questions which examined the influence of technology determinants as measures of explained variation in technology application using regression analysis. Responses are summarized, formulated models tested and analysed, with the results presented in the form of tables, plots and fitted models as a basis for comparison. Some inferences were made with regards to theory and practice. The researcher examined these determinants on the results of the following analysis: influence of perceived usefulness (PU), perceived ease of use (PEOU**),** and altitude (**A)** on Technology**,** impact of Age and years of experience on technology and then the impact of technology on productivity.

4.2 Influence of perceived usefulness (PU), perceived ease of use (PEOU), and altitude (A) on Technology.

This sought to examine the impact of (**PU**), (**PEOU),** and altitude (**A)** on technology, using outputs from stated models of both multiple and logistic regression. Again it attempts to interpret the findings of the outcome with respect to SPSS computer printouts. With influence of perceived usefulness (**PU**), perceived ease of use (**PEOU)** and altitude (**A)** on technology, subjects of various categories of COCOBOD (QCC) staff, examined whether these determinants were critical technology decision factors to them in the Company. The data is summarised and tabulated in table 4.1. Thus, **Table 4.1** illustrates the responses on technology subject to perceived ease of use (**PEOU (X_1)),** perceived usefulness (**PU (X_2)),** and altitude **A(X_3).** Using the information in Table 4.1, there are three (3) explanatory variables which are of interest. These variables are **PEOU**, **PU**, **A**. The coefficients or the parameters which ought, determining are b_1, b_2**,** and b_3. To answer how these variables relate to Technology (y), the response variable, SPSS was used and the printouts are as indicated.

Table 4.1 Responses on level of technology subject to three technology determinants

	Technology Determinant		
Technology (Y)	**PEOU (X_1)**	**PU (X_2)**	**A(X_3)**
35	13	11	5
25	11	9	3
26	17	7	7
28	14	11	10
34	11	12	10
36	12	15	7
27	10	15	3
39	12	20	5
250	**100**	**100**	**50**

4.2.1 Implication by estimated Multiple Regression model

A multiple regression analysis was performed with 'Technology' as the dependent variable and Perceived usefulness, perceived ease of use and altitude as the predictor variables. **Table 4.2(a) and 4.2(b)** present values of these measures (computer printout) generated. There is a straight forward interpretation of the coefficients. The predictor variables (table 4.1) which were examined are **PEOU, PU** and **A**. We stated in the previous chapter, for 'k' variables, the model is expressed, recall (**equation *3.7)***;

$$\hat{Y} = b_0 + b_1 X_1 + b_2 X_2 + \ldots\ldots + b_k X_k$$

The question is how well do the predictor variables account for the variance in the criterion TECHNOLOGY? To answer, we reference the above and then formulate our estimated regression model as expressed by;

$$\hat{Y} = b_0 + b_1 PEOU + b_2 PU + b_3 A \qquad (4.1),$$

b_1, b_2, and b_3, are called the regression coefficients of our predictors while the b_0 is the constant. The regression coefficients of the predictors quantify the amount of linear trend in Technology (**Y**). Now using the information from **Table 4.2(a),** the regression coefficients of the predictors can be estimated.

The coefficients of perceived ease of use (b_1), perceived usefulness (b_2) and attitude (b_3) correspond to **0.44**, **1.25 and 0.34** respectively**.** This is indicated under the 'B' column of **Table 4.2(a).** Replacing them with the values of the regression coefficients, the fitted estimated model is now expressed by;

$$\hat{Y} = 8.02 + 0.44(PEOU) + 1.25(PU) + 0.34(A) \qquad (4.2)$$

Table 4.2(a) **SPSS Output for variables in equation**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(b_0)	8.015	17.324		.463	.666
	PEOU	.439	1.073	.161	.409	.703
	PU	1.252	.547	.850	2.288	.083
	A	.336	.739	.155	.155	.673

a. Dependent Variable: Level of Technology (y)

b. Predictors: (**Constant**), PEOU(X_1), PU(X_2), **A**(X_3)

Table 4.2(b) **SPSS Output for sum of squares**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	*SSR*	151.017	3	50.339	2.004	.256
	SSE	100.483	4	25.121		
	SST	251.500	7			

The coefficients, perceived ease of use (b_1), perceived usefulness (b_2) and attitude (b_3) which are found to be **0.44**, **1.25 and 0.34** respectively, represent the amount of change in technology **(Y)** corresponding to one unit change in a predictor while all other predictors are held fixed at some specified levels. The signs of the coefficients are non-negative implying there is positive relationship between the response variable and the explanatory variables. This means that if we increase perceived usefulness (**PU)** of **technology (Y) by one unit**, then we increase technology by about **1.25** times. Technology is thus, related positively to all the technology determinants. As the elements of determinants increase, more COCOBOD staff would hold onto the technology. Perceived ease of use, Perceived usefulness and altitude are then described as technology determining factors which draw

more staff to technology in QCC of Ghana Cocoa Board. Using the output information from **Table 4.2(b),** the Coefficient of determinant is also determined. The Coefficient of determinant is a measure of the goodness fit for the estimated regression equation. Coefficient of determinant, denoted R^2, is computed as follows.

$$R^2 = SSR/SST \qquad \textit{(Recall 3.8)}$$

$$SST = \sum(Yi - \bar{Y})^2. \qquad \textit{(Recall 3.10)}$$

$$SSE = \sum(Yi - \hat{Y})^2. \qquad \textit{(Recall 3.11)}$$

Using the output information from **Table 4.2(b),**

$$SSR = 151.017$$

$$SST = 251.500.$$

$$R^2 = 151.017/251.500 \qquad \textit{(4.3)}$$

R^2 = **0.600**

These values are examined under the sums of square in **Table 4.2(b).** The coefficient of determinant is a measure of the goodness fit for the estimated regression equation. It can be interpreted as the proportion of the variability in the dependant variable that can be explained by the regression equation. Since the value of the coefficient of determinant is **0.600,** it is said to be good fit for the regression model. What it also means is that 60% of the variance in Y can be explained by the model. SSR is a measure of how much the $\hat{Y}$ values on the estimated regression line deviate from$\bar{Y}$. SST is a measure of how much the Yi values on the estimated regression equation deviate from$\bar{Y}$. The value SSE is a measure of the error in using the estimated regression equation to estimate the values of the dependant variables in the sample. To test the strength of relationship among the variables, we adopt the correlation coefficient method.

Correlation coefficient, denoted r_{xiy} *is given* by;

$$\sqrt{r2}$$

From R^2, the value of Correlation coefficient, ***r =0.775.*** The correlation coefficient is always a value between -1 and +1 and a value of +1 indicates the variables in question are perfectly related. Since correlation coefficient is a descriptive measure of the strength of linear association between variables, then with a correlation coefficient of ***0.775,*** it is absolutely clear the variables in question (**PEOU**, **PU**, **A**) are closely to perfectly related.

4.2.2 Implication by estimated Logistic model

A logistic regression analysis was performed with 'Technology' as the dependent variable and Perceived usefulness, perceived ease of use and altitude as the predictor variables. A total of 50 cases were again analysed and the computer printout of the model summary and the variables in the equations are as shown (**Table 4.2(a) and Table 4.3(b)).** Overall, 84% of the predictions were accurate.

Table 4.3(a) **Model Summary**

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	42.738[a]	.024	.041

Table 4.3(b) **Variables in the Equation**

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	**PU**	.081	.915	.008	1	.930	1.084
	PEOU	.713	.818	.760	1	.383	2.041
	A	.352	.829	.181	1	.671	1.422
	Constant	1.106	.909	1.482	1	.223	3.023

a. Variable(s) entered on step 1: PU,PEOU and A.

Table 4.3(b) illustrates the coefficients, Wald statistics, associated degrees of freedom and probability values for each of the predictor variables. Recall (equation 3.16), the general logistic model is given by;

$$g(x) = \ln\left[\frac{\pi(x)}{1-\pi(x)}\right] = \beta_0 + \beta_1 x + \cdots + \beta_p X_p$$

From the model, our link function which is the logit is expressed by;

$$\textit{Logit}\ (\hat{Y}) = b_0 + b_1\text{PEOU} + b_2\text{PU} + b_3\text{A} \qquad (4.3)$$

Table 4.3(b), shows the predictor variables in the 'B' column while the odds ratios in the '*Exp(B)* column'. Therefore using those values, the estimated logistic model is now expressed by;

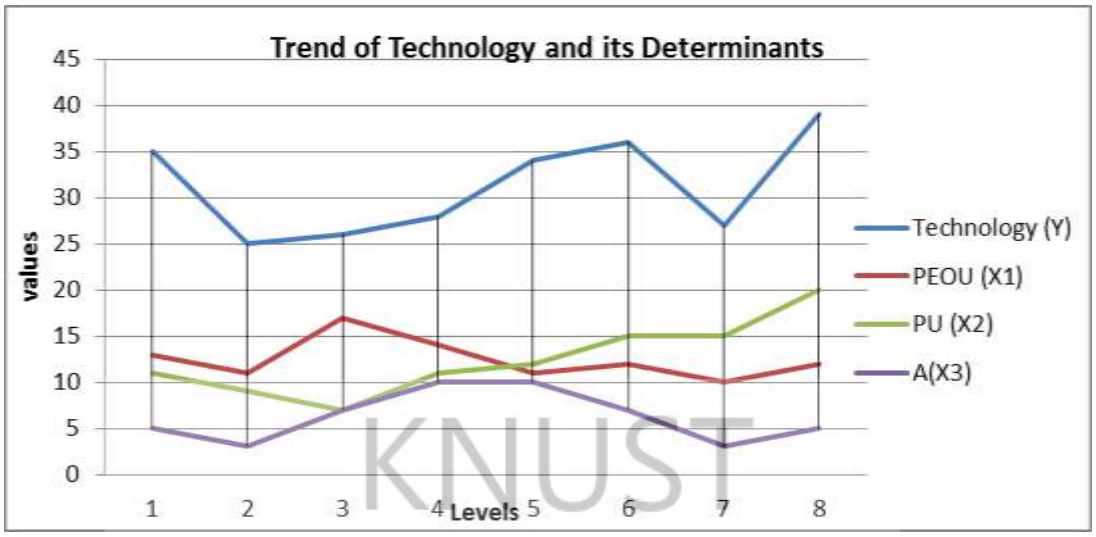
$$Logit\ (Y') = 1.11 + 0.71\ \mathbf{PEOU} + 0.08\ \mathbf{PU} + 0.35\ \mathbf{A} \qquad (4.3)$$

This shows that all the variables reliably predicted technology adoption in Quality Control Company of Ghana Cocoa Board (COCOBOD). The values of the coefficients reveal that each unit increases in PU, PEOU and the A score is associated with an increase in the odds of technology adoption by a factor of 1.084 (B=0.081), 2.041 (B=0.713), and 1.422 (B=0.352) respectively (Table 4.3b). This means that usefulness, ease of use and altitude have a part in explaining actual technology.

4.2.3 Graphical implication

The graph presented in Figure 4.1 depicts the relationship between Technology and three determinants; PU, PEOU and A. The trend of slopes of the PU, PEOU and A curves in this figure can be used as measure of the extent to which these determinants influence technology. From levels 1-2, 2-3, and 6-7, it was observed increases in the trend of the PU, PEOU, and A, saw an increase and in the same trend in the level of technology. The pattern of technology from 6-7was not exception as it followed the trend of the determinants. However, where two determinants trended in the same pattern, technology was in the same direction. Thus, the graph is a clear demonstration of the extent to which technology is influenced by the three determinants.

Figure 4.1 Trend of Technology in relation to PU, PEOU, and A



4.2.4 Estimated Models results and interpretation

The positively significant coefficients of determinants indicate their positive influence on technology adoption which was as presumed. The findings from the models analysis have suggested that perceived usefulness, perceived ease of use and attitude significantly and directly affect technology adoption. The model in ***(4.2)*** shows variation in values of the coefficients. This is a clear demonstration of the significant ways each can contribute to technology adoption. For instance PU, with a value of 1.25, means that it has a maximum and a largest part in explaining actual technology adoption than the other two. This result is consistent with Adams et al. (1992), Davis (1989), Davis et al. (1989), Straub et al. (1995), and Szajna (1996) who reported that user acceptance of an IT system is driven to a large extent by perceived usefulness. Davis (1993) argues that perceived usefulness is the most influential determinant of system usage underscoring the importance of incorporating the appropriate functional capabilities in new systems. This shows clearly that workers are ready to accept and use computers if and only if computers will be useful to the areas of their specialties. This is also similar to findings that examined 'Modeling the effect of experience on student acceptance of Web-based Courseware'. (eg. Stoel and Lee, 2003) and (Agarwal and Prasad, 1999). Previous research shows that perceived usefulness and perceived ease of use are both predictors of technology adoption by individuals, with perceived usefulness being the stronger of the two [Davis, et al. 1989; Gefen and Straub, 1997; Gefen

et al., 2003; Grover and Ramanhal, 1999; Malhotra and Galletta, 1999; Mathieson, et al., 2001; Venkatesh and Morris, 2000) Perceived usefulness is probably a motivator for more people in Quality Control to accept and at same time use technology. Therefore the greater percentage of the people embracing technology in the Company is as a result of the PU.

Model ***(4.3)*** also shows variation in values of the coefficients. For instance PEOU in (***4.3),*** with a value of 0.71, means that it has a maximum and a largest part in explaining actual technology adoption than the other two. Thus, perception of ease of use of technology influenced most of the workers to accept technology in the Company. Davis et al. (1989) found that ease of use is an important determinant of system usage operating through perceived usefulness. Goodwin (1987) argues that the effective functionality of a system, i.e., perceived usefulness, depends on its usability, i.e., perceived ease of use. Later, Davis (1993) suggests that perceived ease of use may actually be a prime causal antecedent of perceived usefulness. TAM also postulates that perceived ease of use is an important determinant of attitude toward using a system. TAM proposes that successful adoption (acceptance) of technology is dependent on its usefulness and its ease-of-use [Davis, et al., 1989]. From the research, the findings are no different from TAM and are therefore consistence with his findings. This also implies that no matter how easy computers are, even to operate or use, there are people who will still not accept them in the Company. The models also demonstrate absolutely clearly that different people are attracted to technology by various things. There were those who did not consider PU and PEOU strong enough to have caused their technology usage. Their action probably could be explained by their difficulty of visualising the unimaginable ease of use of the technology.

Models ***(4.2 and 4.3)*** show the significant and influential role altitude played on technology adoption. The positive coefficients of 0.34 and 0.35 respectively from both models portray the importance of ones attitude in technological decision. What it means is technological choices occasionally are borne from ones attitude. Attitude could motivate quite a number of people to accept and at same time use

computer technology in the Company. Attitude toward the technology might have emanated from the believed of perception usefulness and ease of use of the technology.

Studies,(eg. Stoel and Lee, 2003) and (Agarwal and Prasad, 1999) did portray that, influence of attitude toward technology is conceived from the usefulness and ease of use of the technology. This contravenes results since it is inconsistent with this result. The outcome appears to suggest that if management forces the usage of computers, most staff would oblige to the decision of management. It could again testify to imply the fact that workers attitudes could have been influenced by the decision of management. Strict directive from top management is necessary measure to change some minds set about the usage of the computers, thus translating into action and causing actual usage of technology. Ching-Wen Chen and Echo Huang (2006) study, predicting users' acceptance of online taxation system for their personal income based on technology acceptance model (TAM) and diffusion of innovation (DOI), pointed out that, perceived usefulness and perceived ease of use had a great influence on user's acceptance and usage of online taxation. Their empirical results confirmed that perceived ease of use (PEOU), perceived usefulness (PU), significantly impact taxpayers' attitudes toward using online taxation system (OTS and thus increases productivity.

The current data analysis of the influence of PU, PEOU and A on Technology suggests these determinants contribute positively towards a technology. This was also observed from the modules and that when perception of PU, PEOU and A, increased, the level of technology also increased and thus had a positive impact on productivity. The degree of significance placed on these elements, constituting Perceived usefulness (PU) of the computers, valued or ranked, differently to the different respondents. This implies that an individual's mind set of a technology could easily be influenced, as much as he or she identifies an element of PU, PEOU and A in the technology and whenever the influence is positive, productivity is also assumed to be influenced. From the responses or the models usefulness is seen to play a major role in decision-making toward computers in QCC. Responses on a wide variety of

usefulness with regards to levels of computer acceptance and usage implied computers are useful to their job task performance and worth embracing. Even the number of respondents who claimed they would not accept computers even when they are usefulness was small or negligible . Their action probably emanated from the fact that they wondered how computers will improve their work performance and this, like Cushman and Ela Klecun (2006) became a limitation to their abilities. This indicates that this category of users in the Company has no perception of how useful the computers are, in assisting them perform their job/ tasks better. Their reaction, off course clearly also portrays that not everyone in QCC appreciates the beauty of computers' usefulness and that the group does not use the computers for their office activities. The implication is that management can capitalize on this and educate the poor group supporters on the benefits of the computers relation to productivity.

The implication for the QCC data analysis is no different from Ching-Wen Chen and Echo Huang (2006) and the others. The analysis showed there is a large influence on usefulness. Perceived usefulness of computers accounted for 60% of computer acceptance and also usage in Quality Control Company Ltd. This 60% group knows the benefits of computers to the work they perform. Since computers assist them do all these things, then they are seen as part of their job tasks which cannot be avoided in the office. Obviously from the foregoing discussion, productivity payoff in technology would be a reality in QCC since technology acceptance and its application was very high. Accordingly productivity optimization is directly related to technology acceptance and its application. The more the individuals anticipate computers will be useful to their work the more they are moved to use them. Since the larger worker group uses computers for their job activities, it contributes effectively to quality of performance and increases in productivity. What it implies is workers of the Company want improvements in the jobs they do and are ready to use computers systems to achieve this. Furthermore, to this majority group computers are seen as powerful tools capable of improving the quality and the productivity of their work output. For Management to ensure workers use technology efficiently they must provide those that

bring flexibility to the staff in order to increase the sense of usefulness in the staff. It indicates the user's perception of the amount of effort required to utilize the system or shows the extent to which a user believes that using a particular technology will be effortless. Because computers are seen as effortless tools it continues to win more and more people to their application in the Company. The responses are not surprising. The more these people work with these computers, the more efficient the work becomes thus increasing the Organisational productivity. What this means is that the perception of ease of use is also strong enough to entice the personnel's participation in computers. A lot of the staff use computers for their jobs due to the effortless assistance they require. Since majority of the staff apply the available technology to the jobs they do, productivity is bound to increase. The increased productivity does not necessarily imply large number of work output but also quality of work output. Productivity can also imply people executing their jobs faster or smarter with accuracy. The low poor support group for the ease of use are those who think computers can't be that easy for their operations. This is the group who resist the use of computers for their jobs. The implication of this is that this class of persons would have their jobs or tasks performed at a slower pace compared to technology users.

Ruthvem, Henessy and Brindley (2004), researched on the attitudes of in-service teachers towards the pedagogical use of information and communication technologies (ICTs) in mainstream public schools in England. The study particularly examined teachers' perceptions towards the successful use of computer based tools in subjects such as English, Mathematics and Science. Computer based tools were defined as software applications such as Microsoft Office that could enhance learning. The themes indicated that computer based tools do have a positive effect on students irrespective of subject areas and also increased efficiency.

Ruthvem, Henessey and Brindley (2004) indicates that students were thrilled by their ability to receive immediate feedback, and with regards to grammar and spelling both teachers and students acknowledged that the computer based tools improved their spelling and vocabulary. Teachers also

expressed the ability of computer based tools to expedite the learning processes and enhance learning, and this was particularly popular with mathematics and science teachers who expressed the ease with which they organized and analysed data using spreadsheets.

4.3 Impact of Age and Years of Experience on Technology

Examining its relationship with Age and Years of experience, Technology was subjected to both Age and Years of experience. The responses are collated and tabulated in table 4.4.

Table 4.4 Association between technology subject to Age and Years of Experience.

Technology	Average Age (X)	Years of Experience (X)
35	24.5	3
25	34.5	2
26	37	1
28	42	7
34	47	5
36	52	6
27	57	9
41	64.5	10

A regression analysis was performed on both the response and the predictor variables. ***(4.4)*** and ***(4.5)*** show the models with ***(4.5)*** the estimator for ***(4.4).*** The models were formulated as;

$$\textbf{TECHNOLOGY} = \beta_0 + \beta_1\textbf{AGE} + \textbf{YRSOFEXP} \qquad (4.4)$$

$$\textbf{TECHNOLOGY} = b_0 + b_1\textbf{AGE} + b_2\textbf{YRSOFEXP} \qquad (4.5)$$

Here, the two predictor variables are **AGE** and **YRSOFEXP** (table 4.5), with b_1 and b_2, representing the estimates of the unknown parameters β_1 and β_2. **Tables 4.5(a) and 4.5(b)** present generated values of computer printout.

Table 4.5(a) **SPSS Results for sum of squares**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	SSR	60.396	2	30.198	.870	.474[a]
	Residual	173.604	5	34.721		
	SST	234.000	7			

a. Predictors: (Constant), Years of Experience, Age

b. Dependent Variable: technology

Table 4.5(b) **SPSS Results for Variables in the Equation (Coefficients)**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	26.136	8.861		2.950	.032
	Age	.010	.289	.022	.033	.975
	Years of Experience	.897	1.186	.490	.756	.484

a. Dependent Variable: technology

To predict how well the predictor variables account for the variance in TECHNOLOGY, it is assumed TECHNOLOGY is the dependent variable. 26.14, 0.01 and 0.90, read from **Table 4.5(b)** constitute the values of the unknown parameters (b_0, b_1, b_2) respectively. The fitted estimated model now becomes;

$$\textbf{TECHNOLOGY} = 26.14 + 0.01\textbf{AGE} + 0.90\textbf{YRSOFEXP} \qquad \textit{(4.6)}$$

As discussed earlier, positive coefficients of the determinants (AGE and YEARS OF EXPERIENCE) indicate their positive influence on technology adoption which as presumed. The model has suggested that AGE and YEARS OF EXPERIENCE, significantly and directly impact technology adoption. The model in ***(4.6)*** shows variation in values of the coefficients. YEARS OF EXPERIENCE is almost 9 times larger than AGE, meaning that it has a maximum part in explaining actual technology adoption than AGE. This is a clear demonstration of significant ways each can contribute to the technology adoption.

$R^2 = SSR/SST$. R^2 =0.258. The value of R^2 here is 25.0%, which suggests that the fit is not good. The coefficient of determination, R^2, indicates the percentage of variation in Y that is explained by all the predictors in the equation. The coefficient of determination R2 = 25% , say, indicates that 75% of

the variation in Y is due to all causes other than the predictors as they appear in the expression b_0 + b_1**AGE** + b_2**YRSOFEXP**. Equivalently, it is stated that 75% variation in Y remains unexplained. ***The correlation coefficient, R = 0.51*** is absolutely clear the variables in question (**AGE**, **YRSOFEXP**) are closely related.

Afari-Kumah and Akwasi Kyere, study (2009), examining computer usage intentions of Ghanaian Tertiary Students, indicated that age and level/year of tertiary students have little significant on Technology. The study purports that experience however, has influence on perceived usefulness. The study also indicates that both perceived usefulness and perceived ease of use had a significant effect on the attitude of students towards computer accept or usage. According to their study, only perceived usefulness significantly influenced the students' intention to accept or use the computer.

Cushman and Ela Klecun's (2006) paper, exploring the experiences of minimal users of ICTs, argued that, experienced technologies, perceived usefulness and perceived ease of use would have to be re-formulated to recognize limitations on people's ability. The study acknowledges people's perception on technology is balanced by the good things that the technology can achieve; the technology becomes a limitation to their progress in every aspect of live.

4.4 The Impact of Technology on productivity

The Data below shows the level of production figures subject to technology in QCC. The study was to investigate the relationship between productivity and technology in terms of quality of work output.

Table 4.6 Association between Productivity subject to Technology

Productivity(y)	Technology(X)
68	39
82	43
56	21
86	64
97	57
94	47
77	28
99	75
59	34
79	52

As we have always done, we formulate our model and then use it to estimate the equation. The estimated regression model is expressed as;

PRODUCTIVITY = $\beta_0 + \beta_1$**TECHNOLOGY** **(4.7)**

Referencing Model (4.7), the explanatory variable is (Technology) and response variable becomes productivity. To establish the relationship between Productivity and Technology, again the data was fed into the SPSS software and the computer printout in tables 4.6(a) and 4.6(b) shows the figures.

Table 4.7(a) **SPSS Results for Variables in the Equation (Coefficients)**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	45.525	9.081		5.013	.001
	Technology	.743	.187	.815	3.977	.004

a. Dependent Variable: Production

Table 4.7(b) **SPSS Results for sum of Squares in the Equation**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	SSR	1365.499	1	1365.499	15.818	.004[a]
	Residual	690.601	8	86.325		
	SST	2056.100	9			

a. Predictors: (Constant), Technology

b. Dependent Variable: Production

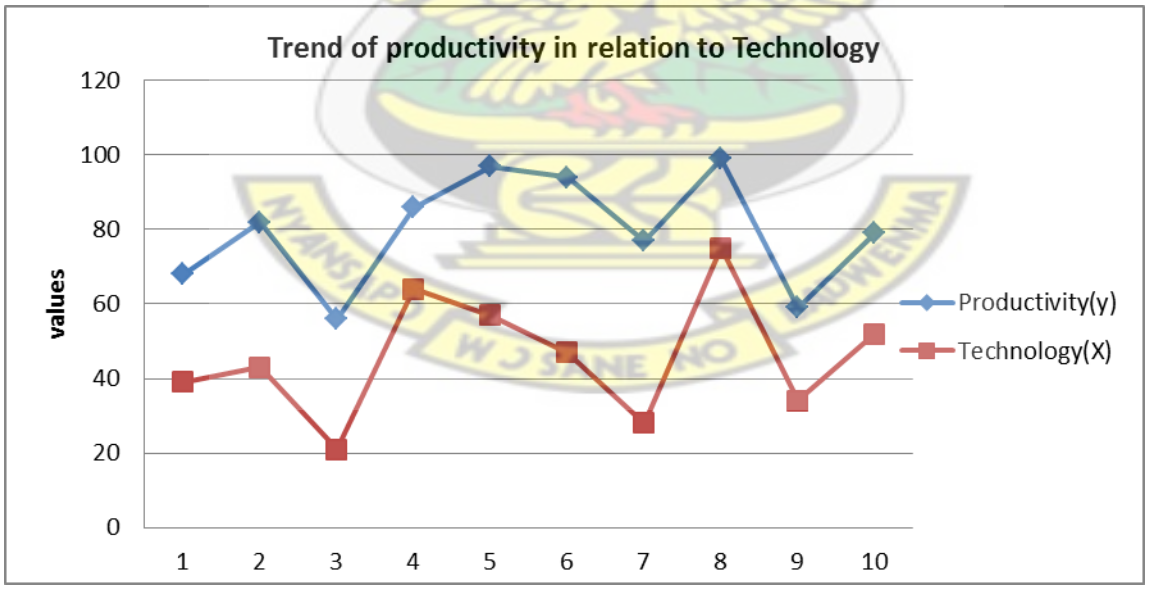
The coefficients of the estimates are determined from the 'Column of table 4.6(a) and is found to be 0.743. The constant of the equation is 45.525. If we now substitute these values into the model (4.7), it becomes;

PRODUCTIVITY = 45.53 + 0.74TECHNOLOGY. **(4.8)**

The positively significant coefficient of TECHNOLOGY indicates its positive influence on production. The production rate was found to be increased by 0.74 in every one unit increase in technology. It implies that the availability of technology encourages increases in production level. R^2 =0.664. A ***correlation coefficient, R = 0.815*** is absolutely clear the response variable (PRODUCTION) and the explanatory (**TECHNOLOGY**) are closely and perfectly related.

Adams (1992) and Davis (1989) study on systems, pointed out that system usage has been the primary indicator of technology acceptance. Straub (1995) noted that system usage influences acceptance and has a notable practical value for managers interested in evaluating the impact of IT. He further indicated system usage is used as the primary indicator of IT acceptance.

Figure 4.2 Trend of productivity in relation to Technology



The graph presented in Figure 4.2 depicts the relationship between Productivity and Technology. The lines of the curves have portrayed similarity in patterns. The patterns are absolutely illustrating the extent to which Technology and Productivity influence each other. Thus the two variables can be said

to relate to each other. When where productivity was increasing, the use of technology was seen to be remarkable. It is obviously clear there is a positively relationship between technology usage and productivity.

This result is consistent with the findings of TAM (Davis, et al. 1989; Gefen and Straub, 1997; Gefen et al., 2003; Grover and Ramanhal, 1999; Malhotra and Galletta, 1999; Mathieson, et al., 2001; Venkatesh and Morris, 2000) and is in consonant with them. Flanagin (2002), states that technology if used, changes the dynamics of organizations by optimizing productivity and also by creating effective communication tools which allow more interpersonal relationships. Hinds and Kiesler (1995), claims that information technology provides an environment in which a variety of people can join the organizational decision-making process thus eliminating organizational inefficiencies (as cited in Flanagin, 2002).

The foregoing discussion and finding also imply that accepting computers because they are easy to operate and also useful to the work you do cause the same users to use the technology for their intended duties. As the people use the technology for their intended duties, productivity of the Company was guaranteed. If jobs and tasks can now be performed faster and more accurately than before then productivity in the Company becomes optimized. Therefore it is undeniably true, that the true benefit of technology comes from its meaningful application, thus, to enhance all standards of organizational performance; there should be systematic unrestricted access to technology over time and within the right social and cultural context.

There are many who believe that the single most important factor promoting the growth of organizational sector is Information Technology.

CHAPTER FIVE
SUMMARY OF RESULTS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the findings, and from them, conclusions and recommendations are made and drawn. The recommendations are made based on the research findings; the influence of Perceived Usefulness, Perceived Ease of Use, and Attitude towards technology, the impact of Age and Years of Experience on technology and then the relationship between productivity and technology. This finding is done with the view of providing information as a measure to safeguard technology investments in Quality Control Company Ltd (QCC) of Ghana Cocoa Board (COCOBOD). The recommendations and suggestions are also aimed at providing guidelines for preliminary assessment into technology adoption thus, leading to efficiency in technology and productivity optimization.

The objective of the study was to examine and explore the influence of Perceived Usefulness, Perceived Ease of Use, Attitude, Age, and Years of Experience on technology and also to establish the actual relationship between technology and productivity. The major objective was then to establish productivity optimisation in relation to technology application. Specifically, it addressed the discussions on how these factors contribute to technology in Ghana together with their effect on productivity. It was not to generalize the findings, but to provide an expansion to the debate and also provide insights to enable people to modify.

5.2 Summary of Major Findings

The estimated models are measured as;

1) $\hat{Y} = 8.02 + 0.44(PEOU) + 1.25(PU) + 0.34(A)$
2) $TECHNOLOGY = 26.14 + 0.01AGE + 0.90YRSOFEXP$

3) *PRODUCTIVITY = 45.53 + 0.74TECHNOLOGY*

4) Perception of usefulness (PU) of technology had a significant influence on an individuals' technological decision.

5) Perception of Ease of use (PEOU) of a technology contributed meaningfully toward ones technological decision in Quality Control Company Ltd.

6) Attitude (A) was found to influence decision on Technology and attitude as a determinant, emanated from PU and PEOU.

7) The Age and years of experience of QCC staff also contributed to their decisions on their technological choices. However, 'years of experience' was more significant as compared to Age.

8) It was further observed that there was a high correlation between productivity and technology, thus, an upward movement in technology also attracted an upward trend in productivity. Optimisation in production levels in Quality Control Company (QCC) was a function of technology application.

5.3 Conclusions

This study sought to examine the influence of technology acceptance and its application and then relate it to productivity optimisation at QCC. The study further attempts to investigate or hopes to predict the influence of PU, PEOU, Attitude, Age and 'Years of Experience' on technology and then establish the relationship between productivity and technology application. To arrive at the actual findings, the research focuses on the influence of perceived usefulness, perceived ease of use, attitude, Age and 'Years of Experience' of the usable personnel towards computer technology. The Technology Acceptance Model together with Regression analysis models were adopted as the theoretical framework. This was done through the administration of questionnaires. From the models output and data analysis in chapter four, the following conclusions can be drawn;

Perceived Usefulness of a technology significantly influences perception towards computer acceptance and usage. The more people perceive a technology to be useful to the work they do, the easier they accept and use that technology. Application of the technology to one's operational areas, optimises productivity.

Perceived Ease of use (PU) of a technology also significantly affects perception towards technology acceptance and usage. Once the work force perceives a technology to be easily used for their work activities, the easier it is to adopt. It must also be pointed out that the influence of attitude towards a technology is dependent on the usefulness and ease of use of the technology. Once workers perceive computers are easy to use and useful, they develop a positive attitude towards the acceptance and use of the computers.

While it is true that technologies are growing significantly across Quality Control Company Ltd, most of the use is as a status symbol for socialization, rather than transacting core business activities. I believe that the true benefit of technology comes from meaningful application to enhance optimal standards in the organization. Although, the research has also shown that QCC personnel are using computers to a certain extent this can be improved further. The predictor of usage and acceptance in this context are perceived ease of use ,perceived usefulness and 'Years of Experience' as such more efforts should be directed towards these activities.

5.4 Recommendations

Management of Quality Control Company Ltd (QCC) should always aim at achieving a balanced productivity payoff from technology investment. At least they should encourage consensus building in every technology investment decision-making. Once this is done, the end-users are committed to accepting and using the technology which would then translate into production.

In introducing new technologies in QCC, the intended systems should be designed, developed and implemented, in such ways as to minimize users' resistance. Thus, perceive usefulness (PU) and ease of use (PEOU) of the technologies, capable of influencing acceptance and usage, must be clearly communicated and if possible demonstrated to the end-users.

In order to understand both the users' mindsets and their activity contexts towards new technologies, successful predictions of acceptance and utilization are important. Just allocating the systems does not return always efficient results. For instance, Quality Control Company Limited (QCC) should not just allocate or implement technology because it has the resources but should investigate if the users' mindsets are prepared for these.

Management should note that appropriate Technology is a necessary for QCC, but not sufficient condition for utilizing it effectively". The mere physical access to technology is not enough in itself to promote utilization. Management should also ensure that the existing technologies are used by their intended users. Technology target groups must sufficiently be trained in the existing and new technologies within the Company so as to ensure maximum acceptance and utilization of them.

The focused survey study will be carried out to further corroborate findings of the exploratory study and then a nation-wide study will be conducted to reach more generalization research conclusions. Again future research can draw some lessons from various social attitudes towards various technologies. Then the talk about technology acceptance and its application meaning productivity optimisation would then be broadened.

More efforts by Management should be expanded towards encouraging the users to increase usage and this is an important agenda to increase more quality and productivity in QCC. Although indicators

show that personnel are using PCs, they should not remain complacent due to the continuous upgrades in software applications. These results also support the advancement of information technology. Managers who are looking into the expectations of employees of the Company should have skills in using computers together with the employees so that productivity would be higher. In future, as the Company increasingly becomes more complex, where firms would compete globally, Management should implement more sophisticated computer project and deal with future challenges.

Finally the researcher also proposes that additional studies employing more qualitative approaches such as field-study or case-study methods be conducted in the region as ways of obtaining a deeper understanding of the factors that influence technology adoption and diffusion, investment decisions, organizational policies and even government policies. Thus, this study is an opportunity for further research from several perspectives. It is worth noting that technology as whole does not optimise productivity unless it's manipulated into meaningful application.

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APPENDIX A: Research Consent Letter

Dear sir/ madam,

The researcher is a student of the Kwame Nkrumah University Of Science and Technology (KNUST). The provided questionnaire is part of a study being conducted as a research Work. The focus of the study is Technology, its application and productivity optimisation in the Ghanaian context. The researcher has chosen Quality Control Company Ltd (QCCL) of COCOBOD for the study and has been granted permission.

I would be most grateful if you could complete the following questions to reflect your opinions and knowledge accurately. Your information will be kept strictly confidential and use for the academic purposes only.

Your cooperation and assistance is most appreciated.

Yours sincerely,

APPENDIX B: Research Questions

QUESTIONNAIRE

SECTION A: ***(Check only the most appropriate one in this section)***

YOUR BACKGROUND

1. Your Station:

- ☐ Accra main office
- ☐ Tema Port
- ☐ Research-Tema

2. Gender:

- ☐ Male
- ☐ Female

3. Highest level of education attained:

- ☐ Primary
- ☐ Commercial/Secondary/SSS
- ☐ College/University

4. **Staff category:**

- ☐ Managerial level
- ☐ Senior level
- ☐ Junior level

5. Age range:

- ☐ 18-29
- ☐ 30-49
- ☐ 50 or Above

SECTION B: ***(Check only the most appropriate one in this section)***

GENERAL INFORMATION ON INFORMATION TECHNOLOGY

1. Does Quality Control Company Ltd have computers?

- ☐ Yes
- ☐ No

2. What is the number of computers in your office?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ More

3. Can the computers in your office access information from each other?

- ☐ Yes
- ☐ Don't know
- ☐ No

4. Is Quality Control Company Ltd connected to the Internet?

- ☐ Yes
- ☐ No
- ☐ Don't know

5. How would you rate the level of computer literacy in your company?

- ☐ Very poor
- ☐ Poor
- ☐ Good
- ☐ Very good
- ☐ Excellent

6. Which one of the following technology (ies) is in frequent use in your department?

- ☐ Internet Services
- ☐ Fax machine
- ☐ Computers
- ☐ Telephone
- ☐ Others

7. Which one of the following technology (ies) in your department do you appreciate most?

- ☐ Internet Services
- ☐ Fax
- ☐ Computers
- ☐ Telephone
- ☐ Others

8. How would you rate your skills in the one you appreciate most in the company?

- ☐ Very poor
- ☐ Poor
- ☐ Good
- ☐ Very good
- ☐ Excellent

9. How would you rate the level of computer technology in your company?

- ☐ Very poor
- ☐ Poor
- ☐ Good
- ☐ Very good
- ☐ Excellent

SECTION C: ***(Check only the most appropriate one in this section)***

THE USEFULNESS OF THE IT SYSTEM

1. If computers would improve the quality of your job in your organization how would you rate your level of satisfaction, in using them?

- ☐ Very poor
- ☐ Poor
- ☐ Good
- ☐ Very good
- ☐ Excellent

2. If computers would give you greater control or flexibility over your work how would you rate your level of satisfaction, welcoming them?

- ☐ Very poor
- ☐ Poor
- ☐ Good
- ☐ Very good
- ☐ Excellent

3. If you are told that using computers in Quality Control Company LTD (QCCL) would increase your job performance how would you record your response, welcoming them?

- ☐ Very poor
- ☐ Poor
- ☐ Good
- ☐ Very good
- ☐ Excellent

4. If computers would improve the work you perform in your office, how would you rate your response level, embracing their usage?

- ☐ Very poor
- ☐ Poor
- ☐ Good
- ☐ Very good
- ☐ Excellent

5. If computers would enhance your work effectiveness in your department, how would you record your response, embracing them?

- ☐ Very poor
- ☐ Poor
- ☐ Good
- ☐ Very good
- ☐ Excellent

6. If the Internet service in QCCL will not improve the performance of communication, how would you rate your response level to its introduction?

☐Very poor

☐Poor

☐Good

☐Very good

☐Excellent

7. If the Internet Technology in QCCL is enhancing the quality of communication, how would you record your response to its usage?

☐Very poor

☐Poor

☐Good

☐Very good

☐Excellent

8. What would be your stand if you are told a technology to be introduced in QCCL would increase your job or work productivity? How would you record your level of response welcoming its introduction?

☐Very poor

☐Poor

☐Good

☐Very good

☐Excellent

9. If computers will enable you to accomplish your tasks more quickly, how would you rate your level of response in welcoming their implementation?

☐Very poor

☐Poor

☐Good

☐Very good

☐Excellent

10. If you find computers useful to the work you do, how would you record your usage level if you have access to?

☐Very poor

☐Poor

☐Good

☐Very good

☐Excellent

SECTION D: ***(Check only the most appropriate one in this section)***

EASE OF USE OF THE SYSTEM

1. How would you rate your readiness welcoming computers in your department if learning to operate them would be easy for you?

☐Poor

☐Fair

☐Good

☐V. Good

☐Excellent

2. **How ready would you rate yourself towards using computers if learning to operate a computer technology would be easy for you?**

☐Poor

☐Fair

☐Good

☐V. Good

☐Excellent

3. **How would you rate your level of readiness to welcome computers if you find them easy to do what you want them to do for you?**

☐Poor

☐Fair

☐Good

☐V. Good

☐Excellent

4. **What would be your level of readiness to the use of computers if you find them easy to do work you want them to do for you?**

☐Poor

☐Fair

☐Good

☐V. Good

☐Excellent

5. **How would you record your level of satisfaction, welcoming an information technology in your company if it would be easy for you to become skillful at using it?**

☐Extremely dissatisfied

☐Dissatisfied

☐None

☐Satisfied

☐Extremely satisfied

6. **How would you record your level of satisfaction of using a computer in your department if interacting with it is often frustrating?**

☐Extremely dissatisfied

☐Dissatisfied

☐ None

☐Satisfied

☐Extremely satisfied

7. **If learning to operate a technology will be easy for you, how would you record your level of agreement, welcoming such a system?**

☐Strongly agree

☐Agree

☐ None

☐Disagree

☐Strongly disagree

8. If QCCL introduces an information technology which is within your entire control, how would you record your level of agreement, using such a system?

☐Strongly agree

☐Agree

☐None

☐Disagree

☐Strongly disagree

9. How would you react to the introduction of any computer system in your department which you find difficult to operate?

☐Strongly agree

☐Agree

☐None

☐Disagree

☐Strongly disagree

10. In general, how would you rate your level of satisfaction toward a computer system in your company if you would be able to use it effectively?

☐Extremely dissatisfied

☐Dissatisfied

☐None

☐Satisfied

☐Extremely satisfied

SECTION E: ***(Check or circle only the most appropriate one in this section)***

ATTITUDE

1. Would you like the introduction of computers in Quality Control Company LTD? How would you record your level of attitude towards it?

☐Strongly agree

☐Agree

☐None

☐Disagree

☐Strongly disagree

2. How would you rate your level of support agreement to the use of computers if they provide attractive learning environment?

☐Strongly agree

☐Agree

☐None

☐Disagree

☐Strongly disagree

3. How would you rate your level of agreement to the use of computers if QCC management enforces the use of computers?

☐Strongly agree

☐Agree

☐None

☐Disagree

☐Strongly disagree

4. How would you rate your level of agreement to the use of computers if they are fun to use?

☐Strongly agree

☐Agree

☐None

☐Disagree

☐Strongly disagree

5. People who are important to you think that you should use computers for your work. Would you say the reaction is …?

☐Strongly agreed

☐Agreed

☐None

☐Disagreed

☐Strongly disagreed

SECTION F: ***(Check or circle only the most appropriate one in this section)***

PRODUCTIVITY

1. How would you record your level of agreement, using computers have reduced inefficiencies in COCOBOD?

☐Strongly agree

☐Agree

☐None

☐Disagree

☐Strongly disagree

2. How would you react to the introduction of any computer system in your department which does not improve your work output?

☐Strongly agree

☐Agree

☐None

☐Disagree

☐Strongly disagree

3. In general, how would you rate your level of increased productivity to the use of technology in your department?

- ☐ Extremely dissatisfied
- ☐ Dissatisfied
- ☐ None
- ☐ Satisfied
- ☐ Extremely satisfied

4. How would you rate your level of low output errors to the use of computers?

- ☐ Strongly agree
- ☐ Agree
- ☐ None
- ☐ Disagree
- ☐ Strongly disagree

5. How would you rate your level of quality of work output to the use of computers?

- ☐ Strongly agree
- ☐ Agree
- ☐ None
- ☐ Disagree
- ☐ Strongly disagree

6. How would you rate your level of job processing speed to the use of computers?

- ☐ Strongly agree
- ☐ Agree
- ☐ None
- ☐ Disagree
- ☐ Strongly disagree