KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI

FACULTY OF ARTS AND SOCIAL SCIENCES

DEPARTMENT OF ECONOMICS

THESIS TOPIC:

MEASUREMENT OF TECHNICAL EFFICIENCY AND ITS DETERMINANTS AMONG MAIZE FARMERS IN ASANTE AKYEM NORTH MUNICIPALITY

SUBMITTED BY

COLLINS DANSO OPPONG

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN ECONOMICS

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DECLARATION

I wish to declare that the content of this work is the result of my effort under the supervision of Mr. Eric Oteng-Abayie and that no part of it has been presented in whole or part for any certificate, diploma or degree in this university or elsewhere. Those whose work(s) were partly adopted are dully acknowledged in the text. I therefore present this work for the award of Master of Philosophy (Economics) Degree.

COLLINS DANSO OPPONG	....	....
	Signature	Date

CERTIFIED BY:

MR. ERIC OTENG-ABAYIE	....	…..............................
Supervisor	Signature	Date
MR. J. APPIAH-NKRUMAH	....	…..................................
Head, Department of Economics	Signature	Date

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DEDICATION

This work is dedicated to my lovely son, Kelvin, for the good luck bestowed on the entire family. Beloved son, is my prayer that this work will improve the quality of your life in subsequent years to come. To my darling wife, Elizabeth, for her sincere love and commitment. Also, to my Mum and Dad, Mercy Pokuaa Abrokwaa and Oppong-Anane Collins, for their unflinching support.

ABSTRACT

Agriculture is the backbone of Ghana's economy likewise that of Asante Akyem North Municipality. Agricultural productivity varies mainly due to differences in efficiency and production technology. Efficiency measurement has been the concern of most researchers with much focuses on the estimation of technical efficiency levels (scores) and their determinants. Based on empirical studies, policy makers have realised that one important source of growth for the agricultural sector is efficiency gain through greater technical efficiency. This study attempts to measure the level of technical efficiency of maize farmers in Asante Akyem North Municipality by identifying its determinants, estimating the scores and evaluating the importance of the socio-economic variables on technical efficiency. Technical efficiency is defined as the ratio of the observed output to the corresponding frontier output and is estimated from the composed error term. Technical efficiency is estimated using the maximum likelihood and seemingly unrelated estimation methods under the specification of the Cobb Douglas stochastic frontier model with half normal assumption for inefficiency effects. The study used well structured questionnaire to obtain cross-sectional data from 250 maize farmers in the farming areas of the municipality. The results from the study indicate that the mean technical efficiency of maize farmers in the municipality is 73%; implying that actual maize production is in shortfall of 27%. However, efficiency scores range from 17.3% to 95.48%. Analysis of the determinants of technical efficiency indicates that, access to credit and education, hybrid seed, weedicide, male farmers and farm size are positively related to the technical efficiency of maize farmers. Fertilizer application, labour hours, number of seed sowed per hole and farmer's family size were negatively related to the technical efficiency of farmers. However, all the variables were statistically significant except, fertilizer application and farmer's family size; which were statistically insignificant at 5% level. Based on these findings, the study recommends the loosening of various constraints associated with credit acquisition, diversification of produce and also the promotion of farmers' cooperatives to ease the accessibility of credit to farmers. Secondly, redesigning the F-CUBE programme to improve the quality of education and providing informal agricultural education to farmers within the farming areas, will be useful mechanisms to improve efficiency of maize farmers. Additionally, there is the need to train more extension officers, equip and motivate them with adequate facilities and attractive remuneration to enable them deliver. Finally it is recommended that, further studies can be pursued through an extension to cover allocative efficiency, greater geographical area, inclusion of additional variables, increase in sample size and the use of Data Envelopment Analysis.

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LIST OF ABBREVIATIONS

AANMA	Asante Akyem North Municipal Assembly
BLUE	Best Linear Unbiased Estimator
COLS	Corrected Ordinary Least Square
CSIR	Council for Scientific and Industrial Research
DEA	Data Envelopment Analysis
DMUs	Decision Making Units
FAO	Food and Agriculture Organisation
F-CUBE	Free Compulsory Universal Basic Education
GDP	Gross Domestic Product
GSS	Ghana Statistical Service
HYV	Higher Yielding Variety
ISSER	Institute of Social, Statistical and Economic Research
LDC_S	Less Developed Countries
MLE	Maximum Likelihood Estimation
MOFA	Ministry of Food and Agriculture
OLS	Ordinary Least Square
PH	A number from 0 to 14 that describes the acidic or alkaline nature of a substance
R&D	Research and Development
SFA	Stochastic Frontier Analysis
SRID	Statistics, Research and Information Directorate
TE	Technical Efficiency

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CHAPTER ONE

INTRODUCTION

1.0 Background of the Study

Agriculture has been the mainstay of the Ghanaian economy since the discovery of the country (Al-hassan, 2008), through the era of independence to this current period (FAO-statistics, 2004). According to the World Bank country reports for 2010 and 2011, the agricultural sector contributes about 33.7% of GDP and provides livelihood for over 56% of the nation's total labour force. Furthermore, it supplies 90% of the food needs (FAO Statistics, 2010) for the country's teaming population of 24,223,431 (GSS, 2011) plus the supply of raw materials for the agro-based industries.

According to Asiedu (2010), Ghana's farming system is characterized by food and export crop production, livestock rearing and non-traditional activities. It is also characterized bypeasant and large scale commercial farming. Maize is one of the most dominant food crops produced by smallholder farmers under traditional cultivation methods in Asante Akyem North Municipality (Asante Akyem North Municipal Assembly's Annual Report, 2010). In Africa likewise in Ghana, productivity in agriculture has declined to the extent that even though the sector is the backbone of the economy, only 20% of agric produce are traded among Africans as compared to 65% among the advanced countries whose economies are industrial based (FAO Statistics 2012). Additionally, growth in agriculture in 2011 was only 2.8%, contribution to GDP declining from an average of 55% in the 1980s to 41% in 1995 and currently it is about 33.7% (World Bank Report, 2010 and 2011). Slow agricultural growth means that over 56% of the country's population particularly the rural folk, earns low income and as such, the rate of savings and investment opportunities are severely limited. As a result, growth in non-agricultural sectors remains low, which in turn limits employment growth and aggravates rural poverty in the country. Even though conscious policies (such as free mass spraying, subsidization of farm inputs such as fertilizer and improved seed and the celebration of farmer's day to commend farmers at the national and local levels) have been implemented by government to revamp the sector, persistent low productivity in the sector and high food importation reveal marginal success of these policies.

Currently, policy makers have started to believe that, an important source of growth for the agricultural sector is efficiency gain through greater technical and allocative efficiency of farmers in response to better information and education. Technical efficiency, according to Kebede (2001), is the maximum attainable level of output for a given level of production inputs, given the range of alternative technologies available to the farmer. Measurement of technical efficiency is important for productivity growth, especially in developing agricultural economies, where resources are meagre and opportunities for developing and adopting better technologies have lately started dwindling (Ali and Chaudhly, 1990). It is also a success indicator of performance measure by which production units are evaluated. Therefore, it is imperative to measure the level of technical efficiency and to evaluate its determinants among maize farmers with Asante Akyem North Municipality as a case study.

1.1 Statement of Problem

According to the World Bank Report in 2010 and African Report in 2011, the Ghanaian agricultural sector is operating below its potential due to inadequate supply of necessary infrastructures in the rural areas which form the bulk of agricultural zones in the country. In addition, the efficiency levels of farmers are very low due to limited access to credit which translates into low working capital, thus impeding their ability to purchase productivity-enhancing-inputs such as improved seeds, fertilizers, weedicides, pesticides etc. Low technical efficiency among farmers translates into low average yield in agricultural produce. This is evident from the fact that maize yield per hectare is averagely 1.5 metric tonnes (MOFA, 2009) is far below the average of 5.2 to 6.4 metric tonnes per hectare (CSIR, 2012) with improved technical efficiency of farmers in the country.

These trends also raise questions about the kind of technology adopted in maize cultivation and the level of production in Asante Akyem North Municipality and Ghana as a whole. Although in recent times the diffusion of new technologies in agriculture such as fertilizer application, hybrid seed and weedicide have been more widespread in maize production than other food crops, full potential has not been reached in Ghana. Technological impact on maize yield is generally marginal with little attention being focused on it. Generally, the available literature has identified physical, environmental and socio-economic factors as important determinants of technical efficiency in food production across the globe.

Considering the fact that maize is important for food security in Ghana and that, empirical research on the measurement of technical efficiency of maize farmers has not been materialized in Asante Akyem North Municipality, a study of this nature is necessary to be pursued. Measuring the current level of technical efficiency will give an indication of the potential gains in output if technical inefficiencies in production were to be eliminated from maize production. This will provide valuable information for better direction of adjustment which can be useful at micro and macro levels to farmers and policy makers for the improvement of technical efficiency of farmers with existing resources.

Therefore, this study wants to open a new dimension to farmers and policy makers on how best to improve maize production by determining the extent to which it is possible to raise the level of farmers' technical efficiency in Asante Akyem North Municipality, with focus on determinants such as; gender, access to education, farmer's family size, farm size, fertilizer application, type of seed, number of seed sowed in a hole, amount of weedicide, labour hours and accessibility to credit.

1.2 Objectives of the Study

The main objective of this study is to measure technical efficiency at aggregate level among maize farmers in Asante Akyem North Municipality. To achieve the main one, the study has been designed to fulfill the following specific research objectives.

1 Estimate the levels (scores) of technical efficiency of maize farmers in Asante Akyem North Municipality in Ghana, using the available data.

2 Identify the factors that influence the level of technical efficiency of maize farmers in Asante Akyem North Municipality in Ghana.

3 Evaluate the importance of the determinants of technical efficiency of maize farmers in Asante Akyem North Municipality in Ghana.

4 Describe the relationships between the socioeconomic characteristics of farmers and their technical efficiency

1.3 Research Questions

In connection with the research objectives, the estimation and determinants of technical efficiency of maize farmers in Asante Akyem North Municipality in Ghana poses the following research questions:

1. What are the levels of technical efficiency of maize farmers in Asante Akyem North Municipality in Ghana?
2. What factors influence the level of technical efficiency of maize farmers in Asante Akyem North Municipality in Ghana?
3. What is the correlation between technical efficiency and its determinants?

4. What policies should be recommended to improve the level of technical efficiency of farmers in Asante Akyem North Municipality in Ghana?

1.4 Study Hypothesis

There are four hypotheses to be testedwith the generalized likelihood ratio test under the null and alternative hypothesis; in which the null hypotheses will be rejected if $_{LR>}\chi C^2$. These are;

a. The study hypothesizes that the Cobb Douglas stochastic specification is robust for the adequate representation of the frontier production function.
b. The study also hypothesizes that each farmer is operating on the technically efficient frontier and that; the asymmetric and random errors are zero. This concludes that all maize farmers in the municipality are fully technically efficient.
c. The study hypothesizes that; farm size, average labour hours spent daily on farms, amount of weedicide applied, number of seed sowed in a hole and accessibility to credit; have significant relationship with maize yield in Asante Akyem North Municipality.
d. The study also hypothesizes that gender, family size, access to formal education, type of seed and amount of fertilizer have significant relationship with the technical efficiency of maize farmers in the municipality.

1.5 Method of the Study

To ensure originality, primary data is used for the study. Data is obtained from maize farmers in the maize producing areas of Asante Akyem North Municipality in 2011. Maize is cultivated and produced in the remote areas of the municipality and therefore these destinations were the specific research areas of interest for the location of maize farmers. Farm level and socioeconomic variables of interest including: gender, access to formal education, farmer's family size, farm size, amount of fertilizer applied by the farmer, type and number of seed sowed in a hole, amount of weedicide, labour hours and farmers' accessibility to credit were used for the study. To achieve high level of consistency, representativeness and also in line with the central limit theorem, the sample size has been broadened to cover two hundred and fifty (250) maize farmers. These farmers were drawn from five selected rural areas in Asante Akyem North Municipality. Both probability and non-probability sampling techniques were employed to obtain the sample units or the respondents (maize farmers). The study used well structured questionnaires as the survey method to solicit for the relevant data from the maize farmers.

According to (Fare et al., 1993; Lovell et al., 1994; Grosskpof et al., 1996; Coelli and Perelman, 1996), the majority of efficiency studies have been motivated by the desire to estimate the frontier production function and to calculate technical efficiencies. Following, Aigner et al. (1977) and Meeusen and Van Den Broeck (1977), the Cobb Douglas stochastic frontier model was employed for the study. In addition, the Cobb Douglas stochastic production function and determinants of technical efficiency are estimated using the maximum likelihood and seemingly unrelated estimation methods. Both the likelihood ratio test and t-test were used to determine the statistical significance of the estimates at 1% and 5% level. Furthermore, inferential and descriptive statistics were used to draw conclusions and to analyse the socioeconomic characteristics of farmers respectively.

1.6 Relevance of the Study

The study on measurement of technical efficiency and its determinants among maize farmers has the following purposes.

- First, the study will serve as a policy guide to policy makers to boost food production by expediting action on the improvement of key determinants of maize farmers' technical efficiency in Asante Akyem North Municipality and beyond.
- Secondly, the application purpose of such a study can also help policy makers to forecast maize production in the municipality, based on the estimated level of technical efficiency of maize farmersin Asante Akyem North Municipality.
- It will provide the opportunity for countries whose economies are maize-based to increase productivity in maize production through improvement in technical efficiency.
- Finally it will generate effective policy recommendations based on empirical results to improve the level of technical efficiency of maize farmers in Asante Akyem North Municipality in Ghana.

1.7 Preview of the Study

The study is categorized into five main chapters. Chapter one, as has been detailed already, consists of the background of the study, research problem, objectives, research questions, study hypothesis, method of the study, relevance and preview of the study. The remainder of the thesis is organized as follows: Chapter two discusses the literature review on the determinants of technical efficiency; both theoretical and empirical review. Focus of chapter two is on agriculture in Ghana, maize production in Ghana, methodological review of technical efficiency, review of technical efficiency studies in Ghana, determinants of technical efficiency in general, agriculture and maize production.

Chapter three constitutes the research methodology of the study. This primarily covers the description of Asante Akyem North Municipality, type of data, sampling procedures and survey method used for the study, model specification, estimation method, statistical tests and tools for data analysis. Chapter four presents the data analysis and discussion of results in relation to measurement of technical efficiency and its determinants. The final chapter which is five, winds up the study with the summary of findings, policy recommendations, limitations of the study and conclusion of the study. References and appendices will follow chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter concerns the literature review of the study and it is subdivided to cover agriculture in Ghana, maize production in Ghana, definitions of technical efficiency, methodological review of technical efficiency, technical efficiency studies in Ghana, determinants of technical efficiency in general, agriculture and maize production respectively.

2.1 Agriculture in Ghana

According to FAO-statistics (2004), the Ghanaian economy has been dominated by agriculture since the discovery of the country, through the era of independence to this current period. It is against this background that the first Ghanaian government soon after independence used agricultural wealth as a springboard for the country's overall economic development. The contribution of agriculture to the economy of Ghana can be manifested in the areas of food supply, employment generation, and its contribution to domestic revenue through taxation, foreign exchange earnings through exports, raw materials for agriculture-based industries and as a dominant component of gross domestic product (GDP). For instance, in 2006, the sector contributed 39.9% to GDP and 41.1% of foreign exchange was derived from traditional and non-traditional crops (ISSER, 2007). In the World Bank Report (2011), the agricultural sector contributed 33.7% to gross domestic product and employed 56% of the total labour force of the country (of which most of them were women), and supplies 90% of the food needs (FAO Statistics 2010) for the country’s teaming population of 24,223,431 (GSS, 2012). Despite these gains, agriculture is still highly dominated by the smallholder farming system.

According to Kwarteng, et al. (1994), agricultural sector in Ghana can be categorized into six (6) main sub sectors namely; food crops, industrial crops, export crops, livestock and poultry, fisheries and forestry. Coincidentally, the country is also divided into six distinct agro-ecological or vegetational zones namely; high rainforest, semi deciduous forest, forest savannah, guinea, sudan and coastal savannah. According to Josh (2010), cocoa is the only commercial crop that facilitates 21% of the country's international trade fortunes. Apart from cocoa production which is the largest in the country, major staple crops produced include; cereals (mainly rice and maize) and starchy staples such as yam, cocoyam, cassava and plantain (Asiedu 2010). Crop production in Ghana is for three main reasons: food supply for consumption, raw materials for industrial purpose and cash crop for export. Livestock production includes the rearing of cattle, goat, poultry, pig etc and is on subsistence and commercial basis.

Among the various sectors of the Ghanaian economy, agriculture is expected to lead economic growth in the country. Thus, growth and development in developing countries is dependent on agriculture (World Bank, 2008). In Ghana, government development objective hinges on a demand-driven national agricultural strategy whose goals are development oriented, productivity enhancing, and competitiveness (Asuming-Brempong et al 1991).

According to Bogetic et al. (2007), growth in agriculture reduced poverty rate in Ghana from 51.7% in 1991-1992 to 39.5% in 1998-1999 and to 28.5% in 2005-2006. But with a reduction in agricultural growth by 2.2%, poverty level rose by 6.9% in 2011 (FAO 2011). To enhance productivity in food production, technical efficiency measurements are crucial since it will provide the opportunity to increase agricultural productivity without necessarily increasing the resource base of the country. Squires and Tabor (1990) defined technical efficiency as farmer's ability to produce the maximum output possible from a given set of inputs and production technology. This concept is relative since each farm's production performance is compared to the best-practice input-output relationship or frontier. The best-practices are established by the practices of the most efficient farmers. The deviation of the individual farm from the frontier measures technical inefficiency. From an aggregate and time series perspective, the best-practice frontier is the potential output for the best practice year. Thus, the technical inefficiency in that case, is the gap between the actual output for any particular year and the potential output of the best practice year.

2.1.1 Maize Production in Ghana

Maize is one of the most important crops in Ghana's agricultural sector mainly for food security purpose. It represents the second largest commodity crop in the country after cocoa and is the largest staple crop in Ghana which contributes significantly to several consumer diets. It is the number one crop in terms of area planted and accounts for 50-60% of total cereal production. Maize is the second staple food apart from rice, consumed among many households in Ghana according to Alhassan (2008) and MOFA (2011).

Maize originated in Central and South America and was introduced into Africa by Portuguese in the 16th century. It was introduced in Europe in 1942 from Central and Southern America by Christopher Columbus and later spread to all parts of Africa by the Dutch in Southern Africa (Okoruwa, et al. 2004). After being introduced in the southern part of Ghana, it soon established itself as an important food crop. Earlier on, maize also attracted the attention of commercial farmers, although it never achieved the economic importance of traditional plantation crops, such as oil palm and cocoa. Over time, the eroding profitability of many plantation crops (attributable mainly to falling prices of commodities on the world market and increasing disease problems in cocoa production, deforestation and natural resource degradation) served to strengthen interest in commercial food crops, including maize. Today, maize is Ghana's most important cereal crop. In Ghana, likewise in other African countries, maize is cultivated by both men and women and grown by the vast majority of rural households in all parts of the country except for the sudan savannah zone of the far north.

Maize grows very well in tropical rainforest, semi deciduous forest and guinea savanna areas where there is enough rainfall to produce good yield. The Middle belt of Ghana; including most parts of Ashanti, Brong-Ahafo, Northern, Western and Eastern region supply over 60% of total maize output in the country (SRID and MOFA 2009). Soils ideal for maize cultivation are forest and savannah ochrosols. It can be cultivated once or twice annually, depending on the rainfall patterns in that climatic zone of the area. Maize takes a gestation period of 90 to 120 days, after which it can be harvested, threshed, dried and preserved in silos for consumption or for export. According to the FAO Statistics, a bag of maize weighs approximately ninety (90) kilograms. The economic importance of maize cannot be overestimated and it cut across different spheres of life (Oyewo 2011). It serves as food for human consumption such as pap, pop corn, porridge, banku, kenkey, boiled grains and processed as feed for the poultry industry. Maize is industrially important chiefly for the production of starch and alcohol. The starch can be used as a converter dextrin, syrup and sugar. Oil obtained from maize can be refined for cooking purposes.

From 2005 to 2011, the volume of maize production in the country has been fluctuating due to farmers' inability to afford modern level of technology. For instance 1,171,000 tonnes of maize were produced in 2005, 1,189,000 metric tonnes in 2006, 1,219,600 metric tonnes in 2007, 1,470,080 metric tonnes in 2008, 1,619,590 metric tonnes in 2009, 1,800,000 metric tonnes in 2010 and 1,000,000 metric tonnes in 2011. Annual domestic deficit of maize for the last four years have been estimated between 84,000 and 145,000 metric tonnes (SRID 2009).

Ghana therefore has to import from neighbouring countries to augment local supply. However, the volume of maize production in Asante Akyem North Municipality in 2004 and 2005 were 15,900 and 15,776 metric tonnes respectively (AANMA, 2010).

Maize yields in Ghana are on average approximately 1.5 metric tonnes per hectare (MOFA, 2009). However, yields as high as between 5.0 to 5.5 metric tonnes per hectare (CSIR, 2012) can be achieved by farmers with improved seeds, fertilizer, mechanization, irrigation etc. It has been postulated by agricultural analysts that maize production on commercial basis can help bridge the increasing gap between domestic demand and supply of maize. More importantly, improving farmers' technical efficiency will help achieve this goal.

2.2 Definitions of Technical Efficiency

An economy is efficient when resources are used in a way that maximizes the production of goods and services at the lowest cost for society. According to Kebede (2001), efficiency of production unit may be defined as how effectively variable resources are used for the purpose of profit maximization, given the best production technology available. Farrell (1957) distinguished between the types of efficiency; technical efficiency, allocative efficiency and economic efficiency, by concluding that farm efficiency can be measured in terms of any or all these types of efficiency. Nevertheless, much emphasis is centred on technical efficiency because it is the focus of the study.

According to Leibenstein (1996), technical efficiency in economics, is the effectiveness with which a given set of inputs is used to produce an output. If a firm is producing the maximum output it can, given the resources it employs, such as labour and machinery, and the best technology available, it is said to be technically-efficient.

According to Ali and Chaudhry (1990), Kebede (2001) and Forsund, et al. (1980), technical efficiency is the ability of a farm to achieve maximum possible yield with available inputs. In relation to their definition, it refers to the ability of a firm to produce the maximum output from its given resources. One firm is more technically efficient if it produces an output level higher than another firm with the same level of input usage and technology. Measures of technical efficiency give an indication of the potential gains in output if inefficiencies in production were to be eliminated.

In accordance with the views of Okoruwa, et al. (2004), the level of technical efficiency of a particular firm is characterized by the relationship between observed production and some ideal or potential production. The measurement of firm specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier. If a firm's actual production point lies on the production frontier, it is perfectly efficient. If it lies below the frontier then it is technically inefficient, with the ratio of the actual to the potential production defining the level of efficiency of the individual farmer.

In the opinion of Farrell (1957), Rahman, et al. (2005) and Forsund, et al. (1980), a technically efficient farm produces the maximum possible output from inputs used, given locational and environmental constraints and it minimizes resources used for any given level of output or technical efficiency is input-saving which gives the maximum rate at which the use of all the inputs can be reduced without reducing output. According to Greco (2008), technical efficiency is a prerequisite for allocative efficiency and it describes the production that has the lowest possible opportunity cost. Material and labour resources are not wasted in producing of goods and services under technically efficient production.

Besides technical efficiency, an extension can be made to briefly explain other types of efficiency such as productive efficiency, x-efficiency, dynamic efficiency, economic efficiency and allocative efficiency.

According to Parkin et al (2003), productive efficiency is achieved when it is not possible to produce more of one good without producing less of the other good and therefore occurs only at points on the production possibility frontier (the boundary between those combinations of goods and services that can be produced with the available resource and the state of technology).

Allocative efficiency, according to Greco (2008), is when a society's value for a certain good or service (the amount they pay for it) is in equilibrium with the cost of resources used to produce it. It is typically achieved not by accident but when a society allocates its resources to the production of what society values most. Also, to Farrell (1957), allocative efficiency deals with the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal productivity is equal to the cost of input.

Leibenstein (1996) also identified the concept of X-efficiency and viewed it as the difference between the minimal and the actual costs of a production, or as the difference between the actual and the maximal (potential) output.

In accordance with the views of Parkin, et al. (2003), economic or total efficiency is the product of technical and allocative efficiencies. An economically efficient input-output combination would be on both the frontier function and the expansion path

To Greco (2008), dynamic efficiency is used to describe a market in the long term. A society with a high dynamic efficiency offer consumers more choices of higher quality goods or services than in another. The market experiences dynamic efficiency when research and development improve products over time, and enhance the production of quality goods at cheaper cost.

2.3 Methodological Review of Technical Efficiency

The potential importance of efficiency as a means of fostering production has being recognized by many researchers. Technical efficiency and the question of how it is measured, is also an issue of concern in both developing and developed countries (Ashok, et al. 1995). Applications vary in content because most studies in developing countries are focused on agriculture; while technical efficiency studies have been confined to the industrial (manufacturing) and service sectors in developed countries.

In literature and recent applications (Fare et al., 1993; Lovell et al., 1994; Grosskpof et al., 1996; Coelli and Perelman, 1999), two approaches, parametric and non-parametric have been adopted to find out the technical efficiencies of various enterprises. These two approaches have certain advantages and disadvantages over each other being discussed by Battese (1992), Bravo-Ureta and Pinheiro (1993), Forsund, et al (1980), Coelli and Perelman (1999).

Parametric approach involves econometric modeling and it imposes a functional form on the production function and makes assumptions about the data. The common estimation models under parametric approach are; the Cobb Douglas production function, stochastic frontier function, constant elasticity of substitution function, Tobit model, translog and bootstrapped frontier functions. These models can be applied to production, cost, profit and perhaps revenue functions for the estimation of technical efficiency. Under parametric approach, the corrected ordinary least square (COLS) (Ali and Byerlee, 1991) or the modified ordinary least square (OLS) and two-stage least squares are normally used to estimate cross-sectional data while panel data is estimated by the maximum likelihood estimation (MLE), corrected ordinary least square (COLS) and stochastic frontier analysis (SFA). The parametric approach provides solutions for the problems created by using the non-parametric approach in estimating technical efficiency.

Parametric approach is further divided into deterministic and stochastic frontier production functions. Deterministic frontiers assume that all the deviations from the frontier are a result of firms' inefficiency, while stochastic frontiers assume that part of the deviation from the frontier is due to random events (reflecting measurement errors and statistical noise) and part is due to firm specific inefficiency (Forsund et al 1980; Battese, 1992; Coelli et al., 1998).

The stochastic frontier approach, unlike the other parametric frontier methods, makes allowance for stochastic errors arising from statistical noise or measurement errors. The stochastic frontier model decomposes the error term into a two-sided random error that captures the random effects outside the control of the firm and the one-sided inefficiency component which is within the control of the farmer or firm. The foundation of Stochastic Frontier Analysis (SFA) was laid independently of each other in papers by Aigner et al. (1977), Meeusen and Van Den Broeck (1977). In the last couple of decades, there has been a surge with extensions to estimate technical change, efficiency change, and productivity change measures using stochastic frontier analysis (e.g. Kumbhakar and Lovell, 2000; Greene, 2004). Some evidences from the literature involving parametric approaches are:

Battese, et al., (1996) used a single stage stochastic frontier model to estimate technical efficiencies in the production of wheat farmers in four districts of Pakistan ranging between 57 and 79 percent. The older farmers had smaller technical inefficiencies.

Nkamleu et al, (2006) examined 27 countries covering five sub-regions of Africa, over the period 1971-2000, and established TE for African countries relative to the meta-frontier, between 57% and 94%. Central African countries led with 94% with Southern African scoring the least. Western African countries measured 72% relative the African Frontier whilst a measure of 92% was recorded for individual countries relative to the sub-regional frontier. The three ten-year mean TE were relatively stable, 1971-1980, 75%; 1981-1990, 73% and 1991-2000 was 76%. The continental average compares with the results of Thiam, *et al* (2001), based on a meta-analysis of developing countries that, overall average TE for developing countries was 68%.

Bedassa and Krishnamoorthy (1997) used a two-step stochastic approach to estimate technical efficiency in paddy farms of Tamil Nadu in India. They concluded that the mean technical efficiency was 83.3 percent, showing potential for increasing paddy production by 17 percent using present technology. Small and medium-scale farmers were more efficient than the large-scale farms.

In measuring technical efficiency of maize producers in Eastern Ethiopia for farmers within and outside the Sasakawa-Global 2000 project, Seyoum, et al. 1998 used a translog stochastic production frontier and a Cobb-Douglas production function. Some of the key conclusions from this study were that younger farmers are more technically efficient than the older farmers. The mean technical efficiency of farmers within the SG 2000 project was estimated to be 0.937 while the estimate of the farmers outside the project was 0.794.

A study by Wilson, et al. (1998) on technical efficiency in UK potato production used a stochastic frontier production function to explain technical efficiency through managerial and farm characteristics. The mean technical efficiency across regions ranged from 33 to 97 percent.

Using a stochastic frontier production function model, Karanja estimated the levels of technical efficiency/inefficiency across the high potential, medium and low potential regions in Kenya. The regional variable captured the soil and climate differences as the source of inefficiency.

A study by Liu, et al. (2000) on technical efficiency in post-collective Chinese Agriculture concluded that 76 and 48 percent of technical inefficiency in Sichuan and Jiangsu, respectively, could be explained by inefficiency variables. They used a joint estimation of the stochastic frontier model.

Awudu and Huffman (2000) studied economic efficiency of rice farmers in Northern Ghana. Using a normalized stochastic profit function frontier, they concluded that the average measure of inefficiency was 27 percent, which suggested that about 27 percent of potential maximum profits were lost due to inefficiency. This corresponds to a mean loss of 38,555 cedis per hectare.

Awudu and Richard (2001) used a translog stochastic frontier model to examine technical efficiency in maize and beans in Nicaragua. The average efficiency levels were 69.8 and 74.2% for maize and beans, respectively.

In a study by Wilson, et al, (2001) a translog stochastic frontier and joint estimate technical efficiency approach was used to assess efficiency. The estimated technical efficiency among wheat producers in Eastern England ranged between 62 and 98%.

A study by Mochebelele and Winter-Nelson (2002) on smallholder farmers in Lesotho used a stochastic production frontier to compare technical inefficiencies of farmers who sent migrant labour to the South African mines and those who did not.

In using stochastic frontier function, Belen, et al., (2003) made an assessment of technical efficiency of horticultural production in Navarra, Spain. They estimated that tomato producing farms were 80 percent efficient while those that raised asparagus were 90 percent efficient. Therefore, they concluded that there exists a potential for improving farm incomes by improving efficiency.

Gautam and Jeffrey (2003) used a stochastic cost function to measure efficiency among smallholder tobacco cultivators in Malawi. Their study revealed that larger tobacco farms are less cost inefficient. The paper uncovered evidence that access to credit retards the gain in cost efficiency from an increase in tobacco acreage. This suggested that the method of credit disbursement was faulty.

Parikh and Shah (1995) also measured technical efficiency, in the North-West Frontier province of Pakistan. The study involved the use of a translog frontier production function on cross-sectional data from 397 farms during the 1988/89 cropping season. The average technical efficiency level was found to be 96.2%.

O'Donnell (2002) provided evidence that, using a Bayesian methodology, U.S. Agricultural technical efficiency was 64% with variation among states.

Alternatively, non parametric approaches do not impose a functional form on the production frontiers and do not make assumptions about the error term. Mathematical modeling or linear programming approaches were used; the most popular non-parametric approach has been the use of data envelopment analysis. Data envelopment analysis (DEA) uses a non-parametric piecewise linear production frontier in estimating technical efficiency. It comes up with a single scalar value as a measure of efficiency. Efficiency of any firm can be defined in terms of either output maximization for a set of inputs or input minimization for a given output.

In DEA, relative efficiencies of a set of decision-making units (DMUs) are calculated. Each DMU is assigned the highest possible efficiency score by optimally weighing the inputs and outputs. DEA constructs an efficient frontier composed of those firms that consume as little input as possible while producing as much output as possible. Those firms that comprise the frontier are efficient, while those firms below the efficient frontier are inefficient. For every inefficient DMU, DEA identifies a set of corresponding benchmark efficient units (Coelli, et al. 1998). A DEA model may be either input-oriented or output-oriented. Both output-oriented and input-oriented DEA models produce the same technical efficiency estimate for a farm under the assumption of constant returns to scale in production. Apart from measuring the performance of firms, empirical studies have also been carried out to study the determinants of efficiency. In this context, a two-stage DEA has been employed by a number of researchers. This entails obtaining DEA efficiency scores in the first stage. In the next stage the efficiency scores are used as the dependent variable, which is regressed on the external environmental factors to determine what causes differences in efficiency levels across the DMUs under study.

However, Coelli (1995) claims that since linear programming does not suffer from statistical problems such as simultaneous equation bias, the choice of a measure does not affect the efficiency estimates significantly. What is important is that in deciding on the orientation of a DEA model, one should also consider the variables decision making units (DMUs) that have most control. If DMUs have more control over output variables than input variables, the DEA model should be output-oriented; otherwise, the model should be input-oriented. For instance, agricultural farms, such as dairy farms, usually have more control over their inputs than their outputs. Some of the disadvantages of non-parametric approach (DEA) are as follows.

Schmidt (1986) argued that the results obtained by non-parametric approach might be less precise because non-parametric approach makes less use of information than the parametric approach. A subset of observation is used to measure the frontier. Therefore Farrell's model is sensitive to extreme observations and measurement error (Forsund, et al 1980). Another limitation of this approach is that, it is conceptually difficult to separate the effects of uncontrollable environmental variables and measurement error from the effect of differences in farm management (Jaforrullah and Whiteman, 1999). Other disadvantage of DEA is that, tests of hypothesis in relation to differences in technical efficiency cannot be performed statistically (Schmidt, 1986; Jaforrullah and Whiteman, 1999). Some of the examples of technical efficiency studies with DEA estimation methods are as follow:

Feroz, et al. (2008) have demonstrated the usefulness of DEA in performance measurement in the US pharmaceutical industry and have shown the applicability of DEA in arriving at an unbiased account of relative performance in a set of companies.

Applying DEA, Hashimoto and Haneda (2008) observed that the R&D efficiency of Japanese pharmaceutical industry has worsened throughout the decade 1983-92. In the Indian context, after controlling for firm size and initial efficiency levels, Saranga and Phani (2009) found that in the era prior to the introduction of the product patent regime, higher R&D investments in pharmaceutical firms translated into higher efficiencies.

Chilingerian (1995) analyzed both technical and scale efficiency using DEA and a multi-factor Tobit model to study the variables which were associated with higher levels of performance of physicians. The study revealed that a substantial amount of money could be saved if every physician practised medicine as efficiently as the most competent physicians.

Jackson and Fethi (2000) investigated the performance of Turkish commercial banks using DEA. Using a Tobit model they identified the variables which explained the efficiency of some banks as the size of the bank, the number of branches, profitability, ownership and capital adequacy ratio. They found that larger and more profitable banks are more likely to operate at higher levels of technical efficiency.

A study conducted by Luoma, et al. (1998) to examine the productive efficiency of Finnish health centres applied DEA and Tobit analysis to evaluate how various economic, structural and demographic factors affect inefficiency. The results indicated that a higher level of central government grants and a higher taxable income per inhabitant are predictors of inefficiency. Hwang and Oh (2008) measured the performance of Korean software firms. With efficiency measured by using DEA, they used a Tobit regression to investigate whether the presence of Intellectual Property Rights (IPR) have a stronger effect on efficiency. Their results indicated that the average efficiency of software firms which possess any kind of software IPR was higher than that of firms not having them.

Fethi, et al. (2000) used a two-stage DEA application to assess the efficiency of European airlines. Their empirical findings confirmed that concentration and subsidy policies have a negative impact on the efficiency of European airlines.

2.4 Review of Technical Efficiency Studies in Ghana

Prior to this study, several technical efficiency studieshave been pursued in Ghanarelated to agricultural and non-agricultural sectors. Below are some of the technical efficiency studies being acknowledged in this study.

Djokoto (2011) estimated the technical efficiency of agriculture in Ghana using a time series stochastic frontier estimation approach. He identified that labour is the main determinant of technical efficiency in Ghanaian agriculture.

Agyemang, et al. (2012) examined the technical efficiency of cocoa farmers in Bibiani-Anhwiaso-Bekwai District in Ghana through stochastic frontier production function analysis. It was estimated that the mean technical efficiency of the cocoa farmers was 49%. They also found that farmer's experience in cocoa production, farmer's participation in the Cocoa Disease and Pest Control (CODAPEC) programme, and household size were the main significant factors affecting the technical efficiency of the cocoa farmers in the District.

Dzene (2010) investigated the determinants of technical efficiency of Ghanaian cocoa farmers for the period 2001 to 2006 using the stochastic frontier model. He found that the mean technical efficiency of the entire cocoa farmers in the country was 44.2% but was higher in Western and Ashanti Regions relative to the Brong Ahafo Region. The result found that demographic factors and non-labour inputs except household size and insecticides were significant and positively related to the technical efficiency of Ghanaian cocoa farmers.

Kyei, et al. (2011) analysed the determinants of technical efficiency of cocoa farmers in the Offinso District in Ghana. They established that quantity of fertilizer, pesticides, modern equipments, farm sizes, educational level, farming experience and family size of the farmer can help improve the level of technical efficiency of the cocoa farmers in the Offinso District.

Abatania, et al. (2012) examined the technical efficiency of farm households in Northern Ghana using data envelopment analysis (DEA) with bootstrapping. They found that the average technical efficiency of the sampled farms were 77.26%. They identified that hired labour, geographical location of farm, gender and age of head of household were the main significant factors affecting technical efficiency of farm households.

Seidu Al-hassan (2008) examined the technical efficiency of farmers growing irrigated and non-irrigated rice in Northern Ghana using the transcendental logarithmic (translog) production frontier. The study concluded that rice farmers were technically inefficient because there is no significant difference in mean technical efficiencies for non-irrigators (53%) and irrigators (51%). According to him, the main determinants of technical efficiency of rice farmers in northern Ghana are education, extension contact, age and family size.

Shamsudeen, et al. (2011) examined the technical efficiency of groundnut farmers in West Mamprusi District of the Northern Region of Ghana in the 2008/2009 cropping season. The study used the Cobb-Douglas Stochastic Frontier Model. The mean technical efficiency was estimated to be 70%. The factors that were significant in increasing farmers' technical efficiency were large farmsize, formal education, credit and the use of tractor for land preparation.

Owusu-Ansah, et al. (2010) evaluated the technical efficiency of Ghanaian Insurance companies from the year 2002 to 2007, using parametric and non-parametric approaches. It was observed that Ghanaian general insurers operated at an average overall efficiency of 68%, technical efficiency of 87% and scale efficiency of 78%. It was observed that higher dimension and market shares are the significant determinants of Ghanaian general insurers.

Frimpong (2010) investigated into the efficiency of banks in Ghana using a non-parametric approach. The study found that out of 22 banks, only 4 of them were efficient

2.5 Determinants of Technical Efficiency in General

The determinants of technical efficiency are extended to the general perspective across the world, with emphasis on Africa. According to Rahman, et al. (2009), most of the empirical studies show that socio-economic characteristics, farm characteristics, demographic, environmental, physical and non-physical factors are important determinants of technical efficiency. Below are several examples.

Reddy (2002) investigated productivity differences between tenant and owner operated sugar cane farms in Fiji using stochastic frontier production function. Significant difference was found between two types with respect to input usage, productivity and technical efficiency. Mean technical efficiency estimates for tenant operated farms and owner-operated farms were 0.82 and 0.90 respectively.

Hazarika and Alwang (2003) used data from the Malawi financial Markets and household food security survey to examine the effects of access to credit from formal sources and tobacco plot size, on cost inefficiency among Malawian smallholder tobacco cultivators. Farm- specific cost inefficiency was estimated using stochastic frontier model. It was found that tobacco cultivation was significantly less cost inefficient per acre on larger plots. While access to credit by itself had no statistically apparent effect on cost inefficiency and it reduced the gain in cost efficiency from a larger plot size.

Rauf (1991) estimated the relation between education and technical efficiency during Green Revolution in the entire irrigated areas of Pakistan. Cobb Douglas production function was used to investigate this relationship. It was found that the effect of education on technical efficiency was substantial. But the effect of higher education on technical efficiency was more compared to that of primary education.

Caves and Barton (1990) conducted studies in the USA and showed that more intensive competition leads to more efficient technical choices. Based on an analysis of firms from 19 UK manufacturing sectors, Hay and Liu (1997) concluded that in a more competitive market environment firms have a relatively strong incentive to improve their efficiency. Accordingly, many studies found that industry affiliation of a firm which can be regarded as a proxy of the competitiveness of the market environment explains a large portion of the differences in the firms' performances (e.g., Schmalensee 1985; Wernerfelt and Montgomery 1988).

Beeson and Husted (1989) in a cross-state study for the US found that a considerable part of the variation of efficiency can be attributed to regional differences of the labour force characteristics, levels of urbanization and industrial structure. An illustrative example for the role of regional determinants of efficiency is the prevailing difference of productivity between East and West Germany.

With regard to the determinants that are internal to a firm, Alvarez and Crespi (2003) in an analysis of micro, small, and medium-sized Chilean manufacturing firms (1,091 firms from all manufacturing industries in 1996) found that efficiency is positively associated with the experience of the workers, modernization of physical capital and product innovation activity. Other variables such as outward orientation, education level of the owner and participation in public support programs did not affect the efficiency of the firms.

Gumbau-Albert and Maudos (2002), using a complete panel of 1,149 Spanish firms from 18 manufacturing sectors, arrived at the conclusion that firm size and the amount of investment into physical assets is conducive to technical efficiency. Technical efficiency was also relatively high in firms that were subject to high competitive pressure on the market. In this study, the lowest levels of efficiency were found in the firms operating in more concentrated markets with a presumably low level of competition and in firms with public ownership participation.

Accordingly, Carlson (1972) arrived at the conclusion that the technical efficiency of Swedish industries is determined by protections against competition; Bloch (1974) found the same to be true for Canada. According to Lovell (1993), a high level of competition will enhance the technical efficiency of firms.

Torii (1992) claimed that the efficiency can be related to the scale or size of a firm if it is assumed that; maintaining or improving efficiency demands a cost in terms of the firm's management. A number of studies found that a high level of outsourcing has a positive effect on efficiency, but some studies also state that the positive role of outsourcing is overestimated.

The evidence of the effect of a firm's ownership structure and legal form on efficiency is mixed (e.g. Shleifer 1998). One stream of literature states that it has a considerable influence on a firm's technical efficiency (e.g. Bottasso, et al. 2004); while others state that it is unimportant (e.g. Orazem, et al. 2003)

Burki and Terrell (1998) determined technical and scale efficiencies of small manufacturing firms in Pakistan using DEA. It was identified that output could be increased by 6 to 29% by improving technical efficiency. Education and experience found positively affecting technical efficiency.

Zhengfei and Lansink (2003) developed a test for disposability of individual inputs on non-radial efficiency measures and also analyzed the impact of congestion on overall technical efficiency for individual inputs using panel data from Dutch cash crop farms over the period 1989-1992. Analysis of overall of inefficiency revealed that weak disposability constituted the largest component of inefficiency and congested farms on an average, had a less effective management and operated on a larger, but less efficient production scale.

The impact of foreign ownership on the level of efficiency was considered by Delis and Papanikolaou (2009), Jackson and Fethi (2000) and Fethi, et al. (2000). To determine the efficiency of banks, another independent variable which was considered is their profitability (Jackson and Fethi, 2000).

The age of the firm can also be a determinant of its efficiency level (Hwang, et al. 2008). In his study of the clinical efficiency of 36 physicians in a single hospital, Chilingerian (1995) employing a two-stage DEA, took the age of the physicians as one of the independent variables in the Tobit model.

Technological knowledge is important for a firm to attain and sustain its competitive advantage (Narasimha, et al. 2003). Leachman, et al. (2005) considered R&D intensity (ratio of expenditure on R&D and sales) as one of the explanatory variables determining the level of efficiency of manufacturing performance.

Hwang and Oh (2008) took R&D intensity as one of the determinants of Korean software firms.Some empirical studies found that the long-run performance of firms depends on the firm-specific advantages such as R&D (Gregory, et al. 2005).

2.6 Determinants of Technical Efficiency in Agriculture

This section of the empirical review is devoted to the determinants of technical efficiency in agriculture within developing and developed countries. Empirical studies show that socio-economic and farm characteristics, environmental, physical and non-physical factors are some important determinants of technical efficiency in both developing and developed countries' agriculture as identified by Rahman, et al. (2009). These variables may measure information status and managerial skills, such as education, technical knowledge and extension contacts, as well as system effects exogenous to the farm, such as credit, input markets or tenancy (Ali and Byerlee, 1991).

Thus, individual farmer variability (technical inefficiency) and not random variability is the major cause for yield variability (Kalirajan, 1981). According to Ogundele, et al. (2004), technical efficiency in agriculture has been established to be determined by gender and age of the farmer, labour hours spent on farms, extension visitation, family size or number of dependants of the farmer, farm size, fertilizer application, type of seed (local or hybrid) sowed by farmers, agro-chemicals (weedicide and pesticide), access to education and level of education, access to credit, access to extension service, labour hours, farming experience, level of technology etc. Below are several examples:

Pudasaini (1983) documented that education contributed to agricultural production in Nepal through allocative effect. He found that even though education enhances agricultural production mainly by improving farmers' decision making ability, the way in which it is done differs from environment to environment. Thus, in a technologically dynamic agricultural system, education improves farmers' allocative ability, enables them to select improved inputs and optimally allocate existing and new inputs among competing uses. On the other hand, in traditional agriculture, it enhances their decision making ability mainly by increasing their ability to better allocate existing farm resources.

Kumbhakar et al. (1991) investigated the determinants of technical and allocative inefficiency in US dairy farms. The stochastic frontier approach was used involving a single-step maximum likelihood procedure. The findings were two. First, levels of education of the farmer are important factors determining technical inefficiency. Second, those large farms are more efficient (technically) than small and medium-sized farms. The conclusion was that both technical and allocative inefficiencies decrease with an increase in the level of education of the farmer. This is similar to the conclusion reached by Ajibefun and Daramola (2003), that education is an important policy variable and could be used by policy makers to improve both technical and allocative efficiency.

However, Kalirajan and Shand (1985) argue that although schooling is a productive factor, farmers' education is not necessarily related significantly to their yield achievement. Illiterate farmers, without the training to read and write, can understand a modern production technology as well as their educated counterparts, provided the technology is communicated properly.

Using Tamil Nadu rice farmers as a case study, Kalirajan and Shand (1985) conducted a quantitative analysis of various types of education in relation to productivity in order to determine whether schooling of farmers had a greater influence on yield than non-formal education (defined as a farmer's understanding of the technology). The findings revealed that schooling (education) of farmers had an independent effect on yield, but it was not significant. On the other hand, a farmer's non-formal education was found to have a significant and greater influence on yield. They concluded that farmers' schooling and productive capacity need not be significantly related under all circumstances.

Adesina and Djato (1997) recommended that rural development efforts should not be biased towards "educated" farmers as "non-educated" farmers are just as efficient. For Weirs (1999), at least four years of primary schooling are required to have a significant effect upon farm productivity.

Kalirajan (1981b) explained that extension workers' limited contact with the farmers and farmers' misunderstandings of the technology were responsible for the difference between the actual and maximum yields among the farmers. The researcher stressed the need for policy makers in a South Indian state to focus on extension work in order to increase rice production and reduce inefficiency.

Parikh and Shah (1995) identified that; lack of education, restricted credit and fragmented holdings were found to be the causes of technical inefficiency among farms in the North-West province of Pakistan. They observed that; the level technical efficiency was dependent on levels of credit and education, farmers' ages, and the extent of land fragmentation among farms in the North-West province of Pakistan.

Owens et al. (2001) investigated the impact of farmer contact with agricultural extension services on farm productivity using panel data obtained during the period 1993–1997 in Zimbabwe. The results showed that access to agricultural extension services, defined as receiving one or two visits per agricultural year, raises the value of crop production by about 15%. The results also show that the impact of agricultural extension services differed across individual crop years, with the impact being markedly different in drought and non-drought years.

Ogundele, et al. (2004), show that farm size significantly determines levels of technical efficiency in Nigeria. Other determinants included labour, herbicides, seeds, education and farming experience. In overall terms, they computed the average technical efficiency for each rice farm group at 90%.

Huang, et al. (1986) identified that large farms are more technically efficient than small farms in two states in India. Ahmad, et al. (1999) found that extension services and the availability of agricultural credit could improve technical efficiency of rice farmer in Pakistani Punjab.

A study by Battese and Coelli (1995) on paddy rice farms in Aurepalle India used panel data for 10 years and concluded that older farmers were less efficient than the younger ones. Farmers with more years of schooling were also found to be more efficient but declined over the time period.

Wang, et al.(1996) found significant relationship between technical efficiency of farmers and farm size. Alternatively, some studies found no such significant relationship between technical efficiency and farm size (Byrnes et al 1987,).

According to Wilson, et al. (1998), years of experience in potato production, irrigation and small-scale farming were positively correlated with technical efficiency of UK potato production. Kumbhakar, et al. (1989), identified a direct relationship between technical efficiency and farm size for Utah dairy farmers.

Bravo-Ureta and Rieger (1991) found that; farm size, extension service, education and experience were the significant determinants of technical efficiency of New England dairy farms.

Kalirajan (1981) identified a direct relationship between technical efficiency and farmer's experience, educational level, farmer's experience, number of visits by extension workers, upon an investigation into a district in India.

Ali and Flinn (1989) identified a significant relationship between fertilizer application and technical efficiency of Basmati rice farms.

Sharif and Dar (1996) also identified that education and farm size have a positive but diminishing impact on technical efficiency in accordance with a study among rice farmers in Bangladesh.

Ngwenya, et al. (1997) concluded that technical efficiency effects were positively and significantly related to the size of the farms in a sample survey of wheat farmers in Eastern Free State, province of South Africa.

Battese, et al. (1993) found the adoption of new technology and better extension services to be the important factors for the improvement of efficiency among wheat producers in the four districts of Pakistan.

Hadri and Whittaker (1999) observed that the more efficient farms were those who used higher volume of environmental contaminants in a study involving farmers in the south west of England for the year 1987-1991.

Kebede (2001) showed that farming experience and education were both significant variables for improving technical efficiency in a study of Nepal paddy farm. He identified that labour credit and geographical location are important determinants of technical efficiency of Nepal paddy farm.

Kalirajan and Shand (1989) identified that farming experience, level of education, access to credit and extension contacts had significant influences on the technical efficiency of Malaysian farms.

Wilson, et al. (2002) observed that, having more years of managerial experience and a large farm were also associated with higher levels of technical efficiency in a study of wheat farms in Eastern England.

Lass and Gempesaw (1992) found hired labour, land, and machinery inputs to be related to the technical efficiency of Massachusetts's dairy farms.

Wang, et al. (1996) identified that farm labour and farmers' education are crucial for the improvement of technical efficiency of Chinese rural agricultural operations.

Adesina and Djato (1997) found a positive relationship between women as farm managers and technical efficiency in African agriculture.

Thiam, et al (2001) found that the type of crop seed used for planting directly determines the technical efficiency of agriculture in developing country.

Demir and Mahmud (2002) found that agro-climatic variables such as rainfall and land quality are major determinants of technical efficiency in Turkish agriculture.

Kumbhakar, et al. (1991) showed that levels of education of the farmers and size of farms were important factors determining the technical efficiency of U.S. dairy farmers.

Johnson, et al. (1994) found that factors such as management structure, resource base and different policies on capital and other input allocation were contributing towards wide variability in the technical efficiency of farms in Ukraine.

In Asia, Li and Wahl (2004) examined technical efficiency in Chinese Agriculture. Technical efficiency estimated, ranged from a high of 0.91 to a low of 0.71%. Labour (-0.111) and land (-0.018) were negatively related to Agricultural output measured as total value added. Power and fertilizer were positively related to output. Indeed, only, fertilizer was elastic, with a coefficient of 3.221.

Dhungana, et al (2004) found that farm manager's gender, age, education and family labour were important determinants of technical efficiency in Nepalese rice farms.

Helfand and Levine (2004) found that, type of land tenure, access to institutions and markets, and modern inputs were found to be important factors causing differences in technical efficiency across farms in the Center-West of Brail.

Latruffe et al. (2005) identified education to be positively related to the technical efficiency of Polish livestock farms.

Chavas, et al (2005) found that, the incidence of herding, food insecurity, loan withdrawals and land tenure security were negatively related to the level of technical efficiency in household farms in Gambia.

Gorton and Davidova (2004) found that; family setting, corporate structures and farm size were the determinants of technical efficiency of farms in six central and East European countries.

Osborne and Trueblood (2006) observed that; the use of farm inputs is a major determinant of technical efficiency of crop production among Russian corporate farms for 1993-1998

Sharif and Dar (1996) identified that, education and growing experience were positively related to the technical efficiency of Bangladesh rice farmers. Ecological issues also appear to have paramount implications for sustainable agricultural production.

Tadesse and Krishnamoorthy (1997) found that 90% of the variation in output among paddy (IR-20) farms in Tamil Nadu, India, was due to differences in technical efficiency. The mean technical efficiency was calculated as 83%. They recommended that for small paddy farmers to follow the efficient resource use pattern, there is the need to provide them with more land and extension services.

2.7 Determinants of Technical Efficiency in Maize Production

The following empirical studies give an insight into the determinants of technical efficiency in maize production.

According to Chirwa (2007), the main determinants of technical efficiency among maize farmers in Southern Malawi are type of seed, fertilizer and farmers' club.

Seyoum, et al. (1998) investigated the technical efficiency of maize produce in Ethiopia and compare the performance of farmers within and outside the programme of technology demonstration, using Cobb-Douglas stochastic production functions. Their empirical results showed that farmers that participated in the programme are more technically efficient with mean technical efficiency equal to 94% compared to 79% for those outside the project.

Kalaitzandonakes and Dunn (1995) argue that conflicting empirical results on the relationship between technical efficiency and education would be in part attributable to difficulties in the measurement of key variables. Calculation of technical efficiency with three alternative frontier methods (COLS, ML and DEA) for a sample of Guatemalan corn farms was made. Results showed significant difference both in the average technical efficiency of the sample and the efficiency rankings of individual farms. Furthermore, following two-step procedures, it was shown that the choice of efficiency measurement technique could alter the importance of education as a contributing factor to increased technical efficiency.

A study conducted by Oyewo (2011) revealed that farm size and quality of seed were the main determinants of technical efficiency in maize production in Oyo state. The result indicated that farm size and quality of seed were significant and positively related to technical efficiency.

Nyangweso, et al. (2005) conducted a study on technical efficiency in smallholder maize production in Uasin Gishu District, Kenya. The result of the study shows that; usage of tractors will improve the technical efficiency of smallholder maize production than the use of oxen.

Tchale and Sauer (2007) studied the efficiency of maize farming in Malawi. Analysis of the study indicated that, maize farmers who used organic fertilizer were more technically efficient than those who used inorganic fertilizer.

Hasan (2008) investigated into the efficiency and constraints of maize production in the NorthernRegion of Bangladesh. The study identified that hybrid seed, fertilizer application and price of grains were the main determinants of technical efficiency of maize production in the region.

Aye and Mungatana (2010) conducted a study into the technical efficiency of maize farmers in Nigeria. The findings of the study established the fact that; hybrid seed, education, extension service, credit and land were the main determinants of technical efficiency of farmers. Additionally, maize farmers who used hybrid seeds were more technically efficient than those who used the traditional type.

Yilmal and Berg (2011) estimated the technical efficiency of maize production in Jimma Zone, Southwestern Ethiopia. They identified that ownership of livestock, participation in extension program and access to infrastructure were the factors creating different levels of technical efficiency among maize farmers.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

The methodology part of the study constitutes the description of the study area (including demographic characteristics, agricultural system, relief and drainage, climate, vegetation and soils), data collection (also including type of data, sampling and data collection techniques), model specification (empirical stochastic model for technical efficiency and assumptions of the models), determinants of technical efficiency, estimation method, econometric and statistical tests and tools for data analysis.

3.1 Description of the Study Area

Asante Akyem North Municipality is the geographical area earmarked for this study. This is because maize production is the major occupation in terms of agriculture in the area and there has been recent development in mechanizing maize production in Asante Akyem North.

The Asante Akyem North Municipal Assembly is one of the 27 Districts in the Ashanti Region. It was caved out of the erstwhile Asante Akyem District Council in 1988 as part of Ghana's Decentralization process. It has Konongo-Odumasi as its twin capital town. The Municipality is located in the eastern part of Ashanti Region and lies between latitude $6^0$30' North and $7^0$30' North and longitude $0^0$15' West and $1^0$20' West. It covers a land area of 1,160square kilometres with an estimated population of 169,976 in 2010 (GSS, 2010 population census). The Municipality shares boundaries with Sekyere East and Sekyere Afram plains to the North, Kwahu South to the East, Asante Akyem South on the South and Ejisu-Juaben Municipality on the West. The municipality has Agogo-Hwidiem as an urban area in addition to the capital, Konongo-Odumasi, and several towns and villages such as Nyaboo, Patriensa, Kyekyebiase, Juansa, Domeabra, Ananekrom, Obenemase, Praaso, Amantena, Pataban, Brekete, Nyanoase and Oyemso. The map of Asante Akyem North Municipality is displayed in appendix 2.

3.1.1 Demographic Characteristics

The estimated population of Asante Akyem North Municipality according to GSS (2012) is 169,976; of which females constitute 51% while 49% are males. Even though the Ashantis dominate by constituting over 80% of the total population, there are also other Northerners, Ewes, Fantes etc in the municipality. About seventy percent of the inhabitants live in the urban areas of Agogo-Hwidiem and Konongo- Odumase in the Municipality.

Agriculture is the dominant occupation in the municipality constituting 53.9% of all occupations and employing inhabitants between the ages of fifteen and above. Likewise other parts of Ghana, agriculture in the municipality is still highly dominated by the smallholder farming system with only 6% of farmers cultivate more than five acreages of land and 72% below five acreages of land. There are others who engage in trading and vocational services at the percentages of 16.3% and 15% respectively. Others also engage in considerable mining at Konongo and Obenimase.

3.1.2 Relief and Drainage

The topography of the Municipality is generally undulating. From the north, the land rises gently to heights between 305 and 610 metres and is interrupted by a stretch of the Akwapim-Mampong Range, which is between 610 and 762 metres. Beyond this range is the southern part of the Municipality covered by highlands, ranging between 305 and 610 meters. Lowlands between 152 and 305 metres are found in the northern portion where the land slopes gently towards the Volta Lake. The Akwapim-Mampong Range serves as a watershed for many rivers and streams, which drain the Municipality. Prominent among them is the Anum to the West, Owerri to the South, Oyin to the East and Onwan and Egyan in the North. The steep slopes at Kyiriyawa near Hwidiem and at Onyem have created waterfalls, which are yet to be developed as tourist sites.

3.1.3 Climate and Vegetation

The Municipality lies within the semi-equatorial belt characterized by double rainfall maxima occurring in March and November. The first rainy season is from March to July and second is from September to November. The rainy seasons are normally characterized by high humidity and torrential rainfall often accompanied by lightening and thunderstorms. The rainy season accelerates flowering and fruit bearing than in the dry season. The dry harmattan season occurs between December and March and is associated with drought conditions such as rainfall being rare, hazy atmosphere, high pressure, dry winds (low humidity), extremely high temperature during the day and low temperature in the night. Due to intense sunshine and low humidity in the harmattan season, most streams and springs dry up, trees shed their leaves to avoid transpiration and bushfires are common. Temperature is found to be uniformly high all year round with a mean annual temperature of 26^0C.

With regards to vegetation, the Municipality lies within the moist semi-deciduous forest belt. The major vegetation types are;

- The open forest covering 576 square kilometres over the highland area
- The closed forest covering 230 square kilometres on the range and
- The wooded savannah covering 246 square kilometres.

These vegetation zones consist of different species of tropical woods such as odum, wawa, ofram, sapele, sanfina, onyina, kyenkyen, mahogany, otie, yaya, etc which have high economic value. Most of the original forests in the municipality have degenerated into secondary forest and grassland due to excessive logging, erratic climatic system, indiscriminate felling of trees, bush fire and poor farming practices such as shifting cultivation, continuous cropping, slash and burn, and bush burning for fresh forage for cattle feeding.

In some parts of the municipality extending into the Afram Basin, the semi deciduous forest is gradually degenerating into interior wooded savannah primarily due to the presence of Fulani herdsmen and intensive farming activities.Timber, foodstuffs, raw material etc are obtained from the forest for industrial and domestic use. Most of the forest belts are rich with delicacies such as snails, bush meats, mushrooms and fruits which are seasonal between late February and April. However, most of them have gone into extinction due to rampant bush fires and the excessive use of agrochemicals in farming.

3.1.4 Soils and Nature of Farming

Two major soils have been identified in the Municipality; the forest ochrosol and savanna ochrosol. The forest ochrosol is found in the closed forest zone while the savanna ochrosol is located in the open forest and wooded savanna areas. The forest ochrosol is fertile for the production of maize, oil palm, cassava, cocoyam, plantain, cocoa and vegetables. The savannah ochrosol is well leached, richly supplied with organic matter and is also good for the cultivation of yam, cassava, grains and cereals, watermelon, groundnut and vegetables. It is therefore not surprising that cash crops and food crops are abundantly produced in the Municipality.

Farming system normally practiced in the municipality are monocropping, mixed farming and cropping and ecological farming. These farming systems are characterized by food crop production on subsistence basis though commercial farming exists. It is also climatic determined and dominated by the use of simple tools such as cutlass, hoe, mattock, rake, axe etc. Food crops commonly grown in the municipality are plantain, cocoyam, yam, cassava and maize. Even though food crops dominates, livestock farming, ecological farming and vegetable cultivation such as pepper, onion, garden eggs and okro are also produced in the municipality. Others like tomato, watermelon and oil palm are also produced. About one-third of the farm produce are marketed in the municipality for domestic consumption and the remaining part is conveyed to urban centres such as Accra and Kumasi for sale.

3.2 Type of Data used

The study used primary data and it is cross sectional by nature because data in 2011 farming season is used. Primary data based on farm-level and socio-economic characteristics of farmers were collected through a survey of maize farmers in Asante Akyem North Municipality. Additionally, secondary data relating to demographic issues (such as population size) of the study area were collected from Asante Akyem North Municipal Assembly.

3.2.1 Sampling and Data Collection Method

Maize farmers were the focus of the study and therefore they constituted the population; but the study considered a sample of 250 maize farmers from the Municipality. A multi-stage sampling technique was used to select 250 maize farmers from the study area. Initially, the study employed purposive sampling to select five maize growing areas in the municipality. This was because maize farmers were purposeful for the study and therefore interested places should be the maize growing areas. These five maize growing areas in the municipality were; Ananekrom, Brekete, Nyanoase, Amantena and Pataban. The selected areas were significant for the study because, these were the main areas where maize was largely produced. Again, the rationale behind the selection of these specific areas was to represent the topographic, climatic and vegetation zone differences in the Municipality. In terms of food production, maize constituted thirty percent (30%) followed by plantain and twenty percent (20%) with the consideration of all agricultural produce in the municipality.

After the identification of the maize growing areas in the Municipality, the study proceeded to use the simple random sampling method to select the 250 maize farmers from the identified areas where seventy (70) of them were picked from Ananekrom and the remaining four villages supplied forty-five farmers each. More farmers were selected from Ananekrom relative to others, because, maize production in the area was higher than any other part of the municipality. Because the focus of the study was on maize farmers, farmers, regardless of being under mono-cropped or mixed cropped, small or large farm size was selected for the study. Consideration was not only given to maize output on the market but also those that were consumed and those offered as gift. Data collection based on household survey was carried out in December, 2011in the study area.

Data was gathered from two hundred and fifty maize farmers through direct administration of questionnaires. The sample survey was carried out by the researcher together withfour selected assistants. A two-day intensive training was organized for the assistants to familiarize themselves with the study area and how questionnaires should be administered. Through this medium, they were able toovercome the barrier of communication with the farmers and also understand the culture of the inhabitants. It must however be noted that two hundred and fifty copies of questionnaires were issued but each questionnaire consisted of nineteen open question items. The researcher together with his assistants personally interacted with some of the maize farmers at village marketing centres and others at their homes. Some of the farmers were literates and therefore, were able to administer their questionnaires personally. Low level educated farmers were guided to administer theirs.

Wide ranges of data regarding farm level and socioeconomic characteristics of farmers were collected. The farm level data included; quantity of fertilizer, farm size, labour hours, amount of money spent on weedicide, type of seed, number of seed sowed in a hole, and output of maize. In addition, information pertaining to farmers' socioeconomic characteristics like gender, age, access to credit, access to formal education and family size were also gathered in the course of the survey. Under the settings of the study area, these were the conventional factors affecting maize farming in the municipality. It must be noted that climatic and most physical factors that can in one way or the other, affect maize production, were not considered in this study due to the absence of accurate and reliable data on these variables within the Municipality.

The questionnaire was pre-tested to enable the correction of mistakes, evaluate the relevance of a given question, add relevant information, excludes irrelevant ones and to make overall improvement on the standard of the questionnaire in line with the objectives of the survey. During the administration of the questionnaire, appropriate supervision on the answering of questions was made to ensure a valid response on regular basis. Incomplete questions were detected and improved by carrying out revisits to the maize farmers. Day to day follow up and motivations of the assistants were executed to improve the overall quality of the survey. Hidden information peculiar to the study area, were secretly obtained through discussions made with key informants in the municipality to supplement the primary data. The survey captured about eighty percent of maize producing areas in the municipality.It took the researcher and his assistants, two weeks to complete the survey.

The survey experienced several challenges common to many fieldworks. The most serious one was how to access the farmers for personal interactions. Nevertheless, the researcher with his assistants managed to get them on board for interactions. In some instances, monies have to be paid to farmers before accepting to interact with the researcher. Although the survey was time consuming, maximum effort was made to execute it on schedule and therefore bad implication on the quality of the responses and on the coordination of the entire survey was virtually absent.

3.3 Model Specification

Production is the process of converting our limited resources into goods and services using the available technology (Parkin et al, 2003). In accordance with the views of Asiedu (2010), production is the creation of goods and services from the existing resources to directly satisfy human wants or for further production. In order words, it shows how resources are transformed into goods and services useful to mankind. An economic resource that is used in the production of a particular good is called an input and can be physical or mental (Mansfield, 1975). According to Parkin, et al. (2003), the production function is the relationship between the maximum output attainable and the quantities of inputs (both labour and capital). The model specification for maize production followed the Cobb Douglas form according to Aigner and Chu (1968).

$$\Upsilon = f\left(F^{\beta 1}, L^{\beta 2}, W^{\beta 3}, C^{\beta 4}, S^{\beta 5}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 3a_1$$

Where; Υ=Maize yield (in bags), F=Farm size (in acreages), L=Average labour hours spent daily on farms (in hours), W=Amount spent on weedicide, C=Accessibility to credit S=Seed quantity (Number of seed sowed per hole). From equation 3a, maize yield has been expressed as a function of farm size, average labour hours spent daily on the farm, amount spent on weedicide, accessibility to credit and number of seed sowed per hole.

Also, the model specification of the determinants of technical efficiency among maize farmers followed the general specification according to Parkin, et al. (2003) and McConnell et al. (1998).

$$TE = f(G, Fa, E, St, Ft)..3b$$

Where; TE=Technical efficiency, G=Gender of the farmer, Fa=Farmer's family size E=Farmer's education, St=Type of maize seed, Ft=Quantity of fertilizer applied.

From equation 3b, technical efficiency of maize farmers has been is expressed as a function of gender, farmer's family size, farmer's education, type of maize seed (hybrid seed) and quantity of fertilizer applied by the farmer. In considering the setting of the study area, these socioeconomic variables are assumed to influence the level of technical efficiency of farmers in the municipality.

It must be noted that dummies are introduced for variables like type of seed, gender, farmer's education and access to credit. Variables without dummies are farm size, farmers' family size, quantity of fertilizer, labour hours, amount of weedicide and number of seeds sowed per hole on the farm.

3.3.1 Stochastic Model for Technical Efficiency

Following the approach of Aigner et al. (1977) and Meeusen and Van Den Broeck (1977) in estimating a stochastic frontier production function, a Cobb-Douglas function was fitted to the field data. This functional form has been employed consistently in related efficiency studies (Chirwa, 2007; Battese, et al. 2005; Abdulai et al. 2000; and Awudu, et al. 2000)

Technical efficiency of maize farmers is estimated through the estimation of Cobb Douglas stochastic frontier model.The Cobb Douglas function is earmarked for modeling cross sectional data involving agricultural economics due to its consistency with theory, versatility and relative ease of estimation. Stochastic frontier model is also preferred to other models because of its ability to decompose the disturbance term $\mathrm{e}_i$into two components; random error, accounting for deviation owing to factors outside the control of the farmer (v_i)and error term accounting for deviation due to inefficiency effects (u_i).i.e. factors within the control of the farmer.

The linear transformation of ($3a_1$) is achieved by taking the natural logarithm of both sides of the equation to obtain ($3a_2$):

$$\ln\Upsilon = \beta_o + \beta_1 lnF + \beta_2 lnL + \beta_3 lnW + \beta_4 C + \beta_5 lnS + v_i \text{-} u_i \ldots\ldots\ldots\ldots (3a_2)$$

In consistent with technical efficiency estimation, equation ($3a_2$) is further rationalized and modified to obtain equation (3c).

$$\ln\Upsilon = \beta_o + \frac{1}{2}(\beta_1 lnF)^2 + \frac{1}{2}(\beta_2 lnL)^2 + \frac{1}{2}(\beta_3 lnW)^2 + \beta_4 C + \frac{1}{2}(\beta_5 lnS)^2 + v_i \text{-} u_i \ldots\ldots\ldots (3c)$$

Where; Υ=Maize yield (in bags)

F=Farm size (in acreages)

L=Average labour hours (both family and hired) spent daily on farms (in hours)

W=Amount spent on weedicide (in Cedis)

C=Access to credit (1 for access, 0 for no access)

S=Quantity of seed (number of seed sowed per hole)

β_o=Constant parameter to be estimated

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$=Regression parameters to be estimated

ln=natural logarithm

$e_i = v_i - u_i$ Stochastic or error term consisting of two independent elements v (accounting for random error) and u (accounting for the deviation because of inefficiency effects). In deriving the u from the composed error, we use the formula according to Murillo (2004).

$$E\left[\frac{U_i}{\varepsilon_i}\right] = \frac{\sigma\lambda}{1+\lambda^2}\left[\frac{f_s(\varepsilon_i\lambda/\sigma)}{f_c(-\varepsilon_i\lambda/\sigma)} - \frac{\varepsilon_i\lambda}{\sigma}\right] \text{......................(3d)}$$

Where $f_s(\cdot)$ is the density of the standard normal distribution and $f_c(\cdot)$ is the cumulative density function, (Murillo-Zamorano 2004). To yield consistent parameters of the above equations, the maximum likelihood estimation will be used likewise most research works involving technical efficiency. The assumption that the model is half normal means that all efficiency scores are positive. The restrictions imposed on the model produces various interesting results such as the value of

$$\sigma = (\sigma_u^2 + \sigma_v^2)^{1/2} \;; \quad \lambda = {}^{\sigma_u}/_{\sigma_v} \text{ and } \quad \gamma = \frac{\sigma_u^2}{(\sigma_u^2 + \sigma_v^2)}$$

Where σ= total variation

σ_u^2= variation due to inefficiency

σ_v^2= variation due to noise

Lambda (λ) is the ratio of the standard deviation of the inefficiency component to that of the noise component. How high the value of lambda (λ) is; determines how strong the evidence of the presence of inefficiency in the data. Gamma (γ) specifies the ratio of the variation due to inefficiency to the total variation. With parametric restriction between 0 and 1, a high gamma (γ) also depicts the explanatory power of inefficiency in total variation (Radam, et al. 2010). In addition, a log-likelihood ratio test is also conducted to verify whether the estimation frontier model is robust. This is a test to show the significance or otherwise of the inefficiency component.

The null hypothesis which states that there is no inefficiency (H_0: u=0) is tested against the alternative hypothesis (H_1: u>0). If the null hypothesis is true then the stochastic frontier model reduces to an OLS model with normal errors.

In the contest of this study, technical efficiency of farmers is expressed in terms of the ratio of observed output to the corresponding frontier output (estimated output), conditioned on the level of inputs used by the farmer. In other words, a farmer is fully technically efficient given that actual maize output is equal to potential output (Hasan, 2008). Technical inefficiency on the contrary is defined as the amount by which actual production of the farmer is less than the potential output (Wambui 2005).Therefore, Wambui's (2005) formula for estimating technical efficiency scores as used by the study is given as;

$TE_i^* = \frac{Y_i}{Y_I^*}$…………(3e), This is also equivalent to $TE_i^* = exp^{(-u)}$

Technical inefficiency$=1-TE_i^*$…………………(3f)

Where; TE_i^* is the output oriented technical efficiency of ith maizefarmer

Y_i is the scaler output of farmer i,i=1,….N,

Y_I^* is the production frontier or the highest predicted value for the ith farmer,

$exp^{(-u)}$ = Exponent of inefficiency effect

In this study, technical efficiency is evaluated at a bench mark of 82% as postulated by Grabowski, et al. (1990). According to Grabowski, et al. (1990), anything below 82% shows an element of inefficiency. To identify the effects of certain variables on technical efficiency of farmers, the estimated technical efficiency scores are regressed against gender, farmer's family size, farmer's education, type of maize seed (hybrid seed) and quantity of fertilizer applied.

$$TE = \rho_0 + \rho_1 G + \rho_2 Fa + \rho_3 E + \rho_4 St + \rho_5 Ft + \text{e} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3g)$$

Where; TE= Estimated technical efficiency of maize farmers

G= Gender, measured as dummy (if male 1, female 0)

Fa= Farmer's family size

E= Farmer's education as dummy (0 for no education, 1for yes education)

St= Type of seed, measured as dummy (0 for local, 1 for hybrid and 2 for both)

Ft= Quantity of fertilizer applied (in bags)

ρ_0= Constant parameter

$\rho_1, \rho_2, \rho_3, \rho_4, \rho_5$= Regression parameters to be estimated

e=Error term

3.3.2 Assumptions

Several assumptions underlie this study. The first one is that farmers have identical production function in which the production inputs and socioeconomic variables are exogenously determined in the models. This means that the variables are independent on each other. Secondly, according to Aigner, et al. (1977), e_i is an error term assumed to be made up of two components: (v_i) is a random error having zero mean, and it is associated with random factors such as measurement errors in production and weather which is outside the control of the farmer and it is assumed to be independently and identically distributed as $v_i \sim iid\ N(0, \sigma^2 v)$. (u_i) is assumed to be non-negative random variable, truncated half normal, independently and identically distributed as $u_i \sim iid\ N(0, \sigma^2 u)$ and associated with farm-specific factors (such as machine breakdown and variable input quality), which leads to the *ith* farmer not attaining maximum efficiency of production. (u_i) is associated with technical inefficiency of the farmer and ranges between zero and one.

3.4 Determinants of Technical Efficiency

In literature, there are several important determinants of technical efficiency. However, some are considered in the literature while others are not. The number of seed sowed in a hole on the farm is also an important determinant of technical efficiency of maize farmers in the study area even though it has been neglected by other studies. The use of tractors and animals for farming and accessibility to land, are some important determinants of farmers' technical efficiency in other parts of the world, but they are irrelevant for the purpose of this study in the municipality and therefore have been excluded from the variables of interest.

Based on the setting of the study area and the literature reviewed in chapter two, these variables were directly or indirectly (through the production function) expected to determine the level of technical efficiency of maize farmers in the Municipality. They are gender, farmer's level of formal education, farmer's family size, farm size, quantity of fertilizer applied by the farmer, type of seed, number of seed sowed in a hole, amount of weedicide, labour hours and access to credit. By intuition, the number of seed sowed in a hole also depicts the quantity of seed planted.

From Table 3.1, farm size, weedicide, access to credit and education, male farmers (gender), hybrid seeds and fertilizer application, are all expected to be positively related to technical efficiency. However, labour hours, number of seeds per hole and farmer's family size is expected to be positively or negatively related to technical efficiency of maize farmers, based on what is in the literature. The variables with their corresponding expected signs have been presented in Table 3.1.

Table 3.1 Expected Signs for Determinants of Technical Efficiency

Variable	Parameter	Expected Sign
Farm size	β_1	+
Labour hours	β_2	+/—
Weedicide	β_3	+
Access to Credit	β_4	+
Seeds per hole	β_5	+/—
Gender (Male)	ρ_1	+
Farmer's Family size	ρ_2	+/—
Access to Education	ρ_3	+
Type of Seed (hybrid)	ρ_4	+
Quantity of Fertilizer	ρ_5	+

3.5 Estimation Method

For the purpose of this study, the parameters of equation (3c) and (3g) are estimated using the seemingly unrelated and maximum likelihood (ML) methods, following estimation by Battese and Corra (1977).

This means that the Cobb Douglas stochastic function was estimated first so as to help estimate the scores of technical efficiency of maize farmers. Maximum likelihood estimation is appropriate for the study, because it has the ability to decompose the error term (e) into random error (v_i) and asymmetric error (u_i); which are independently and identically distributed. Also, the presence of dummy variables in the model requires the maximum likelihood method.

3.6 Econometric and Statistical Tests

Basically the t-test and the likelihood ratio test were used to test for the statistical significance of the independent variables in equation 3c and 3g at 5% and 1% level. This helped to provide enough grounds for the acceptance or rejection of farm level and socioeconomic variables as determinants of maize output and technical efficiency of maize farmers respectively.

3.7 Tools for Data Analysis

The data obtained was analysed using both inferential and descriptive statistics. Inferential statistics such as the parameter estimates and gamma (γ), which is defined as the total variation of output from frontier and can be attributed to technical (in)efficiency; were used to draw conclusions. Descriptive statistics such as tables, means, standard deviations and percentages were employed to analyze the socioeconomic characteristics of farmers. Microsoft Excel and Stata were used in the estimation of maize output and technical efficiency functions. They were used to test for the presence of econometric errors such as hetereoscedasticity and for its correction. The models were also verified to ensure that they were correctly specified. This was to aid the estimation process.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS

4.0 Introduction

This chapter presents the results and discussions of the study. The analysis of this chapter is detailed with regards to hetereoscedasticity, hypothesis testing, summary statistics of the variables, the estimated Cobb Douglas stochastic function, technical efficiency, determinants of technical efficiency, estimated potential yield and mean technical efficiency of socioeconomic variables. The study used maximum likelihood and seemingly unrelated estimation approaches to estimate the technical efficiency of two hundred and fifty farmers. This has been disaggregated into technical efficiency and cropping pattern, commercial and subsistence farmers respectively.

4.1 Hetereoscedasticity

Hetereoscedasticity is a condition where there is a violation of one of the assumptions of ordinary least square (OLS) in which the variance of the error term is not constant. In other words, the variance of the error term changes as the regressors change i.e. var(u_i)=σ_{ui}^2. The consequence of hetereoscedasticity is that the estimates will be unbiased, but inefficient. In this case, the variance of the error will be either too small or too large, thus committing type 1 or type II error.This will not make the estimates BLUE.

Hetereoscedasticity is mainly prevalent in cross sectional data set such as the one used in this study. It can be caused by increase or decrease in the level of dependent and independent variables being accompanied by changes in their variances towards the same direction. Hetereoscedasticity is automatically eliminated by taking natural logarithm at both sizes of the Cobb Douglas Stochastic frontier equation.

4.2 Hypothesis Testing

Using a log likelihood ratio test, with a calculated value of 28.08 against the probability value of 0.000, there is a strong decision to reject the null hypothesis and thus conclude that the Cobb Douglas production function is an adequate representation of the frontier production function. The second null hypothesis explores the test that all farmers are technically efficient; thus operating on the technically efficient frontier and that the systematic and random errors are zero. This assertion is rejected in favour of the presence of inefficiency effects. The evidence is confirmed by the high value of the estimated lambda (λ=2.7756).

The statistical significance of hybrid seed, weedicide, farm size, education, credit, gender, labour hours and number of seed per hole at 1% and 5% levels, confirms that socioeconomic variables have significant relationship with the technical efficiency of maize farmers. Table 4.2 and 4.6 outline the results of these hypotheses.

4.3 Summary Statistics of Variables

The statistics for the non-dummy variables gathered from 250 maize farmers are presented in Table 4.1. On the average, a maize farmer has a family size of (5.34) peoples; with a standard deviation of (1.412). This indicates that the family size of a maize farmer does not vary significantly from one to another. Farm size cultivated by farmers has a mean of (5.032) acreages and standard deviation of (3.192). This implies that farmland cultivated, varies significantly from one farmer to another. Fertilizer application has a mean of (2.045) bag per farmer, but varies greatly from one farmer to another due toit's high standard deviation (1.395). The number of seed sowed per hole (quantity of seed) and average labour hours spent on the farm have means of (3.496) and (3.5) hours and standard deviation of (0.861) and (0.982) respectively. This implies that the number of seed sowed in a hole does not change significantly from one maize farmer to another.

Table 4.1 Summary Statistics for Survey Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Family size (in numbers)	250	5.34	1.412	1	9
Farm size (in acreage)	250	5.032	3.192	1	50
Fertilizer (in bag)	250	2.045	1.395	0	35
Seed per hole(in numbers)	250	3.496	.861	2	5
Weedicide (in Cedis)	250	210.1	115.4	0	1400
Labour (both family and Hired labour used, in hours)	250	3.525	.982	1	7

Source: Author's calculation

The average amount of money spent on the purchase of weedicide is 2.10.1 Ghana Cedis, with a high standard deviation. This implies that weedicide application varies significantly from one farmer to another. Finally, the number of labour hours spent daily on farms does not vary significantly from one maize farmer to another.

4.4 Estimated Cobb Douglas Stochastic Function.

The linearised Cobb Douglas Stochastic function (equation 3c) is estimated using the Maximum likelihood method, with maize yield as the endogenous variable while farm size, labour hours, weedicides, access to credit and number of seed sowed in a hole are the exogenous variables. The result of the estimated Cobb Douglas stochastic function is presented in Table 4.2.

Table 4.2 Maximum Likelihood Results- Cobb Douglas Stochastic Function

Variables	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Farm size	.2012	.0282	7.14	0.000***	.1460	.2564
Labour hours	-.1689	.0665	-2.54	0.011**	-.2992	-.0385
Weedicide	.0909	.0076	11.99	0.000***	.0760	.1057
Credit (access)	.3139	.0563	5.58	0.000***	.2037	.4242
Seed quantity	-.6245	.0740	-8.44	0.000***	-.7696	-.4795
Constant	2.0330	.1183	17.18	0.000***	1.8010	2.2649
σ_v	.1566	.0196			.1225	.2001
σ_u	.4346	.0339			.3729	.5064
σ^2	.2133	.0266			.1612	.2655
λ	2.7756	.0475			2.6825	2.8688
Likelihood-ratio test of sigma u=0: chibar2(01)=28.08 Prob>=chibar2 = 0.000***						
Number of observation = 250						

Note:*** and ** represent 1% and 5% level of significance, respectively.

Source:Author's estimates (2011)

From Table 4.2, the study identified that farm size, weedicides and accessibility to credit are positively related to maize output. Given that other factors are the same, if there is a unit increase in farm size; maize yield will increase by 0.201. The positive relationship between maize yield and farm size is in conformity with literature and the expectations of the study. This substantiates the fact that increasing farm size will be accompanied by large volume of maize output.

Similarly, a unit increase in the amount of weedicide will cause maize yield to increase by 0.091 assuming that other variables are held constant. The positive relationship between weedicide and maize yield is in line with the literature and the expectations of the study. This is true because weedicide prevents weeds from competing with crops for soil nutrients thereby providing better yield.

Also, if there is a unit increase in the accessibility to credit for farmers, then maize yield will increase by 0.314. If farmers have access to credit, then they will have enough working capital to afford yield-enhancing inputs such as irrigation facilities, fertilizer, weedicide and hybrid seed to increase maize yield. Additionally, appropriate technology including the use of tractors, planters, harrows and combine harvesters can be employed if farmers have access to credit. This conforms to literature and the expectations of the study.

Conversely, it was established from the findings of the study that labour hours and number of seed sowed in a hole are negatively related to maize output. Therefore a unit increase in labour hours spent on farms will reduce maize output by -0.169. This is consistent with some findings even though others dispute this fact. If farmers and farm labourers spend more hours on their farms without the introduction of improved technology, then output will fall.

Also, if the number of seed sowed per hole changes by a unit, maize yield will fall by -0.625. The negative relationship between maize yield and number of seed sowed in a hole is attributed to the fact that, putting so many seeds in a hole will mean more seeds competing for less soil nutrients and water within each hole. Therefore, regardless of the amount of fertilizer applied, yield will obviously be low. This negative relationship does not conform to the literature and the expectations of the study.

Maize yield will be equal to 2.033 if farm size, labour hours, weedicide, credit and quantity of seed were to be zero. The study established the fact that farm size, weedicide, credit and quantity of seed are all statistically significant at 1% level except labour hours which is significant at 5% level. This means that appropriate measures can be taken to improve the positively related ones and to correct the negative ones.

4.5 Estimates of Technical Efficiency

As indicated earlier, Technical Efficiency of the ith farmer is calculated from the following;

$TE_i^* = \mathrm{e}xp^{(-u)} \times 100$ (TE is converted into percentage by multiplying this equation by 100)

Technical efficiency is estimated using the conditional expectation of the above equation, conditioned on the composed error ($e_i = v_i - u_i$) from Table 4.2. This is then evaluated, using the estimated parameters in Table 4.2 and Table 4.6. Technical Efficiency is computed for each farmer with the farmers later disaggregated into two; i.e. those engaging in subsistence farming and others in commercial farming. Table 4.3 shows the mean, minimum and maximum technical efficiencies for all maize farmers.

Table 4.3 Seemingly Unrelated Results- Summary of Technical Efficiency

Variable	Obs	Mean	Std. Dev.	Min	Max	Range
TE	250	73.61	14.17	17.32	95.48	78.16

Source: Author's estimates (2011)

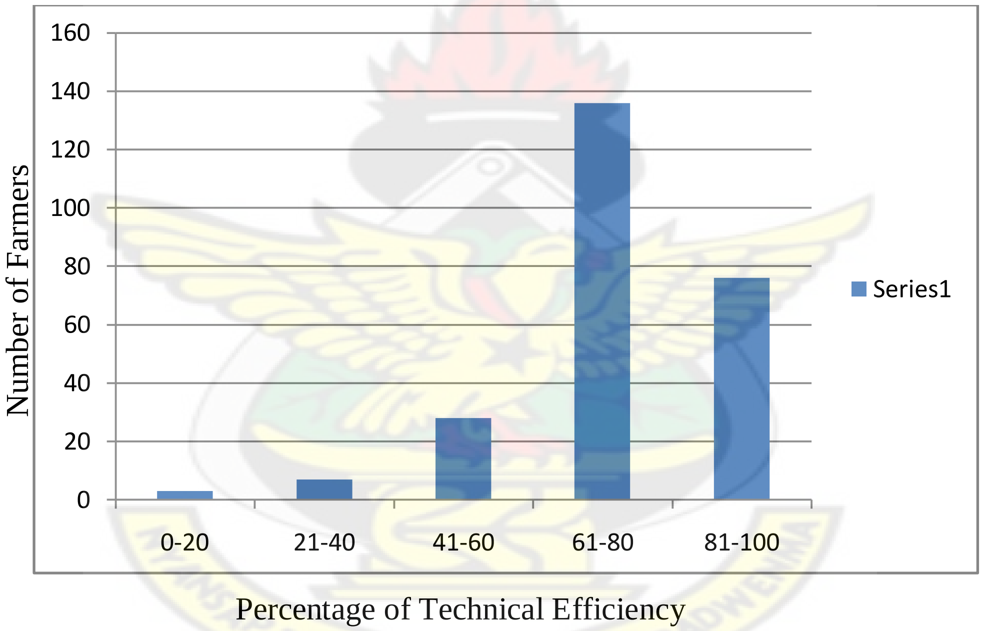
The mean technical efficiency of maize farmers is 73%. This implies that, on average, maize farmers in the municipality are able to produce about 73% of potential output from a given mix of production inputs. This means that actual maize production is in shortfall of 27%. This also suggests that on average; about 27% of maize yield is lost because of inefficiency. The mean TE of 73 % is higher than 53% and 59% respectively for non-irrigated and for irrigated rice in Northern Ghana (Al-Hasan, 2008) but lower than the average technical efficiency of 85% for fish farms in Ghana (Onumah, et al. 2010).

In respect of the dispersion of the TEs, the minimum and maximum are 17.32% and 95.48%. The maximum TE of 95.48% shows that the highest TE of the maize farmers was only 4.52% below the frontier. The minimum of 17.32% indicates that inefficiency in 2011 farming year was greater than 80%. This shows the extent of inefficiency. The high TE of 95.48% exceeds China's 92% high (Li and Wahl, 2004); however, China's low of 71% exceeds the Municipality's minimum of 17.32%. The technical efficiency scores possess a range of 73.16% indicating the difference between the lowest and the highest TE. With a standard deviation of 14.16%, there is less variability of the efficiency scores among maize farmers in the municipality.

Gamma $(\gamma) = \frac{\sigma_u^2}{(\sigma_u^2 + \sigma_v^2)}$ is also a measure of the level of inefficiency in the variance parameter and it ranges between 0 and I. From the Cobb Douglas Stochastic model, γ is estimated at 0.885. This implies that about 88% of the residual variation in output is attributed to inefficiency and that 12% of the variation in output among maize farmers is due to random shocks outside farmers' control. Examples of such random shocks are floods, bushfires, diseases and weather (poor distribution of rainfall). From Table 4.2, the estimates of $\lambda(2.776)$ and $\sigma(0.462)$ are large and significantly different form zero; thus indicating a good fit and correctness of the specified distributional assumption. Lambda (λ) is the ratio of variance of $u(\sigma_u)$ over the variance of $v(\sigma_v)$ and this provides an indication that the one sided error term (u), dominates the systematic error (v), therefore the variation in actual maize yield comes from differences in farmer's practice rather than random variability.

In absolute terms, out of 250 maize farmers, 149 of them have their level of technical efficiencies above the mean technical efficiency (73%), where as the technical efficiencies of 101 maize farmers are below the average technical efficiency. These represents 59.6% and 40.4% respectively. With regards to 82% bench mark of being technically efficient as postulated by Grabowski, et al. (1990), the study identified 76 technically efficient maize farmers constituting 30.4% of the sample size. Also, 174 maize farmers were found to be technically inefficient on the score that their technical efficiency scores were below the 82% bench mark. This also represents 69.6% of 250 farmers.

Figure 4.1 Histogram of Predicted Technical Efficiency of Farmers



Source: Field survey (2011)

Additionally, figure 4.1 is a histogram which shows the estimated technical efficiencies of maize farmers. Out of 250 maize farmers, 78 farmers had technical efficiency of 81% and 100%, 134 farmers had between 61% and 80%, 28 farmers also had between 41% and 60%, 7 farmers had between 21% and 40% and 3 farmers had 20% and below.

4.5.1 Technical Efficiency of Commercial and Subsistence Farmers

The farm-specific technical efficiency is categorized into two sectors i.e. commercial and subsistence maize farmers. For commercial maize farmers, the study meant those involved in maize cultivation purposely for sale on market whereas subsistence farming implied those purposely for home consumption. Out of 250 maize farmers, 155 of them engaged in subsistence maize farming. This indicates 62% of the total maize farmers. Alternatively, commercial maize farmers constituted 38% which in absolute terms is 95 out of 250 farmers. A summary about the technical efficiency of commercial and subsistence maize farmers is displayed in Table 4.4

Table 4.4 Technical Efficiency by Sector and Cropping Pattern

Technical Efficiency of Commercial and Subsistence Farmers								
Sector	N	Percentage of farmers	Mean	Std. Dev.	Min	Max	82% & Above	Below 82%
Commercial Farmers	95	62	74.94	10.6	37.63	95.48	23 (24%)	72 (76%)
Subsistence Farmers	155	38	72.6	15.9	17.32	93.4	53 (34%)	102 (66%)
Technical Efficiency and Cropping Pattern								
Cropping Pattern	N	Percentage of farmers	Mean	Std. Dev.	Min	Max	82% & Above	Below 82%
Monocrop	163	65.2	79.2	8.39	50.7	95.48	55 (33.7%)	108 (66.3%)
Intercrop	87	34.8	63.1	18.0	17.3	86.14	21 (24.1%)	66 (75.9%)

Source: Author's calculation

From Table 4.4, the mean technical efficiency of commercial maize farmers is 74.94% which is less than the bench mark of 82% but slightly higher than the mean technical efficiency for all farmers. Out of 95 farmers, 23 of them are technically efficient whereas 72 of them are technically inefficient. These represent 24.21% and 75.79% respectively. The mean technical efficiency of subsistence maize farmers is 72.80% which is lower than the mean technical of commercial farmers and the bench mark at 74.94% and 82% respectively. Analysis of the technical efficiency of the whole sample reveals that 76 out of 250 maize farmers are technically efficient. With this statistics at hand, the study further identified that 53 out of the 76 technically efficient farmers are in the subsistence sector while the remaining 23 are commercial farmers.

These indicate 69.7% for the former and 30.3% for the latter. From the general perspective, the analysis of the data indicates that, farmers in commercial farming appear to be more technically efficient than those in subsistence farming. This is because the mean technical efficiency of commercial farmers (74.9%) is greater than that of the subsistence farmers (72.8%) although they are all below the bench mark of 82%.

Again the farmer with the highest technical efficiency score (95.48%), is in commercial farming while the lowest technical efficiency score (17.32%) can be found among subsistence farmers. Majority of commercial farmers have better access to credit than subsistence farmers. Due to the limited access to credit, subsistence farmers probably cannot afford basic farm inputs thereby experiencing low yield.

4.5.2 Technical Efficiency and Cropping Pattern

In Asante Akyem North Municipality likewise elsewhere in Ghana, maize is planted as either a mono-crop or intercrop with other crops. Most often, the motive of intercropping maize with other crops such as cassava, plantain, yam, cocoyam, tomatoes, pepper etc is to diversify their investment in crops. This can help reduce the risk of total crop failure and also to obtain year round income from their farms. Also farmers have access to relatively smaller sizes of land due to land fragmentation among families.

In this study, 163 farmers planted only maize (mono-cropping) while the remaining 87 farmers planted maize and other crops (intercropping). In percentage terms, these represent 65.2% and 34.8% of the total maize farmers (250). These are captured in Table 4.5

From Table 4.5, the mean technical efficiency of maize farmers under mono-cropping is 79.23% (0.7923) while the mean of those under intercropping is 63.1% (0.631). Additionally, out of 76 technically efficient farmers, 55 of them are under mono-cropping as compared to 21 of them who intercropped their maize with other crops. This also means that 33.7% of farmers in mono-cropping are technically efficient while 24.1% are efficient under intercropping.

Despite the advantages involved in intercropping maize with other crops, evidence from Table 4.5 shows that more farmers engage in maize mono-cropping and on average, more technically efficient than those who add other crops. This may probably be justified as that; farmers have more attention for the maize crops since it is the only crop planted. Also, they may not compete with other crops for nutrients; thus resulting in higher yield.

4.5.3 Estimated Potential Yield of Maize Farmers

In the estimation of technical efficiency of maize farmers, the study estimated the potential yields for the entire 250 maize farmers. This is to establish the maximum possible output that farmers could have achieved with appropriate technology. This is also disaggregated into potential yield for commercial and subsistence maize farmers respectively. Table 4.5 summarizes the results from the estimation of potential yield.

Table 4.5 Summary of Potential and Actual Yield of Farmers

Potential Maize Yield				
	Mean	Std. Dev.	Min	Max
Maize Farmers	29.12	31.53	3.99	248.36
Potential Yield by Sector				
Sector	Mean	Std. Dev.	Min	Max
Commercial Farmers	51.42	41.29	19.52	248.3
Subsistence Farmers	15.46	8.52	3.99	33.53
Actual Maize Yield				
	Mean	Std. Dev.	Min	Max
Maize Farmers	21.6	23.1	1.5	195

Source: Author's calculation

From Table 4.5, it was found that the mean potential yield per maize farmer is 29.1 bags of maize while that of actual yield per farmer is 21.6 bags. This means that on average, each maize farmer has the capacity to produce about 29 bags of maize but 21.6 bags of maize were averagely produced by each maize farmer. This means that the mean actual yield is in short fall of the mean potential yield by about 7.5 bags of maize, thus indicating elements of technical inefficiency in maize production. The maximum and minimum potential yields among the maize farmers are 248.4 and 4 bags of maize.

In comparison with actual production, the maximum and the minimum are 195 and 1.5 bags of maize respectively. The study also identified that potential yield per acreage of land is 5.8 bags but actual yield per acreage is 4.2 bags of maize. This means that on average, acreage of farm land produced 4.2 bags of maize which is lower than the average potential yield that acreage of land could produce (i.e. 5.8 bags of maize). Table 4.5 provides a summary on maize output of farmers.

4.5.3.1 Potential Yield of Commercial and Subsistence Farmers

Further analysis from the estimation of potential yield shows that the mean potential yields of commercial and subsistence maize farmers are 51.4 and 15.5 bags of maize. This implies that, on average, a commercial maize farmer has the potential to produce more bags of maize than the subsistence maize farmer. A summary of the estimated potential yield for both commercial and subsistence farmers is presented in Table 4.5.

4.5.4 Determinants of Technical Efficiency

This section focuses on the estimates of the determinants of technical efficiency. From equation (3g) in chapter three, technically efficiency was expressed as a function of gender (male), family size, education, type of seed (hybrid) and amount of fertilizer. This equation is estimated by the seemingly unrelated approach and the results are presented in Table 4.6. From Table 4.6, the following analysis can be made.

If there is a unit change in educated farmers, then technical efficiency will also change by (0.020).This means that an increase in farmers' education increases technical efficiency (decreases technical inefficiency). Access to education equips farmers to make decisive policies regarding fertilizer and chemical applications and also better management practices to improve technical efficiency. The positive relationship between education and technical efficiency is consistent with the expectation of the study and results from other studies such as structural adjustment and economic efficiency of rice farmers in Northern Ghana by Awudu and Huffman (2000). Therefore education is statistically significant at 5% level.

Also, it was established from the findings that; the coefficient on the dummy variable, gender (male farmer) is positively related to technical efficiency and statistically significant at 5%. Technical efficiency will change by (0.0475), if there is a unit change in male farmers. Other things being equal, male farmers are more technically efficient than female farmers.

Table 4.6 Maximum Likelihood Results- Determinants of Technical Efficiency

Variable	Coef.	Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Gender (male)	.0475	.0218	2.18	0.029**	.0048	.0901
Family size	-.0069	.0059	-1.18	0.239	-.0183	.0046
Education (access)	.0201	.0111	1.80	0.040**	-.0018	.0419
Seed type (hybrid)	.0821	.0196	4.19	0.000***	.0437	.1204
Fertilizer	-.0122	.0104	-1.17	0.244	-.0326	.0083
Constant	.6611	.0382	17.31	0.000***	.5862	.7359

Note: *** and ** represent 1% and 5% level of significance, respectively.

Source: Author's estimates (2011)

This could probably be explained by the fact that in our traditional African societies, men are always accorded greater respect and recognition, probably because of cultural prejudices, and therefore have more access to credit, education and land than women. The FAO estimates that, in Sub-Saharan Africa as a whole, 31% of rural households are headed by women, mainly because of the tendency of men to migrate to the cities in search of jobs. Despite this substantial role, women are being neglected and marginalized in terms of access to credit, education and land. This makes them technically inefficient as compared to men.This result is in accordance with the literature and the expectations of the study.

From the results of the study, it was established that technical efficiency is positively related to hybrid seed (type of seed) in that if there is a unit increase in the usage of hybrid seedsfor farming, technical efficiency will improve by (0.082). This may be attributed to the fact thatthe hybrid seeds mature early, yield heavily and are more resistant to diseases. This provides higher yield and improves farmer's technical efficiency than those who use local seeds. The positive relationship between hybrid seed and technical efficiency conforms to the literature and the expectation of the study.

It was also established from the findings of the study that, technical efficiency is negatively related to farmers' family size. Thus, a unit increase in family size will reduce technical efficiency by (-0.069). This also means that large family size of farmers reduces their technical efficiency. This negative relationship is disputed by some literature in that, farmers with large family sizes have more supply of family labour. Further inquiry into this assertion revealed that farmers with large family sizes have to allocate more funds to cater for their ward's education, health and personal needs. In the end, less amount of money maybe left for farming activities. Complementing this situation, children do not get enough time to support their parents regularly on farms due to the existence of Free Compulsory Universal Basic Education and Capitation Grant policies. Therefore, large family size invariably brings negative effect on output and technical efficiency.

Also, the study identified a negative relationship between technical efficiency and fertilizer application. Technical efficiency will fall by (-0.0122) if there is a unit increase in the amount of fertilizer applied by farmers. This can probably be as a result of poor management of fertilizer; including the application of fertilizer which is not ideal for maize cultivation, untimely application of fertilizer and excessive use of fertilizer leading to the salinity of the soil. Again, the effect of the fertilizer could not be felt probably because it was not complemented with adequate rainfall or irrigation. Such conditions could make the maize crops unproductive and adversely affect the level of technical efficiency of the maize farmer.

Nevertheless, this negative relationship between fertilizer application and technical efficiency is not in conformity with what the literature and the expectations of the study.

Technical efficiency will be (0.6611) if all explanatory variables (gender, family size, education, type of seed and fertilizer) are to be equal to zero. The study found that; gender, education and hybrid seed are statistically significant at 5% level. Hybrid seed is even statistically significant at 1%. However, farmer's family size and fertilizer application are statistically insignificant at 5% level.

In addition, the determinants of maize output indirectly affect technical efficiency of maize farmers through maize output. Therefore, from Table 4.2, it can be established that; farm size, weedicide and access to credit are positively related to technical efficiency of maize farmers. On the contrary, average labour hours spent daily on farms and number of seeds sowed per hole is negatively related to technical efficiency of maize farmers. All the variables are statistically significant at 5% and even 1% level. The positive impact of credit on technical efficiency is expected because alleviating credit constraints facilitates timely purchase of inputs, and thus increasing productivity via decrease in technical inefficiency. This result is consistent with the study on rice farmers in Ghana by Awudu and Huffman (2000).On the contrary, Haji (2006) found a negative impact of credit accessibility on technical, allocative and cost efficiency.

4.5.5 Mean Technical Efficiency of Socioeconomic Variables

After the computation of technical efficiency scores, the study proceeded to identify the mean technical efficiencies of socioeconomic factors that are considered as dummies. They are gender, type of seed, education and accessibility to credit. These results have been presented in Table 4.7. From Table 4.7, the mean technical efficiency of female farmers is 67% and that of male farmers is 77%. Out of 250 maize farmers, 171 of them are males while 79 are females representing 68.4% and 31.6%. This implies that male farmers were more involved in maize cultivation than females.

Types of seed were also grouped into local, hybrid and both. The mean technical efficiencies for the three categories are 62%, 77% and 78% respectively. From Table 4.7, it can be concluded that 71.6% of maize farmers used the hybrid seed for their farms, 21.6% of them used local seed and 6.8% for both local and hybrid. The most technically efficient farmer used the hybrid type of seed for his farm while the inefficient farmer used the local type to sow.

The study also categorized the farmers into educated and uneducated farmers. In this regard, those who have acquired primary, secondary and tertiary education were all captured as educated farmers. From the findings of the study, it was established that 75.6% of maize farmers were educated while 24.4% did not have access to any formal education. Though majority of the farmers were educated, most of them ended their education at the J.H.S. and S.H.S. levels.

Under credit, farmers were grouped into those who had access to credit and those who were inaccessible to credit. Those accessible to credit borrowed from their relatives, friends and bank (Asante Akyem Rural Bank Limited) and through their personal savings. The mean technical efficiency of farmers who had access to credit and those who did not are: 76% and 68% respectively. In addition, 67 farmers did not have any funds to invest in their farms while 183 farmers had access to credit although they were not enough to meet their demands. The most technically efficient (95.48%) was among those who invested huge amount of funds in their farms. On the contrary, the farmer with the least technical efficiency (17.3%) is among those who had no access to credit. This substantiates the point that accessibility to credit is one of the key determinants of technical efficiency among the maize farmers.

Table 4.7 Mean Technical Efficiency of Socioeconomic Variables

Gender	Mean	N	Std. Deviation	Maximum	Minimum
Female (0)	.6702	79	.18014	.93	.17
Male (1)	.7666	171	.10754	.95	.31
Total	.7361	250	.14169	.95	.17
Seed type	Mean	N	Std. Deviation	Maximum	Minimum
Local (0)	.6182	54	.2013	.91	.17
Hybrid (1)	.7678	179	.1007	.95	.38
Both (2)	.7769	17	.0729	.88	.63
Total	.7361	250	.1417	.95	.17
Education	Mean	N	Std. Deviation	Maximum	Minimum
Uneducated (0)	.7044	61	.17035	.91	.20
Educated (1)	.7464	189	.12998	.95	.17
Total	.7361	250	.14169	.95	.17
Credit	Mean	N	Std. Deviation	Maximum	Minimum
No Access	.6780	67	.21175	.95	.17
Access	.7574	183	.09750	.94	.38
Total	.7361	250	.14169	.95	.17

Source: Author's Calculation

CHAPTER FIVE

SUMMARY, RECOMMENDATIONS AND CONCLUSION

5.0 Introduction

This chapter contains the summary of findings, recommendations based on the findings of the study and conclusion of the study. There is also a section that highlights directions for further studies and limitations of this study.

5.1 Summary of Findings

Econometric frontier models were estimated under the specification of the Cobb Douglas stochastic production function with half normal assumption for inefficiency effects. Results show overall mean technical efficiency of 73% which implies that actual maize production is in shortfall of 27%. However, technical efficiency scores range between 17.3 to 95.4% among maize farmers in Asante Akyem North Municipality. In addition, gamma (γ) is estimated at 0.885, which means that about 88% of random variation in production is explained by inefficiency. With a bench mark of 82% according to Grabowski, et al. (1990), the study concluded that 76 farmers were technically efficient while 174 farmers were inefficient representing 30.4% and 69.6% respectively.

The categorized commercial and subsistence farmers have revealed that commercial farmers were more efficient than subsistence farmers because the mean technical efficiency of commercial farmers is 74.9% and that of subsistence farmers is 72.6%.

Also, farmers practicing maize monocropping system were more technically efficient than those who intercropped their maize crops with other crops. There is a wide difference between the mean technical efficiency of farmers in mono-cropping (79.2%) and those who grow maize with other crops (63.1%).

In addition, the average potential yield of a maize farmer is estimated to be 29 bags of maize but 21.6 bags of maize were averagely produced by each maize farmer. The study also identified that potential yield per acreage of land is 5.8 bags but actual yield per acreage is 4.2 bags of maize indicating that, average potential yield per acreage of land exceeds average actual yield per acreage. This also attests to the fact that technical inefficiency exists among the maize farmers.

With determinants of technical efficiency, the results, however, support the hypothesis that technical efficiency increases with hybrid seed, weedicide, farm size, access to education and credit and male farmers; while average labour hours and number of seed per hole were found to be negatively related to technical efficiency. However, fertilizer application and farmer's family size were statistically insignificant at 5% level.

5.2 Recommendations

One of the most important avenues for minimizing cost of production is to increase yield per unit area through improvement in farmers' technical efficiency. Given that natural factors such as rainfall, sunshine, wind and PH system of the soil are potent, then socioeconomic variables such as credit, hybrid seeds, farm size, weedicides and education can help improve the level of technical efficiency of the farmers. On this score, the study proposed the following recommendations.

This study has shown that access to credit reduces technical inefficiency and thus shifts actual production frontier closer to the potential production frontier. Credit is necessary to encourage technical innovations, such as use of yield-enhancing inputs (hybrid seeds, weedicide and other farm inputs), which cost slightly more, but improves production by transforming the entire input-output relationship.

First and foremost, to improve technical efficiency of farmers for the revival of agriculture through credit accessibility, there must be a reduction in the interest rate on loans which will facilitate credit accessibility to farmers. The limited access to credit by farmers could be due to high interest rate, and hidden charges. Reduction in the interest rate will then reduce the cost of borrowing and hence a fall in the cost of production.

Secondly, special directive to financial institutions would foster easy accessibility of credit by farmers. Although agriculture is the mainstay of most African economies, it is quite regretful that less than 10% of loan portfolio in Africa is devoted to agriculture. There is the general reluctance on the part of financial institutions to grant loans to farmers in developing countries due to the risk of default associated with repayment. Therefore, the central bank can provide special directive to financial institutions to inject most of their loan portfolio into the agricultural sector and also reduce the bureaucracies involved in securing loans.

Government should also subsidize significant part of the cost of agricultural inputs such as fertilizer, weedicide, tractors, hybrid seed and others; so that the averagely poor farmer can afford the needed inputs for his or her farm.

In addition to the above recommendations, farmers should re-invest their plough back profit as additional credit. Government should establish a minimum price policy for maize as it has been done for cocoa. This will make farmers certain about their estimated proceeds based on output.

Moreover, farmers can form co-operatives so as to pool their existing resources together. This will help in the provision of collateral security for loans, cheap cost of labour locally referred to as “nnoboa”, proper marketing techniques and to bargain on better prices for their farm produce.

Formal and informal education in agriculture must be provided for students and farmers to improve their technical efficiencies in maize production. In the short term, informal education must be seriously provided in public gatherings (such as market places and churches) within the rural areas to equip farmers with modern methods of farming. In the long term, free compulsory universal basic education (F-CUBE) and the 'Capitation Grant' policies should be redesigned properly and rigidly enforced to improve the level of education in schools. Specifically, agriculture should be made a compulsory subject in the syllabus from basic to tertiary education level. This will help broaden the knowledge of the youth in agriculture. Also, stringent laws must be enacted to prosecute parents and guardians who fail to send their children to school.

Equipping extension officers would furthermore reduce the debut facing maize farmers.To meet the challenges of agriculture and food security confronting Ghana in recent times, the country must invest heavily in its human capital by training more extension officers and to research into better yield-enhancing inputs and production methods. Qualified extension officers must be motivated to work hard through higher remunerations and better condition of service.

5.2.1 Directions for Further Studies

This study has only exposed the level and determinants of technical efficiency of maize farmers within Asante Akyem North Municipality in Ghana. But, there are numerous directions in which this study can be extended.

First, this study focused on maize farmers in Asante Akyem North Municipality. An extension could be made to widen the geographical study area to cover all maize growing areas in Ashanti Region and perhaps the entire country. This will give a broader view regarding how differences in climate and soil will affect technical efficiency.

Secondly, the study solely focused on the measurement of technical efficiency, but an extension to include allocative efficiency, would give more insight into the field of efficiency studies. More interestingly, this study considered cross-sectional data, but time series data can be used to evaluate how technical efficiency has changed over time or is consistent with time.

More importantly, the study can be extended to adopt other estimation methods in addition to stochastic frontier analysis such as translog and data envelopment analysis (DEA), so as to compare and contrast the results from various methods. Moreover, the estimation of technical efficiency was only on maize production. In order to measure technical efficiency from the general perspective of agriculture; cocoa, plantain, cocoyam, yam, cassava, poultry, fruits and vegetables can be included. The sample size can be extended beyond two hundred and fifty farmers.

Finally, this study can be redesigned to include other variables of interest such as; farmer's age, years of farming (farming experience), specific amount of credit invested in farms, amount of rainfall, type of soil and fertilizer applied and the PH system of the soil which will give more insight into the variation of technical efficiency among farmers.

5.3 Limitations of the Study

This study, as a human related activity, is engulfed with socioeconomic and other factors that limit the extent to which the study could have been perfected.

First, in the estimation of technical efficiency, frontier function assumes that all inputs have been considered in maize production. However, in this study as well as others, it is possible to raise questions about whether all inputs have actually been accounted for, since farmers who are apparently inefficient mayjust use more or less of certain unmeasured inputs. In order words, not all socio-economic characteristics have been considered in this study since some variables applicable in other parts of the world, are not relevant under the setting of the study area.

More importantly, it was difficult to gain access to the farmers because all of them were not in the same farming area at the same time. Due to this, it was costly and time consuming to move from one farming area to another. It can therefore be concluded that, time and financial constraints impeded the early completion of this work.

5.4 Conclusion

This study sets out to estimate levels of technical efficiency of maize farmers in Asante Akyem North Municipality and to explain variations in technical efficiency among the farmers through socioeconomic and farm level characteristics. Farmer specific technical efficiencies are computed using 2011 cross sectional data from maize farmers in the Municipality. The maximum likelihood and the seemingly unrelated estimation approaches were jointly used to estimate the technical efficiency scores under the specification of the Cobb Douglas stochastic frontier approach.

Despite the long history about government commitment to revamp the agricultural sector through several interventions at the national, regional and local levels, maize farmers in Asante Akyem North Municipality in Ghana, are technically inefficient. Several policy issues emerge from the findings of the study. On a whole, it is concluded that the mean technical efficiency of maize farmers is 73% implying that there is a shortfall of actual maize production by 27%. It has been established that access to credit, education, hybrid seed, farm size and weedicide are positively related to technical efficiency of maize farmers while fertilizer, labour hours, number of seeds sowed and farmer's family size are negatively related to technical efficiency. However, farmer's family size and fertilizer application were statistically insignificant at 5% level.

As part of the recommendations to improve technical efficiency, both formal and informal education should be redesigned to improve the quality of education and sensitize farmers on the cost effective method of production. There should also be the removal of bottlenecks associated with credit acquisition, establishment of minimum price for maize and promotion of farmers' co-operatives to ease the availability of credit to farmers. Finally, the government can improve the level of technical efficiency of farmers by enacting laws that will provide equal accessibility to credit, education and land for all farmers (including males and females).

Clearly, as noted by Wambui (2005), the explanatory variables included here, although indicate the importance of the socioeconomic factors; they do not fully capture the extent to which the factors can explain variations in technical efficiency of maize farmers. Future studies could probably include variables such as farmer's age, years of farming (farming experience), specific amount of credit invested in farms, amount of rainfall, type of soil and fertilizer applied and the PH system of the soil. Their inclusion will improve the precision of measuring technical efficiency and also expand the scope of explanation for variations in technical efficiency among farmers.

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APPENDICES

Appendix 1: Questionnaire

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (K.N.U.S.T.), KUMASI,DEPARTMENT OF ECONOMICS: COLLINS DANSO OPPONG (M.Phil ECONOMICS)

This survey is earmarked to evaluate the level of technical efficiency and it's determinants among maize farmers in Asante Akyem North Municipality. In view of this, l would be grateful for your completion of this form. Farmers' anonymity will not be compromised, following the responses to be provided.

Instruction: Please tick or provide brief answers where necessary.

1. Gender of the farmer.

Male	1
Female	0

2. What is your age as a farmer (in years)? ……………………..

3. How many members constitute your dependants or family members including yourself? ....

4. Did you have access to formal education?

Yes	1
No	0

5. If the answer to question 4 is yes then, where did you end your formal education?

Primary	1
JHS & SHS	2
Tertiary	3

6. If the answer to question 5 is no, then state the rationale for your inaccessibility to education?......................................

7. Have you been visited or educated by extension officers before?

Yes	1
No	0

8. How many acreages of maize farm were you able to cultivate in 2011?
....

9. How many bags of fertilizer did you apply in the cultivation of your maize farm?
....

10. Which type of maize seed did you use to plant?

Local	0
Hybrid	1
Both local and hybrid	2

11. How many maize seeds were averagely sowed per hole on your farm? ....

12. How much Cedis was spent on the purchase of weedicides for your farm within the 2011 farming period? ....

13. Did you have any access to credit for your farm?

Yes	1
No	0

14. If the answer to 11 is yes, then what was the source of funds for your farming activities?
    a. Banks……………
    b. District assembly………….
    c. Co-operatives…………
    d. Relatives and friends………….
    e. Personal savings…………

15. If the answer to question 11 is no, then what was the rationale for your inaccessibility to credit?
    a. Demand for huge collateral………
    b. High interest rate…………
    c. Hidden charges………….
    d. High repayment rate……….
    e. Ignorance………….

16. What was the average labour hours (both family and hired labour) spent daily on your farm in a week? ....

17. How many bags of maize were produced from your farm in 2011? ....

18. On what basis did you plant your maize crops?
    Subsistence……… or commercial…………

19. Did you plant your maize crops with other crops

Yes	1
No	0

Please indicate your locality…………………

Appendix 2: Map of Asante Akyem North Municipality