TECHNICAL EFFICIENCY OF COCOA PRODUCTION IN GHANA: A CASE STUDY OF UPPER DENKYIRA EAST MUNICIPALITY

by

JACQUELINE COBBINA

B.A. (HONS.) ECONOMICS

A Thesis submitted to the School of Graduate Studies in partial fulfillment of the requirement for the award of

MASTER OF PHILOSOPHY (MPHIL) DEGREE IN ECONOMICS

Department of Economics,

Faculty of Social Sciences

College of Art and Social Sciences

Kwame Nkrumah University of Science and Technology

October , 2014

DECLARATION

I, declare that I have personally, under supervision, undertaken the study herein submitted towards the Mphil. Economics and to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

JACQUELINE COBBINA (PG7309812)	.... SIGNATURE	30/10/14 DATE

CERTIFIED BY:

DR. ERIC F. OTENG-ABAYIE (SUPERVISOR)	.... SIGNATURE	30/10/14 DATE

CERTIFIED BY:

DR. SR. EUGENIA AMPORFU (HEAD OF DEPARTMENT)	.... SIGNATURE	31/10/14 DATE

ii

ABSTRACT

Cocoa is an essential crop and plays a critical role for Ghana and the world at large. However, low productivity has been a challenge and as a result efforts by Government and stakeholders have been designed to improve production. However, Ghana still has the lowest average per yield compared with international levels. This study therefore attempts to measure the technical efficiency levels of cocoa farmers and examine the factors that influence the variations in technical efficiency. A multi-stage sampling technique is used to obtain a cross sectional data on 220 respondents. The stochastic frontier model is adopted for the study. The results reveal that the mean technical efficiency of cocoa farmers in the study area is 72%. Analysis of the determinants of technical efficiency indicate that, gender, labour type 1(family), labour type 2(hired) are positively related to technical inefficiency of cocoa farmers. Age of farm, education, credit, extension contact, association, farm size, marital status, fertilizer use and experience of farmer are negatively related to the technical inefficiency of farmers. However, labour type 1(family), association, farm size, fertilizer use and experience of farmers are statistically significant at 10%, 5%, 10%, 5% and 5% respectively. In conclusion, the study recommends policy makers as well as stakeholders to adopt measures to increase production and technical efficiency by focusing on proper management skills on their farms to reduce loss of resources.

Secondly, farmers are encouraged to form help groups (associations) to assistant themselves. Also, credit accessibility should be improved and encouraged to support farmers in need. Finally, extension services must be adequately facilitated to assist farmers be more efficient and productive.

ACKNOWLEDGEMENTS

I would first and foremost thank the Almighty God for blessing, protecting and strengthening me through my period of study. May your name be exalted, honored and glorified.

I express my sincere gratitude to my supervisor Mr. Eric Oteng-Abayie for his time, continuous support, patience, motivation and immense knowledge towards the writing of this thesis. His matured experience and knowledge guided me in all the time of research and writing of this thesis.

Much gratitude also goes to my family for their indefatigable love and support throughout my life.

I do owe a lot of appreciation to Mr. Emmanuel Donkor, Mr. Seth Etuah, Mr. Micheal Boachie, Mr. E.E. Sarkodie, Mr. Mustapha Immurana and Zakaria Maajid Suleiman for their immense contribution and support.

DEDICATION

I dedicate this thesis to God and my family.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

Table **Page**

CHAPTER ONE

INTRODUCTION

1.0 Background of the Study

Agriculture has persistently played a leading role in the provision of food, raw material for industries, employment for the majority, and foreign exchange earnings, which are used in financing development activities in West Africa. Industrial tree crops, mainly cocoa, coffee, oil palm, and rubber, have dominated agricultural exports. Cocoa is the most concern of all perennial crops in some parts of West Africa, and the global chocolate industry. According to Bryce, (2012), West African countries, including Ghana, together accounted for more than 70% of total world cocoa production where family-run farms have proliferated across the landscape in recent decades.

Cocoa holds a unique position in Ghana's economy. It is a major contributor to Ghana's gross domestic product (GDP) and the country's most important agricultural export crop. It is also the country's second important foreign exchange earner after gold. The share of cocoa in Ghana's GDP is 8.2% and about 23% of foreign exchange earnings (GAIN, 2012; ICCO, 2012). It is also a major source of income to over 800,000 farmers and many others engaged in trade, transportation and processing of cocoa (World Bank, 2011). For instance, it contributes about 70% of annual income of small-scale farmers, stakeholders like Licensed Buying Companies (LBC's) depend mostly on cocoa beans for their trading and marketing activities, employment and income generation according to Asamoah and Baah, (2003), also COCOBOD's activities are being funded by the income received from the tax revenue (Boansi David, 2013).

However, the Ghanaian cocoa industry has been afflicted with continuing problems. One of such problems is the decline in productivity. After emerging as one of the world's leading producers of cocoa, Ghana experienced a major decline in production in the 1960s and 1970s, and the sector nearly collapsed in the early 1980s.

However with the introduction of the economy wide reforms in 1983, production steadily recovered in the mid-1980s, and the 1990s marked the beginning of a revival, with production nearly doubling between 2001 and 2003. In recent years, cocoa production has picked up as well although it has not been consistent. For instance in 2010/11, Ghana was able to record 1,000,000 MT of cocoa, a historic achievement for the country.

The country's low productivity in the cocoa sector can be attributed to a number of factors, some of which are; the use of simple farming practices, the negligible use of fertilizers, depletion of soil nutrients, deforestation and low income for smallholder cocoa farmers.
Production in Ghana is characterized by smallholder type production which often involves whole families as working units. These working units are often characterized by low input and output, aging farmers and farms, disease plagued farms, inefficient use of resources, highly de-motivated youth and poor farming strategy. Another characteristic of production in Ghana is low yields on our farms. Generally, Ghana records lower yields of cocoa on our farms compared with other major cocoa producing countries. This is why Ghana is the third cocoa producing country after Cote d'Ivoire and Indonesia.

Binam et al. (2008) observed that Ghana appears to be the least efficient in cocoa production compared with other producing West African countries, which may probably be as a result of the multiplicity of challenges in the Ghanaian cocoa industry as pointed out above.

In realization of the potentials of cocoa in the economy of the country, the government and other non-governmental agencies resorted to introduce policies and other additional interventions to address the problem of low productivity.

1.1 Problem Statement

The significant growth in the Ghanaian cocoa sector is credited to the increasing land areas of cultivation rather than the improvement of yields (MOFA, 2006; COCOBOD, 2007). Achievable yields for cocoa are around 1 to 1.5 tons per hectare, at least 100% higher than average yield levels reported in 2010 (FAO 2007; Gockowski 2010; MoFA 2011).

Yields on Ghanaian cocoa farms are generally low. This explains why although cocoa productivity has recently been increasing, it is still low compared with that of other cocoa producing countries such as Cote d'Ivoire and Indonesia. Currently, the national average yield is estimated to be 400 kilogram per hectare (kg/ha), while Cote d'Ivoire is 600 kilogram per hectare (kg/ha) and that of Indonesia is 1000 kilogram per hectare (kg/ha). From these statistics, it is obvious that the productivity of the Ghanaian cocoa sector is relatively low. The poor performance of the cocoa sector in Ghana could be attributed to low efficiency in production.

For this reason the government of Ghana in consultation with other stakeholders in 1991 designed the Cocoa Sector Development Strategy (CSDS) to help boost production. Under the strategy, cocoa production was projected to increase from 335,000 tonnes in 1991 to about 500,000 tonnes by 2004/2005 and then to 700,000 tonnes by 2009/2010. For the 2010/2011 cocoa season, Ghana recorded a historic 1,000,000 tonnes of cocoa production. It is believed that this increase in the level of cocoa output can be attributed to a number of interventions including, the Cocoa Hi-tech initiative programme implemented by government, increase in land size for cocoa production, and other private sector initiatives, Onumah *et al.* (2013).

However, the success story has not been sustainable as it has been fluctuating. Ghana's 2011/2012 cocoa season saw a decline in production at 879,000 tonnes, which fell further the next year (2012/13 cocoa output) at 835,000 tonnes (Reuters, 2013).

In responds to the fluctuations, government rolled out several programmes over the past twenty-four months to boost production. Some of such initiatives were to distribute 20m hybrid seeds to cocoa producers, expand farm rehabilitation services, accelerate the replacement of old cocoa trees and initiate mass pesticides spraying six-times a year (Delmas Marketing Department: The African Commodity Report 30/11/13).

However, with all these initiatives both by government and stakeholders, Ghana still have a low average yield compared with international levels. Others cocoa producing countries like Cote D'Ivoire and Indonesian as mentioned above continue to have higher average yields than Ghana.

A report by Binam et al. (2008) revealed that Ghana is the least efficient country in cocoa production compared with other producing West African countries.

One then may wonder how efficiency the cocoa farmer in Ghana is. Is the Ghanaian cocoa farmer able to manage and use available resources to achieve maximum possible yield and reduce resource wastage?

It is against this background that the present study estimates the technical efficiency levels of cocoa producers in Ghana; to examine the factors that influence variations in technical efficiency; and recommend solutions to address the inefficiency problem in the sector. In line with this, the Upper Denkyira East Municipality of the Western South region according to Cocobod's administrative demarcations was chosen as a case study.

1.2 Objectives of the Study

The aim of this study is to analyze the efficiency levels of cocoa farmers in the Western South region of Cocobod demarcations. The specific objectives addressed in the study are:

1. To determine the level of technical efficiency of cocoa farmers in Upper Denkyira East Municipality.
2. To identify the determinants of the technical efficiency among the sampled farmers.

1.3 Research Questions

The following questions are guide to the researcher in advancing the core objective of the study and will include but will not be limited to the following;

1. What is the technical efficiency level of cocoa farmers in the in Upper Denkyira East Municipality?
2. What factors influence this level of technical efficiency of cocoa farmers in the in Upper Denkyira East Municipality?

1.4 Study Hypothesis

H_0: The cocoa farmers in the Upper Denkyira East municipality are technically efficient

H_1: The cocoa farmers in the Upper Denkyira East municipality are technically inefficient

1.5 Method of the Study

There are two approaches to measuring technical efficiency, namely, parametric and non-parametric. Most studies on technical efficiency are motivated to use the parametric approach because it permits test of hypothesis concerning the inefficiency effect and parameters in the model. This study adopted the stochastic frontier Analysis (SFA) model because it allows for the decomposition of the error term into random error and inefficiency error rather than attributing all errors as random effects. The stochastic frontier analysis (SFA) model was used to measure the technical efficiency level of farmers. The SFA model consists of two sets of equations. The first equation specifies the stochastic production frontier that relates cocoa output to farm inputs employed in cocoa production. The second model specifies the inefficiency model correlates technical inefficiency with vector of socioeconomic characteristics of the cocoa producers. The parameters in these two equations are estimated simultaneously with the maximum likelihood estimation approach in a single stage procedure. Stata 11 econometric software was employed to run the models. The stated hypothesis was tested using the likelihood ratio test.

1.6 Justification of Study

There have been a few studies on technical efficiency in the Ghanaian cocoa industry (Aneani et al., 2011; Binam et al., 2008; Dzene, 2010; Kyei et al., 2011).

With some researches already done to investigate technical efficiency, new studies at different areas of cultivation with different cocoa agro-ecologies is necessary to improve resource use efficiency and improve the overall national development.

Furthermore, this work will confirm the factors that influence the level of inefficiency in cocoa production, causing a more serious awareness for stakeholders to avoid such practices for better improvement in the industry.

This research will also leave behind some important literature for other research fellows who would like to conduct further research into cocoa in Ghana and elsewhere.

1.7 Organisation of the Study

The study is organized into the five broad chapters. Chapter one presents the Introduction of the study and includes the statement of the problem. The chapter also includes research hypothesis, research questions, objectives of the study and the justification for the study. With Chapter two, various works relating to the study area, both theoretical and empirical data are reviewed, including institutional framework concerning Cocoa production in Ghana. Chapter three presents the methodology of the study. Chapter four presents data analysis in respect of the methodology adopted in chapter three. Finally, chapter five concludes and evaluates the study whilst giving out some recommendations based on conclusions drawn from the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter recounts literature on studies done by other researchers and publications relevant to the current study. The chapter is subdivided to cover the theoretical literature, empirical literature and literature on Agriculture and Cocoa production in Ghana.

2.1 Theoretical Review

This section of literature review deals with the definitions and measurement of technical efficiency.

2.1.1 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. Efficiency according to Kebede (2001) in a production unit may be defined as how effectively it uses variable resources 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 saying that farm efficiency can be measured in terms of any or all these types of efficiency. Other important types of efficiency are; production efficiency, x-efficiency, dynamic efficiency, scale efficiency etc. However, since technical efficiency is our focus in this study, much will be centered on it.

According to Leibenstein (1966), 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.

In the opinion of Farrell (1957), Rahman (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 Kebede (2001), technical efficiency refers to the maximum attainable level of output for a given level of production inputs, given the range of alternative technologies available to the farmer. According to Greco (2014), 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 the production of goods and services in technically efficient production.

According to Ali and Chaudhry (1990) and Forsund et al (1980), technical efficiency is the ability of a farm to achieve maximum possible yield with available inputs. Also to them, technical efficiency is the ability of the firm to produce the maximum output from its given resources. One firm is more technically efficient if it produces a level of output 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.

According to Okoruwa and Ogundele (2008), 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 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.

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.

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 (2014), 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 contribution to production value is equal to the factor cost.

Leibenstein (1975) 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 Ogundari and Ojo (2006), 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 (2014), dynamic efficiency is used to describe a market in the long term. A society with a high dynamic efficiency offers consumers more choices of higher quality goods or services than in another society. For example, as research and development improve products over time, and enhance quality items cheaper to make, then the market experiences increased dynamic efficiency over time. According to Leibenstein (1966), dynamic efficiency refers to the economically efficient usage of scarce resources through time, and thus, it embraces allocative and productive efficiency in intertemporal dimension.

2.1.2 Measurement of Technical Efficiency

Considered as a very important area of economics, efficiency in recent three decades has been of interest to economists.

In both developing and developed countries, technical efficiency and its measurement have become one of the major research topics (Ashok et al, 1995; Hazarika and Subramanian, 1999). Since developing countries are more into agriculture, application is more centered in this sector. Application in developed countries is mainly focused on the industries (manufacturing) and service sectors.

Measurement of technical efficieny of farms, firms and organisation can be identified with different methods and criteria (Coelli et al., 1998).

In estimating technical efficiency two approaches are used on the whole. These are frontier and non-frontier approach. In using the frontier approach, majority of technical efficiency studies have been motivated by the desire to estimate the frontier production function and to calculate technical efficiencies because it is a standard against which the technical, allocative and economic efficiency of firm, farm and organisations are measured. In using cross section data the frontier approach is further divided into non-statistical and statistical methods.

Non-statistical method is further divided into two. They are; non-parametric (Charnes et al., 1978), which is also known as deterministic approach and also refered to as data envelopment analysis (DEA) (it has no fixed functional form for the frontier including all observations in the model) and parametric approaches (Aigner and Chu, 1968; Ali and Chaudry, 1990), also called probabilistic approach based on Cobb Douglas or other form. Statistical methods consist of non-stochastic and stochastic method. Using the non-stochastic frontier approach in measuring technical efficiency, all variations from the frontier are considered to be as a result of inefficiency. The Stochastic frontier function, on the other hand, assumes deviation from the frontier as a result of both random effect and inefficiency. According to Ali and Byerlce, 1991, maximum likelihood and corrected ordinary least squares (COLS) methods are used in estimating statistical methods.

There are two major approaches that have been used in finding the technical efficiencies of diverse ventures. These are in line with literature and they are recent applications (Fare et al., 1993; Lovell et al., 1994; Grosskpof et al., 1996; Coelli and Perelman, 1996). These two approaches; parametric and non-parametric, each have certain advantages and disadvantages over each other being discussed by Battese (1992), Bravo-Ureta and Pinheiro (1993), Forsund, et al (1980), Fried, et al (1993), Coelli (1996), Coelli and Perelman (1999).

As the one of the approaches, parametric method deals with econometric modeling such as the translog, Cobb Douglas and stochastic frontiers and constant elasticity of substitution production functions. Unlike the deterministic frontier, parametric method imposes a functional form on the production function and makes assumptions about the data. In estimating technical efficiency, such medels can be applied to production, cost, profit and perhaps revenue functions. In estimating technical efficiency using the non-parametric approach, certain problems created can be solved by the parametric method. In detailed the parametric approach is into two parts; deterministic and stochastic frontier production functions. With deterministic frontiers, all the deviations from the frontier are as a result of firms' inefficiency, while stochastic frontiers assume that part of the deviation from the frontier is due to random events (thus measurement errors and statistical noise) and part is due to firm specific inefficiency (Forsund et al 1980; Battese, 1992; Coelli et al., 1998).

Unlike other parametric frontier methods, the stochastic frontier approach allows for the error term to be decomposed into the random error term, characterized by factors beyond the control of the farmer or firm, and the other error term associated with inefficiency factor, also characterized by those factors within the control of the farmer or firm. The stochastic frontier analysis were first propagated in papers by these individuals Aigner et al. (1977) and by Meeusen and van den Broeck (1977).

Under the deterministic frontier approach all unusual high random failures, bad weather and even error misspecification, or wrong measurement of input variables are all classified as inefficiency measures. However, a more suitable approach, which is the stochastic approach assumes that any firm or farmer faces its/his own production frontier. It also assumes that the frontier is randomly placed by the whole collection of stochastic elements which might enter the model outside the control of the firm. This is a similar argument to Forsund and Jansen's (1977) rationale for an average versus best practice frontier function. Estimations of technical change, efficiency change and productivity change in the last couple of decades, has been measured by stochastic frontier analysis (e.g., Kumbhakar and Lovell, 2000; Greene, 2004).

Alternatively, the non parametric approach have no fixed functional form on production frontier form neither are there any assumptions on the error term. The most used is the data envelopment analysis (DEA), which uses a non-parametric piecewise linear production frontier in estimating efficiency. They use mathematical modeling or linear programming approaches; the most popular non-parametric approach has been the use of data envelopment analysis. The DEA are classified as input-oriented or output-oriented

2.2 Empirical Review

This section of the literature review deals with the determinants of technical efficiency in general, in the agricultural sector and specifically, in cocoa production across the world with emphasis on Ghana and Africa.

2.2.1 Determinants of Technical Efficiency in General

An investigation by Reddy (2002) on productivity differences between tenant and owner operation of sugar cane farms in Fiji. There was significant difference between two types with respect to input usage, productivity and technical efficiency. Tenant operated farms had mean technical efficiency of 0.82 and that of owner-operated farms was 0.90.

Hazarika and Alwang (2003) examined the effects of access to credit from formal sources and tobacco plot size, on cost inefficiency among Malawian smallholder tobacco cultivators. It was found that tobacco cultivation was significantly less cost inefficiency per acre on large plots. Access to credit had no statistically apparent effect on cost inefficiency and 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. Results showed 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.

Most empirical studies according to Rahman et al. (2009), identify socio-economic characteristics, farm characteristics, demographic, environmental, physical and non-physical factors as significant source(s) or determinants of technical efficiency in any field. Below are several examples.

More intensive competition was found to lead to more efficient technical choices in the USA according to Caves and Barton (1990).

Gumbau-Albert and Maudos (2002), found that farm 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. More concentrated markets with a presumably low level of competition and in firms with public ownership participation were the lowest levels of efficiency found.

2.2.2 Determinants of Technical Efficiency in Agriculture

This section of the empirical review is devoted to the determinants of technical efficiency levels in agriculture within developing and developed countries. The source of efficiency is a major concern for farmers. Some significant determinants of technical efficiency in developing countries' agriculture are socio-economic and farm characteristics, demographic, environmental, physical and non-physical factors according to Rahman, et al. (2009). Some of these variables are equally the determinants of technical efficiency in agriculture among developed countries. Below are several examples.

Farm size has an impact on technical efficiency according to empirical studies. Farm size can be measured as the area under cultivation. i.e. how large or small farmers can cultivate. Different units of measurements are used in different studies, they include; acreage, hectare, kilometers and miles.

According to Ogundele and Okoruwa (2004), farm size is a major significant determinant of technical efficiency in Nigeria. Other determinants included labour, herbicides, seeds, education and farming experience.

Coelli et al (1998) revealed that years of schooling, land size and age of farmers have a positive impact on technical efficiency for Indian farmers..

Another important factor that influences technical efficiency is extension visitation. This can be measured as farmer, extension officer interaction. Thus when there are contacts between the two parties.

An investigation by Owens et al. (2001) on the impact of farmer contact with agricultural extension services on farm productivity revealed 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

Gender, another important determinant of technical efficiency is usually measured as a dummy with male=1 and female=0. Generally, a male is associated with physical strength implying they can do labour intensive jobs and even spend more hours on the farm. This is however different with female farmers.

Seed type is another factor that influence technical efficiency on thefarm. Cross breeds such as hybrid have higher resistance to diseases and higher yields than local seed types.

Fertilizer and agrochemicals such pesticides are also major determinants of technical efficiency on the cocoa farm. Proper usage is known to kill pests and unwanted weeds to encourage crop growth on the farm. However, its disadvantages as a result of misuse prevents some farmers from using them on their farm, some misuse can cause crop yield loss.

Education, another factor that influences technical efficiency is believe to lead to proper assessment of complexities of farmer decision.

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

Lack of education, restricted credit and fragmented holdings acoording to Parikh and Shah (1995), were found to be the causes of technical inefficiency among farms in the North-West province of Pakistan. They also 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.

1.3 Determinants of Technical Efficiency in Cocoa Production

An investigation by Danso-Abbeam *et al* (2012) on production efficiency of cocoa farmers in Bibiani-Anhwiaso-Bekwai Municipality revealed 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 determinants of technical efficiency with a mean technical efficiency of 49%.

Amos (2007) looked at the productivity and technical efficiency involved in cocoa production in Nigeria and revealed that age of farmers, level of education and family size were the main determinants of technical efficiency.

Adedeji (2011) of Oyo State investigated technical efficiency, determinants of production and the sources of inefficiency in cocoa production. The study revealed that farm size (1%) and fertilizer quantity (1%) were the major factors associated with changes in the output of cocoa production while on the farmer's specific socioeconomic variables, only level of education, extension contact and family size were found to be the significant factors of technical efficiency.

Oguntade A. and Fatunmbi T., (2012) examined the effects of Farmer Field School (FFS) on the Technical Efficiency of cocoa farmers in Cross River and Ondo States, Nigeria. The study therefore concluded that the Farmers' Field School participants were more efficient in the use of factors of production than their NFFS counterparts.

Nkamleu et al (2010) investigated on productivity potentials and efficiencies in cocoa production in West and Central Africa (namely Cameroon, Ghana, Nigeria and Cote d'Ivoire). The data and analysis support the view that technical efficiency in cocoa production is globally low, and technology gap plays an important part in explaining the ability of cocoa sector in one country to compete with cocoa sectors in other countries in the West and Central Africa region.

Effendy et al. (2013) studied on the factors that affected the production and technical efficiency in cocoa farming at Sigi Regency – Indonesia**.** Results showed that farmer characteristics such as education, farming experience, and frequency of follow counseling could help to increase the technical efficiency so that the cocoa production could be increased.

Dzene (2010) investigated the determinants of technical efficiency on Ghanaian cocoa farmers for the period 2001 to 2006. The result found demographic factors and non-labour inputs except household size and insecticides to have positive and significant impacts on technical efficiency. Controlling for demographic profile and selected non labour inputs, result suggests that farm level problems including Black pod infestation, mistletoe attack, and termites and other problems, including flooding, weeds and bushfire as affecting technical efficiency among cocoa farmers. Other factors as fertilizer intensity and quality of farm maintenance had positive and significant impacts on technical efficiency.

Onumah *et al (2013)* analysed the productivity, technical efficiency and its determinants among cocoa producers in the Eastern region of Ghana. Results revealed that exogenous factors such as access to extension services, technical support and credit are found to reduce the level of technical inefficiency among the producers. Also older farmers and male farmers were efficient than younger and female farmers. Farmers with more experience in cocoa production also produce with technical efficiency.

2.3 Agriculture in Ghana

Until recently, the agricultural sector dominated the Ghanaian economy from the very beginning, as far back as since independence during Dr. Kwame Nkrumah's (the first president of Ghana) time. The service sector is now the largest contributor to the Gross Domestic Product (GDP) (Budget Statement and Economic Policy, 2013). Ghana at the time of the first president was rich in land, timber, gold and cocoa. Ghana was the world's leading cocoa producer. However, during the decline in the Ghanaian economy all these fell. The cocoa sector almost collapsed in the 1970s. Relief eventually came to cocoa sector and the country at large after the economic reforms in 1983.

Growth in agriculture has reduced poverty rate in Ghana (Bogetic *et al*., 2007) and (Coulombe and Wodon, 2007). It fell from 51.7% in 1991-1992 to 39.5% in 1998-1999 and 28.5% in 2005-2006. Ghana, over the years has been recognized as one of Sub-Saharan Africa's significant success stories in terms of growth and poverty reduction over the past 15 years. There has been increment in real GDP for more than 4 percent per year since 1980 and more than 5 percent per year since 2001. The Ghanaian agriculture sector is still highly dominated by the small holder farming system.

The benefits of agriculture to the country are food provision, employment creation, and contributions to domestic revenue through taxation, foreign exchange earnings through exports, raw materials for agriculture-based industries and as a second dominant component of gross domestic product (GDP) to Ghana's economy.

The sector, according to Animal Production Directorate, Ghana Country Report, (2003), consists of four (4) sectors namely; crops (which is classified into food, Industrial, and

Export crops), livestock, Fisheries and cocoa. However, forestry also contributes along with the four mentioned sectors to the Gross Domestic Products (GDP) of the country. The country is also divided into six distinct agro-ecological or vegetational zones namely; the high rainforest, the semi deciduous forest, forest savannah, the guinea savannah, the Sudan savannah and the coastal savanna.

The country's principle food crops according to (Animal Production Directorate, Ghana Country Report, October 2003), include; cereals (mainly rice and maize), starchy staples such as yam, cocoyam, cassava and plantain and sorghum and millet. There are three main reasons for crop production in Ghana: food production for consumption, raw materials for industry and cash crop for export. Livestock production is at household level and on commercial basis comprising poultry, cattle, pig and other small ruminants.

Technical efficiency measures are vital in enhancing productivity in food production. This is because proper management of resources will give the opportunity to increase productivity without necessarily increasing the resource base of the country. Squires and Tabor (1990) defined technical efficiency as a farmer's ability to produce the maximum output possible from a given set of inputs and production technology. Each farm's production performance is compared to a best-practice input-output relationship or frontier making this concept relative. The best-practices are established by the practices of the most efficient farmers.

2.3.1 Historical Development of the Cocoa Industry in Ghana

Cocoa (Theobroma cacao), is form the family of sterculiaceae. Theobroma, it's genus has twenty two (22) species. However, the only species grown commercially for the production of seeds for chocolate making or for the extraction of cocoa butter is Theobroma cacao (Mossu, 1992a). Cocoa originate from Mexico and parts of tropical America (Manu, 1989a). The African continent in the latter part of the nineteenth century discovered cocoa from these Islands, Fernando Po, Sao Tome and Principe (Mossu, 1992b).

Ghana, formally known as Gold Coast was officially introduced to cocoa by Tetteh Quarshie, after a successful journey form Fernando Po in the Seychelles Island in 1879. However, before Tetteh Quarshie, the Dutch and the Basel Missionaries were the first to plant cocoa in Ghana.

Growth in cocoa in part of the country, especially westwards is somewhat due to migration from the Akwapim Ridge and the Accra palins. Further spread of cocoa in the country was accelerated by the allocation of scattered parcels of forest to the extended families for food and Cocoa cultivation. Since then, Cocoa production has become the main cash crop grown in six out of the ten regions in Ghana.

The important commercial crop of the equatorial region, cocoa, is planted widely across areas bordering the Gulf of Guinea in West Africa. They include Ghana, Cote D'Ivoire, Nigeria, Liberia, Sierra Leone, Togo and Dahomey (Kishore, 2010). In the forest areas of the Ashanti, Brong Ahafo, Central, Eastern, western, and Volta regions of Ghana, most cocoa is produced by around 1.6 million small farmers on plots of less than three hectares (ha) (ESDD, 2002). In 1585, the first cocoa export to Europe from Veracruz to Cadiz recorded (Mossu, 1992c).

Ghana exported about 546.72 tones (T) of cocoa in 1900, 2,856.00T in 1905, over 26,520.00T in 1911 and in 1936, she exported 317,220T, representing half the total world production at the time (Manu, 1989b). In 1964/1965, Ghana became the leading producer of cocoa (Adjinah et al, 2010c).

Cocoa mass spraying exercise between 1959 and 1962 is believed to have resulted in the high production of over 580,000MT recorded in the 1964/1965 season. Production, however, dropped to the lowest level of 158,956MT in 1983/1984, making us lose our place as the world's leading cocoa producer to neighbouring Cote D'Ivoire. Cocoa production on the other hand increased to 734,699 T in 2003/04 cocoa season (GNA, 2005).

There are over 800,000 smallholder farm families employed in the Ghanaian cocoa sector. The number of cocoa farm owners is estimated at 350,000. Cocoa farm sizes are relatively small ranging from 0.4-4.0 hectares (COCOBOD, 2002). A study by Asuming-Brempong et al., (2007) reveals that ninety eight percent (98%) of workers in cocoa farms fell within 18-50 years. For the smallholder cocoa farmers, cocoa contributes about 70-100% of their annual household income (Asamoah and Baah, 2002). Cocoa employs about 50% of the agricultural labour force in Ghana (Seini, 2002).

There has been some interest in the economics literature in recent times since Ghana's robust economic growth occurred at the same time as the country's cocoa sector is booming (Zeitlin, 2005). The strong recovery of the cocoa sub-sector, which improved from 0.5% in 2002 to 16.4% growth in 2003, aided the performance of the agricultural sector of Ghana (The Daily Graphic, Wednesday, 2004). Cocoa export contributed 16% ($246.7 million) in 2001 to total exports (Blankson, 2011). In 2002, cocoa made up for 22.4% (463 million US

$) of the total foreign exchange earnings. 63% of foreign exchange earnings from the agricultural sector was constituted by cocoa (ISSER, 2003). In 2008, cocoa contributed 9% to GDP, according to Dwinger (2010). The agricultural sector, according to the Ministry of Food Agriculture (MoFA), in 2010 contributed about 37.3% to Ghana's GDP. They further stated that the cocoa sub-sector contributed 15% to National GDP. Given that, the cocoa industry is doing so well, Armah (2008) suggests that it is quite reasonable to surmise that the growth of the cocoa industry is the engine behind the country's current impressive economic growth.

2.3.2 Cocoa Processing in Ghana

Cocoa production is carried out as stated above in about six out of the ten regions in the country namely the Volta region, central region, Brong Ahafo, Eastern region, Ashanti region, and the Western region which supply about 50% of annual production (Anim-Kwapong and Frimpong 2005). Cocoa production in Ghana is characterized by two main seasons- the light crop season which starts from September to June, and the main crop season which runs from October to May/June. Cultivation involves a series of activities ranging from planting, maintenance, harvesting, drying and bagging the beans for marketing.

Cocoa production is characterized by smallholder farmers, who normally grow food crops alongside the cocoa cultivation. Cultivation is done using simple tools like cutlass, and sometimes hoes for the land preparation ahead of the seedlings planting. Farmers normally nurse the cocoa seedlings but it was formally supplied by the cocoa research institute of Ghana. Usually, lands a little far away into the bush are selected for cultivation. These eventually reduce disturbances to cocoa trees. (Tudhope 1909).

The land is then cleared, but however leaving some large trees standing as shades for the seedling. Other food crops such as cocoyam and plantain can also be planted before cocoa seedlings to provide a bit of shade. Simple farm tools like cutlass and hole are used in planting. Maintenance is done after planting till harvesting time. The cocoa tree takes about 3-5years to bear fruit, depending on the variety. Amelonado, Amazonia and Hybrid are the three main types of cocoa varieties cultivated in Ghana. The Amelona and the Amazonia take about 5 years to bear fruit unlike the hybrid which requires only 3years of gestation period (COCOBOD 2009; Tudhope 1909).

Within this period, maintenance is carried out by the farmer to ensure good yield. The cost of spraying, fertilizing, maintenance and weeding are all bore the farmer. However, in some cases, according to Tudhope (1909), many well to do farmers give their farm on contract to caretakers to manage. At this point, all maintenance responsibilities will be managed by the caretaker, whilst the owner provides all expenditure to the caretaker to carry out maintenance activities on the farm. This goes on till the harvesting time when the pods turn yellowish in nature. During harvesting time, the owner may divide the yield into three, where the caretaker receives one-third of the crop, while the remaining two-thirds goes to the owner. This is a form of sharecropping. In the Ghanaian language, it is called "*Abusa*", meaning division into three. This may differ from community to community as some may have a fixed proportion of the harvest given to the caretaker (MOF 1999). After harvesting, which is usually done with cutlass, the pods are broken by means of cutting it into two with a cutlass or hitting it against a stone. The beans are then gathered and heaped in the farm to allow fermenting for about 7 days before carring them to the house for drying. It is then bag in 64kg, which is sold to the Licensed Buying Companies (LBC), who have their purchasing clerks in the rural areas.

2.3.3 Cocoa Yield in Ghana

Generally, yields of cocoa are lower in Ghana than in other major producing countries. Whilst the average cocoa yield stood at 600 Kg/ha in Ivory Coast and 1,000 Kg/ha in Indonesia, it was only 400 Kg/ha in Ghana (Business News of Friday, 13 December, 2013). However, production figures showed that yield has increased substantially in virtually all the Municipalities across Ghana in recent times. (Adjinah and Opoku, 2010).

Research has shown that cocoa farmers have a potential cocoa yield of 1000 Kg/ha or more (Aneani et al, 2011). The problem of low yields relative to potential has been ascribed to some constraints such as disease and pest, inefficiency in the allocation of resources and improper cultural practices (Aneani et al, 2011). As confirmed in research works that planting cocoa with unspecified source of seeds at irregular spacing, high density, infrequent weeding, little or no pruning, infrequent removal of mistletoe, infrequent pest and disease control among others cultural practices could give a yield as low as 5.5bags/ha or 2bags/acre.

It has further been observed that, proper farm practices such as; planting improved cocoa seeds from designated gardens used for planting, regular spacing, regular weed management, shade management, frequent disease and pest control, and fertilizer application once a year among other improved cultural practices could give a yield as much as 22bags/ha or 9bags/acre or more.

2.3.4 Causes of low Cocoa Production in Ghana

Ghana is a force to consider, when it comes to the production of Cocoa in the world. However production levels have not been consistent over the years except in the mid-1980s and early

2000 where the yield appeared to have been on track, but this notwithstanding have some elements of inconsistency in it (Dormon et al. 2004). The down trend has been due to a number of factors.

First is drought, which is a major cause of low level of production in the Cocoa sector. During this period the condition of the atmoshire is very bry therefore and slit it of fire could escalate into something big. No wonder bush fires are rampant in this condition. This is triggered by the activities of Marijuana smokers, rat seekers and bad farming practices such as slash and burn method. These normally cause severe fire outbreak which can destroy lots of Cocoa farms. The prolonged drought in 1980s, as advocated by Thompson (2005), damaged an estimated 30-40% lots of Cocoa farms located in Volta, Ashanti and Brong-Ahafo regions of Ghana causing a drastic reduction in the output level of Cocoa. As a result of that, most farmers became discouraged and abandoned their farms; others took the risk and engaged in replanting exercise.

In addition to drought, the second factor which is responsible for the low production of Cocoa in Ghana is aging Cocoa trees. There is the general truth that as an organism becomes old; its capacity to be productive eventually diminishes. MOF (1999) also confirm this with a fact that an estimated 30% area under cocoa cultivation has been unproductive due to the old nature of the trees. Moreover the number of cocoa trees that are grown per hectare has not been encouraging: it has been lower than the recommended number.

Activities of pest and diseases are another factor that causes huge damage in the cocoa production. Mainly caused by *Phytophthora megakarya,* the black pod disease is the most damaging fungal disease that affects cocoa production (Opoku et al. 2007). Most farmers in an attempt to fight this disease end up losing huge sum of revenue, while other have limited effort to fight it. This has led to the prevalence of the black pod disease in five cocoa regions in Ghana with an estimated area of 700,000 hectares as at 2004 (Opoku et al. 2007). Newly affected areas can have estimated losses of 60-80%, whereas on old farms destruction can be very great (Anim-Kwapong and Frimpong, 2005).

Capsid bug is another pest apart from the black pod that infests cocoa crop. *Distantiella theobroma* (Distant) and *Sahlbergella singularis* (Haglund) are the essential species involved in this devastating activity (Ayenor et al. 2007; Dormon et al. 2007). They piers through the Cocoa pod and suck the juice from it, after which they inject the pod with poisonous saliva. This activity kills young cocoa shoots and makes it difficult for older ones to establish. The activities of these insects are more pronounced between September and March during which the weather is dry (Anim-Kwapong and Frimpong 2005).

2.3.5 Marketing System

There are two main components of the marketing system of cocoa in Ghana; internal marketing and external marketing system. Formally the Produce Buying Company were the sole purchasers of cocoa beans directly from the farmers. However, many private companies have been given the license to buy from farmers directly. This according to Cocobod (2009) was done to introduce competitition in the purchase of cocoa to foster efficiency in the internal marketing system. According to MOF (1999), the Produce Buying Company is still the leading buyer of cocoa beans although its market share is limited to about 68% as at 1997/1998 season.

Thompson (2005) notes that Cocobod Producer Price Review Committee determines the price paid to farmer by the License Buyers Company. Cocobod is responsible for keeping private licensed buying companies in check to ensure healthy competition in the internal marketing system. This is normally a percentage of the Free On Board (Fob) price, and it takes into accounts the cost of production to the farmer.

Cocoa beans after purchase are brought to the Quality Control Division of Cocobod to be ensured of quality. They then forward the checked quality beans to Cocobod for sale and storage before exported by the Cocoa Marketing Company (CMC). The beans are sold to both international and local companies for processing (COCOBOD 2009).

2.3.6 Uses of Cocoa

Cocoa is used in the production of products. Some are chocolate powder, biscuits, bars of chocolate and chocolate, sweets, perfume and in pharmacy (Mossu, 1992). It's by-products (husk, fats extracted from husk) can also be used to feed cattle, manufacture fertilizers, pharmaceutical products and soap.

Cocoa is a plant-based food that contains carbohydrates, fats, proteins, natural minerals and some vitamins. Cocoa contains a group of compounds which exhibit health benefits (Kenny et al, 2004). Cocoa contains vitamin E and some vitamin B complex such as thiamine, riboflavin and niacin (Keen et al, 2003). There is a growing body of evidence about the health benefits of cocoa flavanols (Zhu et al. 2002). The cocoa component in chocolate is rich in magnesium, copper, potassium and manganese, sodium, calcium, iron, phosphorus and zinc, which perform important roles in the physiology of the human body (Mursu et al 2004). The Dietary copper content in chocolate contributes to the prevention of heart disease. Also, cocoa flavonols have been indicated to help prevent cholesterol effect.

2.3.7 Major Cocoa Cultural Practices

Land Selection and Preparation

Cocoa cultivation in Ghana is mainly done in the forest lands of the six cocoa regions where rainfall is between 1100mm and 3000mm per annum. Extremely wet and swampy lands are not suitable as well as rocky places (Cocoa Research Institute of Ghana, 1987). The most suitable condition for cocoa production in Ghana is a forestland with deep sandy-clay soil, which is as rich as possible in minerals (Mossu, 1992).

Cocoa farm lands are cleared in the dry season, where unimportant trees are fell and weeds are cleared and burnt (Manu, 1987). Land preparation must be done at least a year before seedlings are planted. Important trees left standing on the farm provide shade for the young seedlings. Lands without trees plant food crop like plantain and cocoyam to provide shade and a conducive temperature for young seedlings (Ghana Cocoa Research Institute, 1987).
Food crops planted alongside cocoa in turn produce food as staple for the benefit of the farmer and for economic sustenance during the growing period of the cocoa (Benneh, 1987).

Fertilizer Application

Application of fertilizer on cocoa production is very important as yield can be increased by 30%. However, more education on its usage is also key. It can be applied to plantations 10 years and above at two years intervals. In order to ensure its effectiveness, timely weed control, removal of shades and removal of mistletoes and other good management practices must be applied on the farm (Cocoa Research Institute (CRI), 1987).

Pests and Diseases Control

There are a couple of recommended agrochemical; pesticide, weedicide and others used on the cocoa farm. Some of such are Confidor, Cocostar, Akate Master, Cabamult, and Atara.

In 2010, the use of organochlorine insecticide was proved to be effective in Ghana in controlling the mirids pest according to International Cocoa Organization (I.C.O). The current recommended insecticides that are being used by the farmers in Ghana include Confidor, Cocostar, Akate Master, Cabamult, and Atara. Insecticides are applied as foliar spray using motorized mist-blowing machines.

Mistletoe, another major parasitic pest attacks mature/grown up cocoa trees. They destroy young banches of cocoa trees if not removed early. Mistletoe is controlled by removal of the affected parts of the tree with the mistletoe altogether to prevent it from spreading to other parts of the tree. This is usually done by the use of a cutlass.

Gutter/Canal Cutting

The canals are made to control water-logging on the cocoa farms by ensuring easy flow of excess water out of the farms as a result of heavy rain.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter consists of description of the study area (with demographic characteristics, agricultural system, relief and drainage, climate, vegetation and soils), data collection (also including the 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

Ghana COCOBOD has its own cocoa administrative districts which are different from the political regions and districts in Ghana. Dunkwa cocoa district, representing Western South region has 12 cocoa districts. It is also made up of three political districts, namely Upper Denkyira East, Upper Denkyira West and Twifo Lower Hemang Denkyira districts of the political administration of Ghana. Dunkwa is situated between latitudes 50 30" and 60 15" N and longitudes 20 10" and 20 30” W. It is bordered in the north by Antoakrom, Obuasi and Bekwai cocoa districts. In the east, it is bordered by, Sefwi Bekwai, Wasa Akropong, and Tarkwa districts, respectively. In the South east, it is bordered by Fumso and Foso cocoa district.

This paper however narrows its study on Upper Denkyira East District, a Dunkwa cocoa district. This is because cocoa is the most widely grown crop in the area and there have been major development projects aimed at increasing production in the municipal.

The Upper Denkyira East Municipal Assembly is one of the (5) Administrative Districts, which were elevated to municipality status in January 2008 within the Central Region. Dunkwa-On-Offin is the Administrative Capital. The Municipal is one of the seventeen Administrative Districts of the Central Region. It lies within latitudes 5°, 30°and 6°.North of the equator and longitudes 1° W and 2°W of the Greenwich Meridian. It shares common boundaries with Adansi South in the North and, Assin District in the East and Twifo Hemang Lower Denkyira in the West and Upper Denkyira West District in the North-West. Upper Denkyira East Municipality covers a total land area of 1020 square kilometers, which is about 10% of the total land area of the Central Region. Some towns in this District are Dunkwa-On-Offin, Ntom, New Obuasi, Nkotumso, Maudaso, Bethelehem, Buabin, Akropong, Nkronua, Nkwaboso/Akwaboso, Afiefiso, Gambia, Asikuma, Meretweso, Mmeradan, Danyaase, Fawomanyo, Kwaku Dum, Mfuom, Mbraim, Nsuam 1, Nsuam 2, Achiase, Esaase, Denkyira Achiase, KPK, Amissah-Krom, Jukwa Bremang, James town, Zion Camp 2, Zion Camp, Tegyemoaso, Pokukrom, Kwameprahkrom, Appiakrom, Atobiase, Wampaamu, Ayanfuri, Dominase, Nkwatanum, Diaso, Denkyira Obuasi, Motiakrom, Nfanteman, Addokrom, Kyerewere, Bebianeha, Jerusalem, Acheampim, Aquakrom, Adjomamu, Atechem, Mintaso, Zamrama Camp, Dunkwa Mfoum, Denkyira Fosu, Kotokyi, Buabinso, Frami, Mradan, Kadudwen, Takyikrom.

3.1.1 Demographic Characteristics

The municipal as at the last census had a population of 72,810, with male consisting of 49.16 percent and female 50.84 percent. The Economy, however, can be classified as mainly agrarian. The good nature of the vegetation found in the Municipality encourages and promotes agricultural activities thus helping to generate income from farm proceeds. About 60%-65% of the working population is engaged in vibrant farming while 15% are in small scale mining and 10% in trading and other varied economic activities. Crops such as Cocoa, oil palm, pineapple, plantain, cassava and corn are cultivated in the municipality with cocoa being the major cash crop grown in the Municipality. There are light industries such as mineral water production and sawn mills. Small scale mining also contributes to the socio-economic development of the Municipality. Most of the male youth derive their livelihood from mining of mineral deposits in the municipality. These include gold, gravel, sand, clay, kaolin and silica.

3.1.2 The Agricultural System

Total arable land is about 75,626 hectares. This represents about 44% of total land area. However, only about 30,250.4 hectares are currently being cultivated. The average farm size is two acres but there are relatively large farms, mostly cocoa and oil palm plantations, with sizes of over four acres.

The types of crops produced in the municipality can be categorized into two, namely; food crops and industrial crops. The major food crops produced in the municipality are cassava, plantain, maize, cowpeas and cocoyam. Cocoa and cassava are generally cultivated as mono crops whilst plantain and cocoyam are intercropped with crops such as cassava and cocoa. Cocoa intercropped with cassava is also commonly practiced. The industrial crops produced in the municipality are cocoa, rubber and oil palm. By far cocoa is the most widely grown crop in the Upper Denkyira East Municipality and is widely grown in the forest areas. The cultivation of cocoa covers about fifty percent 50 % of the total arable land in the municipality. Cocoa farms are normally owned by families and individuals. Cashew is a relatively new crop for farmers in the district and is currently cultivated on a small scale, and mushroom cultivation and snail farming also have potential in the area, which can be exploited by private investors

3.1.3 Relief and Drainage

The area falls under a forest-dissected plateau, rising to about 250m above sea level. There are pockets of steep sided hills alternating with flat -bottom valleys. Dunkwa, the Municipal capital, has series of high lands circling it. The major river in the area is the River Offin. A number of streams which are tributaries of either rivers Offin and Pra flow through the district. Prominent among them are the Subin Ninta, Aponapon and Tuitian in the south, Afiefi and Subin in the north.

3.1.4 Climate

The Municipal falls within the semi equatorial zone with its characteristics. The mean annual temperatures are 29° C on the hottest months and about 24°C in the coolest months. There are two rainfall regimes, but the total annual mean rainfall is between 120cm and 200cm. The first rainy season is from May to June with the heaviest in June, while the second rainy season is from September to October. The main dry season is from November to February.

3.1.5 Vegetation

The Upper Denkyira East Municipal falls within the semi-deciduous forest zone. It consists of three layers which do not differ from the rain forest. The trees in this forest zone do not shed all their leaves at the same time nor are they of the same species. Trees of the lower layer and some of the topmost layer stay evergreen throughout the year. This is due to the generally moist condition of the area. Due to the increasing mining activities in the area, especially in the northern part of the Municipality, very little of the original forest remains, and most of what is left are secondary forests. The forest contains various valuable timber species such as Mahogany and Wawa. Although, the timber industry provides venture for income generation, the logging activities occur in both in and off reserves thus having a negative impact on the rainfall pattern of the Municipality

3.1.6 Soil

The principal soil found in the area is forest ochrosols. The colour of these soils range between drown and orange. The soil is not highly leached as oxysol. Due to the reduction in the amount of rainfall, the soils contain greater quantities of soil nutrients and are generally alkaline.

From the view point of crop production, they are the best soils in the country. Tree crops such as cocoa and oil palm thrive in the area. Cocoa covers about 50% of the districts entire arable land. Other crops like cassava, plantain and cocoa also do well.

3.2 Data Collection

Data collection is a section of the methodology which takes into account the type of data used for the study, the population, sample size, sampling procedure and the survey method adopted for the collection of data from the respondents (cocoa farmers).

3.2.1 Type of Data Used

Data used for the study is purely primary data and it is cross sectional in nature because it covered data in 2012/2013 cocoa season. Primary data based on farm-level and demographic characteristics of farmers were collected through a survey of cocoa farmers in the Upper Denkyira East Municipality, of the Central region of Ghana. Additionally, secondary data such as population size of the study area and other information pertaining to the study area were collected from the Upper Denkyira Municipal assembly.

3.2.2 Sampling and Data Collection Method.

Cocoa farmers constituted the population of the study but samples of the cocoa farmers were considered from Upper Denkyira East Municipality. A multistage sampling technique was used to collect a cross sectional data of cocoa farmers in the Upper Denkyira East Municipality. Consideration of the communities was based on the concentration of cocoa farms in these communities. Forty eight communities were then selected from the municipality. They are ; Gambia, Asikuma, Meretweso, Mmeradan, Danyaase, Fawomanyo, Kwaku Dum, Mfuom, Mbraim, Nsuam 1, Nsuam 2, Achiase, Esaase, Denkyira Achiase, KPK, Amissah-Krom, Jukwa Bremang, Zion Camp 2, Zion Camp, Tegyemoaso, Pokukrom, Kwameprahkrom, Appiakrom, Atobiase, Wampaamu, Dominase, Nkwatanum, Diaso, Denkyira Obuasi, Nkotinso, Motiakrom, Nfanteman, Addokrom, Kyerewere, Bebianeha, Jerusalem, Acheampim, Aquakrom, Adjomamu, Atechem, Zamrama Camp, Dunkwa Mfoum, Denkyira Fosu, Kotokyi, Buabinso, Mradan, Kadudwen, Takyikrom. The number of respondents selected from the communities was based on the number of farms in each community. A list of farmers was obtained from the local offices of the Ghana Cocoa Board (COCOBOD) to aid this process. A total of 220 farmers were randomly selected from the list provided.

These villages were purposeful for the study because cocoa production in the municipality was dominated by these villages. Again, the rationale behind the selection of these specific villages was to represent the topographical, climatic and vegetation zone differences in the Municipality.

Since the study highlighted cocoa production, only cocoa farmers whether in mono-cropping or mixed cropping were ideal for the survey. This also pertained to the farmers who engaged in cocoa production in 2012/2013 cocoa season regardless of the hectare of land cultivated. The sample size constituted two hundred and twenty cocoa farmers and they were selected from the identified villages in the municipality.

Data were gathered from two hundred and twenty (220) cocoa farmers through direct administration of structured interview forms. The sample survey was carried out by the researcher together with four selected assistants, who had good experience in terms of communicating relevant information to the respondents (cocoa farmers). One day training was organized for the assistants to familiarize themselves with how the structured interviews were to be done. A number of two hundred and twenty structured interview forms were issued and each questionnaire consisted of thirteen open and sixteen closed question items. Wide ranges of data regarding farm level and demographic characteristics of farmers were collected. The farm level data included are fertilizer application, farm size, labour, type of seed, Age of trees, pesticide usage and output of cocoa. In addition, information pertaining to farmers' demographic characteristics like gender, age, access to credit, marital status, type of labour, cost of labour, and level of formal education were gathered in the course of the survey. Day to day follow up and motivations of the assistants was executed to improve the overall quality of the sample survey.

The survey did experience several problems common to many fieldwork experiences. Some respondents were reluctant in giving information on their age, cost of labour and output at the end of the cocoa season which resulted in a number of incomplete interview forms. Other constraints were that the towns of study were far apart from each other resulting in delay in data collection.

3.3 Method of Analysis

3.3.1 Analytical Technique

Frequency table was used to summarize and organize the demographic data collected during the field survey. In addition the Stochastic Frontier Analysis (SFA) model was adopted for this study since it allows for the decomposition of the error term into random error and inefficiency error rather than attributing all errors as random effects. In stochastic frontier analysis the firm or farm is constrained to produce at or below the deterministic production frontier. The approach is preferred for efficiency studies in agriculture because of the inherent stochastic nature of the agricultural systems (Ezeh, 2004; Coelli, 1995). The SFA was first proposed simultaneously by Aigner et al. (1977) and Meeuseen and Van Den Broeck (1977) and it is specified for a cross section as:

$$Q_i = f\,(X_i;\, \alpha_i).\ \exp\,(v_i\text{-}u_i), \qquad u_i \geq 0 \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where: Q_i is the production of the ith firm, X_i, vector of input quantities of the $_i$th firm, α, vector of unknown parameters to be estimated; v_i *is* assumed to account for random effects on production that is not within the control of the producer, u_i is a non-negative error term measuring the technical inefficiency effects that fall within the control of the decision unit and f (.) is an appropriate function (in this case, translog frontier).

The SFA has been used currently by authors like Onumah and Acquah (2010), Onumah et al. (2013), Nyagaka et al. (2010), Park and Lohr (2010) Dzene (2010), Nchare (2007) and Ogundari and Ojo (2007) and the approach specifies technical efficiency as the ratio of the observed output to the frontier output, conditioned on the level of inputs used by the farm. Technical inefficiency is, therefore, defined as the amount by which the level of production for the farm is less than the frontier output:

$$TE = \frac{f\,(Xt{:}\alpha).\exp(vi-ui)}{f\,(Xt;\alpha).\exp(-vi)} = \exp(-ut)\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (2)$$

Technical inefficiency = 1- TE

Where (f (X_t; α). exp (v_i-u_i) is the observed output and f (X_t; α). exp (-v_i). Following Battesse and Coelli (1995), the error term, v_i is assumed to be identically, independently and normally distributed with mean zero (0) and a constant variance σ_v^2; {vi □ N (0, σ_v^2)}. The error term, u_i is also assumed to be distributed as a truncation of the normal distribution with mean μ_i and variance, σ_u^2; {u_i □~N (u_i, σ_u^2)} such that the inefficient error term is explained by some exogenous variables specified as

$$\mu_i = Z_i \beta \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (3)$$

Where Z_i is a vector of exogenous variables β is a set of unknown parameters to be estimated. In this research, the single-stage maximum likelihood estimation method is used in estimating the technical efficiency levels of the farmers and the effects of the determinants of efficiency simultaneously. This simultaneous estimation procedure ensures that the assumption of identical distribution of the u_i is not violated. The maximum likelihood estimation of the frontier model yields the estimates of α and the gamma (γ), where the γ measures the total variation of observed output from the frontier (deterministic) output. It is given as the ratio of the variance of the error associated with inefficiency (σ_u^2) to the overall variation in the model (σ^2). The overall variation of the model is the sum of the variance of the error associated with inefficiency (σ_u^2) and that associated with random noise factors (σ_v^2). The gamma estimate is expressed given as: $\gamma = \frac{\sigma u2}{\sigma 2}$, where the γ lies between zero and one ($0 \leq \gamma \leq 1$). The closer the value is to 1, the more the deviation of observed output from the frontier is as a result of inefficient factors; if the value is close to 0 then deviations are as a result of random factors. If the value lies in-between 1 and 0, then the deviation may be attributed to both random and inefficient factors.

3.3.2 Model Specification

Production is the process of converting our limited resources into goods and services using the available technology. Production is the creation of goods and services from the existing resources to directly satisfy human wants or for further production. In short, 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. Thus, the resource can be physical or mental (Mansfield, 1975).

The translog production function stated in model (4) is assumed for the study. The translog function has been proven by other studies to be efficient for technical efficiency (Onumah and Acquah, 2010; Baten et al., 2009).

$$\ln Q_i=\beta_0+\Sigma^3_{i=1}\,\beta_i \ln X_i+1/2\,\Sigma^3_{i=1}\Sigma^3_{j=1}\beta_{ij}\ln X_i \ln X_j+(v_i-u_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where: In = the natural logarithm; i = ith respondent farmer, Q_i = Output of farmer in kilograms (kg), X= Variable inputs, X_j = Fixed inputs, *βs* are parameters estimated. V_is = Assumed to be independently and identically distributed normal, random errors, having zero means and unknown variance (d2v). U_is = Technical efficiency, which are assumed to be independent of V_is.

In equation 4, level of output of cocoa farmers is expressed as a function of farm size, man day, quantity of fertilizer applied and quantity of pesticides used. Considering the setting of the study area and the period of study, these are the conventional or traditional factors in cocoa farming.

The translog production function is alternatively defined as follows:

$$In\ Q_i = \beta_0 + \beta_1\, In\ X_1 + \beta_2\, In\ X_2 + \beta_3\, In\ X_3 + 1/2\ \beta_4 InX_1^2 + ½\ \beta_5 InX_2^2 + ½\ \beta_6 InX_3^2 + \beta_7 InX_1 InX_2 + \beta_8 InX_1 InX_3 + \beta_9 InX_2 InX_3 + e \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (5)$$

Where: In = natural logarithm**,** Q_i = the level of output (Kilogram), X_1 = Farm size (per hectare), X_2 = Labour (man-day), X_3 = Quantity of fertilizer applied (Kilogram), βs = coefficients to be estimated and e = error term ($V_i - U_i$)

To measure the land productivity levels of the farmers**,** the output per hectare of each farmer was computed and further categorized into six ranges. Analysis were made by comparing both the individual yield per hectare (output/ha) of farmers and the mean yield per hectare of all farmers to the national output/ha (400kg/ha).

The technical efficiency in equation (2) was simultaneously estimated with the determinants of technical efficiency. The model to explain determinants of technical efficiency is specified as follows:

$$\mu_i = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5 + \beta_6 Z_6 + \beta_7 Z_7 + \beta_8 Z_8 + \beta_9 Z_9 + \beta_{10} Z_{10} + \beta_{11} Z_{11} + \beta_{12} Z_{12} + \beta_{13} Z_{13} \ldots\ldots \quad (6)$$

The mean of the error term u_i, is explained by economic characteristics of the producer and exogenous factors. Where; μ = error term of farm, Z_1 = Gender of the farmer measured as dummy (if male 1, female 0), Z_2 = Farmer's level of formal education (years spent in school), Z_3 = Association as dummy (in an association 1, not in an association 0), Z_4 = experience of farmer (years of farming), Z_5 = Fertilizer use as dummy (yes 1, no 0), Z_6 = extension contact as dummy, (yes 1, no 0), Z_7 = credit accessibility as dummy, (access 1, no access 0), Z_8 = Improved variety (use hybrid seed 1, no hybrid seed 0), Z_9 = Labour type 1 (use family 1, do not use family 0), Z_{10} = Labour type 2 (use hired 1, do not use hired 0), Z_{11} =Farm size (per hectare),Z_{12} =Age of tree (years), Z_{13}= Marital status (single 0, married 1, divorced 2, widow/widower 3).

3.4 Determinants of Technical Efficiency

In literature several important determinants of technical efficiency such as gender, farmer's level of formal education, access to extension visitation for farmers, farmer's family size, farm size, access to land, the use of animals and tractors, access to credit, labour hours, type of seed and quantity of fertilizer exist. Gender, farmer's level of formal education, farm size, quantity of fertilizer applied by the farmer, quantity of pesticides used, extension contact, labour type 1 (family), labour type 2 (hired), improved variety, marital status and access to credit are equally relevant determinants of technical efficiency of cocoa farmers in the study area though they are also found in the literature. The use of tractors and animals for farming and accessibility of land, are some important determinants of technical efficiency of farmers in most parts of the world, but they are not relevant for farming 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, the following variables are expected to determine the level of technical efficiency of cocoa farmers in Upper Denkyira East Municipality. They are gender, farmer's level of formal education, Age of tree, Association, experience of farmer, extension contact, farm size, fertilizer application, pesticides usage, experience of farmer and credit accessibility. These variables with their corresponding expected signs have been displayed in table 3.4.1.

From table 3.4.1, educational level of farmers, association, experience of farmer, fertilizer use, extension contacts, improved variety, labour type 1 (family), farm size, marital status and access to credit were all expected to have a negative effect on technical inefficiency while labour type 2 (hired) have a positive effect on technical inefficiency. Gender and age of tree, on the other hand could either have a positive or negative effect on technical inefficiency, in accordance with what is in the literature.

Table 3.4.1: Inefficiency Variables Measurement with their Expected Signs

Variable	Description	Measurement	Aprior sign
Z1	Gender	Dummy: 1=male; 0=female	-/+
Z2	Educational level of farmer	Years spent in school	-
Z3	Association	Dummy: 1=yes; 0=no	-
Z4	Experience	Years	-
Z5	Fertilizer use	Dummy: 1=yes; 0=no	-
Z_6	Extension contact	Dummy: 1=yes; 0=no	-
Z_7	Access to credit	Dummy: 1=no; 0=yes	-
Z_8	Improved Variety	Dummy: 1=use hybrid seed; 0= no hybrid seed	-
Z_9	Labour type 1 (family)	Dummy: 1=use family; 0=do not use family	-
Z_{10}	Labour type 2 (hired)	Dummy: 1=use hired, 0=do not use hired	+
Z_{11}	Farm size	Per hectare	-
Z_{12}	Age of tree	Years	-/+
Z_{13}	Marital status	Dummy: single=0, married=1, divorced=2, widow/widower=3	-

3.5 Assumptions

Several assumptions underlie this study. Perhaps the most obvious one stems from the fact that data are obtained from farmers in cocoa production during 2012/2013 major and minor cocoa seasons.

The second assumption is that two models namely (cocoa production and technical efficiency) are estimated. Under this, farmers have identical production function in which all the production inputs are all exogenously determined in both models. This means that the inputs are independent on each other. Additionally, the study assumes that all the production inputs and socioeconomic characteristics are included in the specification of the stochastic frontier model.

Finally, according to Aigner, et al (1977), e_i is an error term assumed to be made up of two components: *vi* 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 $vi \sim iid\ N(0, \sigma_v^2)$. u_i is assumed to be non-negative random variable, truncated half normal, independently and identically distributed as $ui \sim iid\ N(0, \sigma_u^2)$ 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.

3.6 Estimation Method

The single-stage maximum likelihood estimation method is used in estimating the technical efficiency levels of the farmers and the effects of the determinants of efficiency simultaneously. This simultaneous estimation procedure ensures that the assumption of identical distribution of the u_i is not violated. The maximum likelihood estimation of the frontier model yields the estimates of α and the gamma (γ), where the γ measures the total variation of observed output from the frontier (deterministic) output. It is given as the ratio of the variance of the error associated with inefficiency (σ_u^2) to the overall variation in the model (σ^2).

3.7 Econometric and Statistical Tests

Basically the z-test was used to test for the statistical significance of the independent variables of the translog stochastic production function and determinant of technical efficiency at one percent (1%), five percent (5%) and ten percent (10%) level of significance. The mixed chi-square test was also used to test for the statistical significance of the main hypothesis of the study.

3.8 Tools for Data Analysis

A computer programme called Stata 11 software was used in the estimation of cocoa production and technical efficiency functions. It was also used to identify the significant determinants of technical efficiency in the study area.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

4.0 Introduction

This chapter shows the results and the analysis of the study. It begins with descriptive analysis on the demographic characteristics of farmers. Then farm inputs, followed by productivity level of farmers. Finally, analyses on empirical results, consisting of the test of hypothesis, stochastic production estimates and technical efficiency score of farmers and the determinants of technical inefficiency models were done.

4.1 Descriptive Result

Table 4.1 is a summary of the characteristics of cocoa farmers collected during the field survey through the structured questionnaire administered in the study area.

Table 4.1: Demographic Characteristics of farmers

Characteristics of Farmers	Frequency	Percent (%)
Gender		
Female	95	43
Male	125	57
Age of farmer		
18-30	31	14
31-43	68	31
44-56	80	36
57 above	41	19
Marital Status		
Single	32	15
Married	116	53
Divorced	24	11
Widow/Widower	48	22

Table 4:1 Continued

Characteristics of Farmers	Frequency	Percent (%)
Education		
Primary	28	13
JHS	71	32
SHS	27	12
Tertiary	5	2
Non Formal	89	40
Association		
Yes	85	39
No	135	61
Seed Type		
Hybrid	57	26
Local	33	15
Both	130	59
Experience		
0-4	9	4
5-9	50	23
10-14	41	19
15-19	66	30
20above	54	25
Labour Type		
Family	10	5
Hired	47	21
Both	163	74
Labour Cost (Gh₵)		
No payment	8	4
Paid below 100	152	69
Above 100-999	51	23
1000 and above	9	4
Extension Contact		
Yes	110	50
No	110	50
Credit		
Access	28	13
No Access	192	87

Table 4.1 shows the demographic characteristics of the 220 farmers who were interviewed. Of these 57% were male and 43% were female. Most of the farmers (36%) were in the age bracket (44-56 years), followed by those in (31-43 years) 31%, then (57 years and above) recorded 19% and those in (18-30 year group) were 14%. The study revealed that most farmers in the area of study were married, thus, (53%), followed by Widow/Widower (22%), then singles (15%) and finally divorced (11%). Among these farmers, (40%) had no formal education, followed by (32%) of JHS (Junior High Secondary) attendants. Those with SHS (Senior Secondary School) and tertiary education constituted (12%) and (2%) respectively. The Table 4.1 also showed that more than half (61%) of the farmers interviewed had not joined any association, whereas (39%) were part of an association. More farmers (59%) used both hybrid and local cocoa seed on their farms, while the lesser population of farmers under the study area used either hybrid or local cocoa seed, (26%) and (15%) respectively. The years of experience of farmers ranging from (15-19 years) recorded as high as 30%, followed by (20 years and above) 25%, then from (5-9 years) 23% and finally (10-14 years) 19%. Majority of the farmers used both family and hired labour on their farms (74%), with 21% on only hired and 5% on only family labour. With the cost of labour among farmers, majority paid their labour below GhC100.00, while 23% paid from GhC100.00 to GhC999.00. Farmers who did not pay their workers recorded 4% while those who paid high (above GhC1,000.00) equally recorded 4% of the total farmers interviewed. Farmers with extension contacts and those without extension contacts had 50% each. Finally, farmers with no access to credit facilities dominated with (87%) while those with access recorded only (13%).

4.2 Farm Inputs

Table 4.2 presents results on productivity of cocoa farms and the levels of farm inputs employed in the cocoa production. The results in Table 4.2 indicates a mean of 1264.87kg of cocoa bean was harvested from 3.95ha of cocoa farm, using on the average, 14.082 mandays of labour inputs, 226.25kg of fertilizer, and 2.463 litres of pesticides. Moreover, the mean cocoa yield obtained was 320.22kg/ha with minimum of 32kg/ha and maximum of 6080kg/ha (Table 4.2). The labour productivity was 89.83kg/manday, 89.83kg of cocoa was produced for every manday of labour. The minimum labour productivity was 1.6kg/manday while the maximum was 67.56kg/manday (Table 4.2).

Table 4.2: Farm inputs and productivities of cocoa

Variable	Description	Mean	Minimum	Maximum	Standard deviation
Cocoa output	Kilogram	1264.87	32	6080	1002.33
Cocoa yield	Kilogram per hectare	320.22	32	337.778	379.67
Labour productivity	Kilogram per manday	89.82	1.60	67.56	81.29
Farm size	Hectare	3.95	1	18	2.64
Labour	Manday	14.082	20	90	12.33
Fertiliser	Kilogram	226.25	0	3250	249.49
Pesticides	Litre	2.46	1	9	1.27

4.3 Land Productivity Levels of Farmers

Table 4.3 shows the level of productivity, thus, output per hectare (output/ha) of the sampled farmers. This was done by dividing each farmer's total output by per hectare. The computed productivity levels are further ranged into six groups. Range of (1-399) kg/ha, (400-799) kg/ha, (800-1199) kg/ha, (1200-1599) kg/ha, (1600-1999) kg/ha and (2000-2399) kg/ha

(Table 4.3). Of the farmers interviewed 66% ranged between (1-399) kg/ha, while 25% ranged from (400-799) kg/ha. 6% and 1% ranged from (800-1199) kg/ha and (1200-1599) kg/ha respectively (Table 4.3). The remaining (1600-1999) kg/ha and (2000-2399) kg/ha insignificant with 0%. Of the data collected 66% farmers fell below 400kg/ha with the remaining 34% above 400kg/ha.

The average yield per hectare (mean) of the study area was 320.22 kg/ha which was below the current average yield per hectare in cocoa production in Ghana (400kg/ha), although we have the potential to produce more as a country (1000kg/ha) (Table 4.3). The variation in output indicated some level of inefficiency on the average farm under study. This inefficiency could be attributed to a lot of causes, some of which were poor farm maintenance practices, planting low-yielding varieties, and the incidence of pests and diseases (Abekoe *et al*., 2002). Results from the table showed that majority (66%) of the sampled farmers produced below the average yield per hectare (400kg/ha), on the average Ghanaian farm. The remaining minority (34%) produced more than the average yield per hectare (400kg/ha) of cocoa production.

Table 4.3 Land Productivity level of cocoa farms

Output/ha Range	Frequency	Percentage
1-399	145	0.659
400-799	56	0.255
800-1199	14	0.064
1200-1599	3	0.0136
1600-1999	1	0.0045
2000-2399	1	0.0045
Minimum	32	
Maximum	337.77	
Mean	320.22	

4.4 Empirical Result

This section of data analysis and results deals with test of hypothesis, translog stochastic production estimates, technical efficiency scores of cocoa farmers and determinants of technical efficiency in cocoa production.

4.4.1 Test of Hypotheses

A likelihood ratio test was performed to select appropriate functional form for cocoa production. The hypotheses are stated as follows:

H_0: Cobb-Douglas function

H_1: Translog function

2[(log likelihood of Cobb-Douglas) – (log likelihood of translog)]

2(-166.645+154.137) = -25.016.

Since -25.016 is highly significant at 1% we reject the null hypothesis implying that the translog production function is appropriate for cocoa production in the study area.

Result of Likelihood Ratio test of main Hypothesis of the study

The result indicate that the chi-square value (19.33) is significant at 1% and therefore the null hypothesis that all cocoa farmers in the Upper Denkyira East Municipality are technically efficient, thus, ($u=0$), is rejected in favour of the alternative hypothesis that not all cocoa farmers of the Upper Denkyira East Municipality are technically efficient,($u \neq 0$). This, however, suggests that there is the presence of inefficiency in cocoa production in the study area. The likelihood ratio test of main hypothesis of the study is presented in Table 4.4.1

Table 4.4.1 Test of main hypothesis

Hypothesis	Chi-square	Probability value	Decision
$H_0 : u = 0$	19.33	0.00***	H_0 rejected
$H_1 : u \neq 0$			

***, ** and * represents 1%, 5% and 10% significance levels respectively.

4.4.2 Translog Stochastic Production Estimates

From Table 4.5 below the gamma was estimated to be 0.89. This implies that 89% of the deviations in total output are largely attributed to technical inefficiency in input use and other farm practices, whereas random effects (statistical noises) contribute 11% to deviations of actual output from the frontier output. Some of the random shocks could be unfavorable weather conditions, pest and disease infestation and statistical errors in data measurement and model specification. The wald chi-square (102.95) is significant at 1%, indicating that the explanatory variables (labour, fertilizer application and farm size) jointly influence cocoa output.

Results from the Table 4.4.2 show that labour, fertilizer, farm size and labour by fertilizer were significant with the exception of labour square, fertilizer square, farm size square, labour by farm size, fertilizer by farm size.

However, although labour is significant, it has a negative sign, meaning that as labour is increased, cocoa output falls. This can be attributed to the fact that most farmers interviewed are involved in other jobs other than farming. Some farmers have farming as their minor occupation and so spend not enough time working on the farm. Again, due to the illegal mining (galamsey) activities in the study area, labour supply which is mostly predominated by youth, has been engaging in such activities. These operations have also triggered off other economic activities, including food sales at the sites, fuel sales and trading in mining implements. This was also confirmed by Donkoh *et al*. (2012).

Fertilizer application also records a negative influence on output, implying, as fertilizer applied is increased cocoa output falls. From the Table 4.4.2, although most farmers used fertilizer on their farms, not all farmers had adequate knowledge on the application of fertilizer and although the extension officers in the area are actively working, there are not enough to assist all the farmers in the municipality. There are only four extension agents in the study area. Also, there were some farmers who did not use fertilizer on their farms because of its disadvantages. Some fertilizers can damage plant leaves when there is direct contact between the fertilizer and the leave. Also, if a farmer is not ready to use them, he or she is not to buy them and store them over a long period of time. Again, the overuse of chemical fertilizers can harm useful microorganisms in the soil.

The interaction parameter that is significant with a positive sign is labour by fertilizer for the translog specification. This means that labour is complimentary to fertilizer application. Implying that as labour increases, fertilizer application also increases. This implies that in order to increase cocoa output, labour and fertilizer quantities should be increased proportionally. This is in line with the literature that fertilizer application on the farm demands a lot of labour since the activity could be demanding depending on the size of farm land.

Table 4.4.2 Maximum likelihood Estimates of Parameters of stochastic Production

Variable	Coefficient	Standard error	z-value	Probability
Constant	7.017	0.375	18.71	0.000***
Ln(Labour)	-0.828	0.336	-2.46	0.014**
Ln (Fertilizer)	-0.124	0.629	-1.96	0.049**
Ln (Farm Size)	0.205	0.099	2.05	0.040**
Ln (Labour square)	0.515	0.053	0.98	0.328
Ln (Fertilizer square)	0.029	0.024	1.22	0.221
Ln (Farm Size square)	0.161	0.122	1.32	0.188
Ln(Labour*Fertilizer)	0.248	0.106	2.35	0.019**
Ln (Labour*Farm size)	0.349	0.188	1.86	0.063
Ln (Fertilizer*Farm size)	0.143	0.096	1.49	0.135
Diagnostic statistic				
Sigma (U=o)	19.33 (0.000)***			
Sigma square	1.140***	0.158	7.215	0.000
Gamma	0.891***			
Wald chi-square	102.95 (0.000)***			

***, ** and * represents 1%, 5% and 10% significance levels respectively.

NB: The dependent variable is output of cocoa yield.

4.4.3 Technical Efficiency Score of Cocoa Farmers

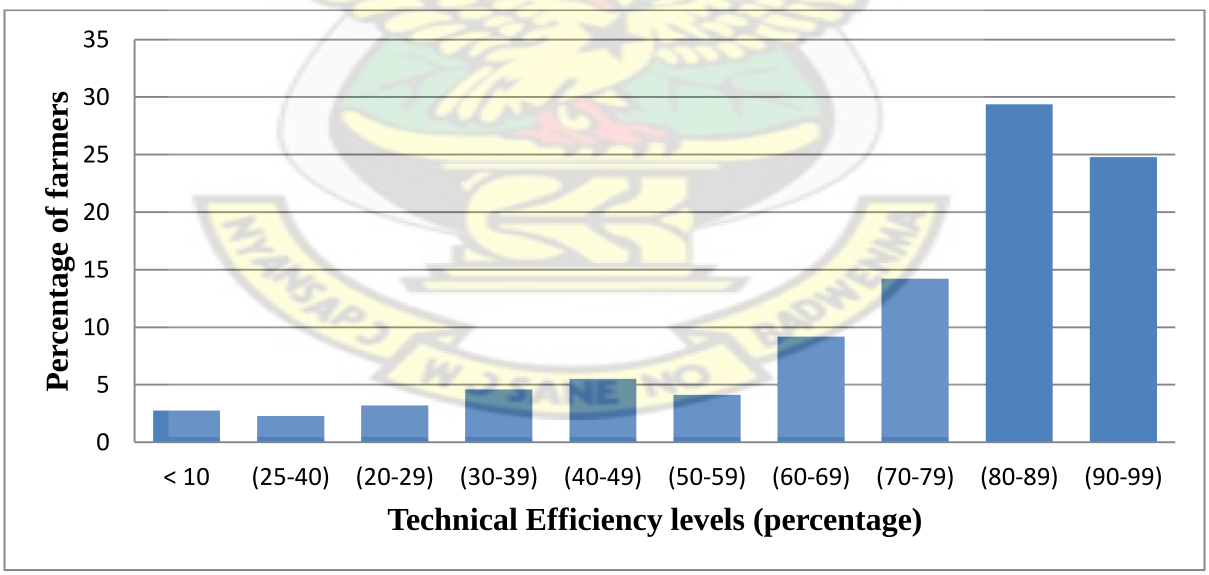
Table 4.4.3 shows the efficiency levels of the sampled farmers. The efficiency levels of farmers were estimated using Stata 11. The estimated levels are further grouped into ten percentage ranges, namely, (below 10), (10%-19%), (20%-29%), (30%-39%), (40%-49%), (50%-59%), (60%-69%), (70%-79%), (80%-89%) and (90%-99%). Of the 220 farmers interviewed, majority (29%) of the farmers operated with technical efficiency levels of (80%-89%) while 25% and 14% operated with technical efficiency levels of (90%-99%) and (70%-79%) respectively. Farmers with technical efficiency levels of (60%-69%) recorded a total of 9%, while 6% and 5% of farmers operated with technical efficiency levels of (40%-49%) and (30%-39%) respectively. (50%-59%) recorded 4%, with (20%-29%) recording 3%. Finally, (10%-19%) and (below 10%) recorded 2% and 3% respectively. Of all individual farmers, 77.52% fell within the technical efficiency levels above 60% in the study area.

The analysis further illustrated that the mean technical efficiency of the cocoa farmers in the study area was 72% as compared to 49% obtained in a study by Danso-Abeam et al. (2012) in the Western part of Ghana and 85% by Onumah et al. (2013) in the Eastern part of Ghana. This implies that on the average, cocoa farmers in the Upper Denkyira municipality are 28% below the best practice frontier output given the existing technology and available input in the municipality. This further implies that if the farmer has to achieve a 100% technical efficiency level, then he would have to bridge the gap between their current performance level and the maximum potential performance of the cocoa industry, by addressing some inefficiency factors some of which were discussed above.

Table 4.4.3 Efficiency Levels of farmers

Efficiency Level	Frequency	Percent (%)
< 10	6	2.75
10-19	5	2.29
20-29	7	3.21
30-39	10	4.59
40-49	12	5.50
50-59	9	4.13
60-69	20	9.17
70-79	31	14.22
80-89	64	29.36
90-99	54	24.77
Mean	72.22	
Maximum	98.08	
Minimum	5.24	
Standard deviation	23.94	

Figure 1: Technical Efficiency Levels



4.4.4 Determinants of technical efficiency in cocoa production

Table 4.4.4 shows the maximum likelihood estimates of the inefficiency model. Farmer association, experience, fertilizer use and extension contacts are significant determinants of technical efficiency in cocoa production. Factors such as education, farmer experience, fertilizer use, age of tree, farm size, credit accessibility, association, extension contact and marital status had a negative effect on technical inefficiency suggesting that those factor increase technical efficiency.

Association is a major determinant of technical efficient with negative influence on technical inefficiency and was significant at 5% level, implying that farmers who belong to a farmer association are more likely to reduce technical inefficiency in cocoa production in the study area. This can be explained by the fact that farmers who were members of an association benefitted from their groups. Such benefits are easy access to relevant information on farm management and introduction of new technologies to boost productivity. Again, farmer's association can obtain technical and financial assistance to support farmers.

Experience, another major determinant of technical efficiency, has a negative influence on technical inefficiency. This implies that experience reduces technical inefficiency, in other words, increase technical efficiency among cocoa farmers in the study area. Thus, more experienced cocoa farmers are more technically efficient in their production than possibly new farmers who are progressive and willing to implement new production systems. This can be attributed to the fact that majority of the farmers interviewed were in the experience age range of (15-19 years), followed by (20 years and above). This implies that cocoa farmers in the study area have been in farming for a long time and have a rich experience of cocoa growing activities. Also, experience equips the farmers with sound agronomic competencies and skills that enhance implementation of good practices to minimize losses. Beniam *et al*. (2004) and Onumah *et al*. (2009; 2013) confirmed this finding in their studies.

The other determinant is fertilizer use, which shows significant negative impact on technical inefficiency. This implies farmers who applied fertilizer are more likely to reduce technical inefficiency than their counterparts. Of the farmers interviewed 79% applied fertilizer at least once a year on their farms which improved their yields compared with the previous season.

Extension contact has a significant negative influence on technical inefficiency. This indicates extension contact reduces technical inefficiency, thus, increases technical efficiency, suggesting that cocoa farmers who have contacts with extension officers are technically less inefficient than farmers with no contacts with extension officers. This result is consistent with the study carried out by Nyagaka et al. (2010) and Binam et al. (2008). This implies that effective extension visits and supervision goes a long way to improve farmers' production efficiency in the study area.

Gender, in this study is not significant but is also a determinant of technical efficiency. This is confirmed in Alhassan's study (2008), where the gender variable was also not significant. Studies by Binam et al. (2008), Onumah and Acquah (2010), and Kibarra (2005) confirm the significance of gender as a determinant of technical efficiency.

Table 4.4.4 Determinants of technical efficiency in cocoa production

Variable	Coefficient	Standard error	z-value	Probability
Constant	1.757	1.487	1.18	0.237
Gender	0.489	0.408	1.20	0.230
Education	-0.059	0.030	-1.94	0.052
Association	-1.546	0.540	-2.86	0.048**
Experience	-0.707	0.307	-2.30	0.022**
Fertilizer Use	-1.896	0.681	-2.78	0.005***
Extension Contact	-0.991	0.501	-1.98	0.048**
Credit	-1.040	1.139	-0.91	0.361
Labour type 1 (family)	1.415	0.846	1.67	0.095
Labour type 2 (hired)	0.884	0.547	1.61	0.107
Age of Tree	-0.067	0.051	-1.30	0.194
Marital Status	-0.453	0.386	-1.18	0.708

***, ** and * represents 1%, 5% and 10% significance levels respectively

NB: The dependent variable is technical efficiency of cocoa farmers.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

5.0 Introduction

This chapter draws conclusion while summarizing the empirical findings based on the objectives of the study. The chapter also contains policy implications of the cocoa industry in relation to the efficiency levels of cocoa farmers in Ghanaian. The final section identifies the limitations of the study.

5.1 Summary of Empirical Findings

First, the study showed that men with 53% dominated cocoa production in the study area. However, with the 47% of women involved in the male dominated tree crop production points to a good sign that daring women had ventured into owning cocoa farms to improve their fortunes.

Secondly, majority of farmers (36%) in the study were within the age bracket of (44-56) years.

The study also revealed that most farmers (53%) in the area of study were married. Then also 40% of the sampled farmers had no formal education.

Also, 59% of the sampled farmers used both hybrid and local seed type on their farms.

Farmers within the experience age bracket of (15-19) years were the majority in the area.

It was again found that 74% of the sampled farmers used both hired and family labour on their farms, with majority paying labour below GhC100.00.

Also, farmers with extension contact equaled those with no extension contact. Farmers with no credit access were the majority (87%) in the study area.

Moreover, gamma was estimated to be 0.89, whereas random factors contributed 11% to deviations of actual output from the frontier output. This implied that the deviation in total output were largely as a result of technical inefficiency.

The study also revealed that output responded positively with farm size, labour by farm size, fertilizer square, farm size square, labour by fertilizer, fertilizer by farm and negatively with labour and fertilizer application. Results from the model showed that labour, fertilizer application, farm size and labour by fertilizer had significant effect on cocoa output.

Again in the study, it was found that association, experience, fertilizer use and extension contact were the main significant determinants of technical efficiency in the municipality.

Another finding was that the average yield per hectare (mean) of the study area was 320.22 kg/ha which was below the current average yield per hectare in cocoa production in Ghana (400kg/ha). Thus majority of the farmers (66%) had their land productivity level below 400kg/ha.

Also, the study revealed that the mean technical efficiency of cocoa farmers in the study area was 72%. Implying that on the average, cocoa farmers in the Upper Denkyira municipality are 28% below the best practice frontier output given the existing technology and available input in the municipality.

5.2 Conclusion

Cocoa, also known as Theobroma cacao is the most interested of all the perennial crops in some parts of West Africa, and the global chocolate industry. It holds a unique position in Ghana's economy, thus, it is a major contributor to Ghana's gross domestic product (GDP) and the country's most important agricultural export crop. It is the second important foreign exchange earner after gold. It is a major source of income to over 800,000 farmers and many others engaged in trade, transportation and processing of it.

In this respect, recognizing the important role of this industry, this study was conducted to investigate the technical efficiency levels alongside their determinants.

The stochastic frontier Analysis (SFA) model was used to measure the efficiency level of farmers while SFA software was also used to analyse data. With regard to the determinants of technical inefficiency, Stata 11 regression model was used to evaluate the correlation between the explanatory variables and the dependent variable (efficiency score).

It was revealed that the average yield per hectare (mean) of farmers in the study area was 320.22 kg/ha which was below the current average yield per hectare in cocoa production in Ghana (400kg/ha).

Also, the study revealed that the mean technical efficiency of cocoa farmers in the study area was 72%, implying that on the average, cocoa farmers in the Upper Denkyira municipality are 28% below the best practice frontier output given the existing technology and available input in the municipality.

Again, the study uncovered five major determinants of technical efficiency of farmers in the study area and these are association, experience, fertilizer use and extension contact.

Finally, the study recommended for policy makers as well as stakeholders to adopt measures to increase productivity and technical efficiency by focusing on proper management skills on their farms to reduce loss of resources.

5.3 Recommendations

From the empirical findings deduced from this study, there are some managerial implications that could help further strengthen and improve the performance of the Cocoa industry. With this respect, the following are some recommendations:

Farmers must work very hard to increase farm wages so as to adequately encourage labour already in the industry to stay. This will in turn motivate other prospective workers to participate in farm operations. Once more, cocoa farmers in the Upper Denkyira East municipality should come together to fight the illegal mining activities in the area by appealing to the municipal security committee to put measures in place to curb their operations since they are a threat to both citizens (labour force) and cocoa production.

Farmers must appeal to the government for innovative ways make fertilizer available, affordable and accessible at the right time. They are to involve themselves in training programs organized by Cocobod or other private agencies on the use of fertilizer as recommended by the CSSVD (Cocoa Swallen Shoot Virus Disease) control department. Cocoa farmers are advised to use certified fertilizers from Ghana COCOBOD on their farms as recommended by Research Scientist at the Crop Research Institute of Ghana (CRIG).

Farmers should further appeal to government for the availability of cocoa agrochemicals, pesticide to be specific, at the right time and at subsidized prices to improve productivity and technical efficiency. They should also participate in training activities to educate themselves on the best farm practice guidelines with respect to pesticide application and its harmful impact on the environment. On the other hand, alternative (non-chemical) measures, such as cultural practices and resistant varieties, should be encouraged in controlling pests and diseases on the cocoa farm. The mass spraying programme should be adequately supported to enable effective operation in the study area.

Again, cocoa farmers are encouraged to form help groups (associations) so they can provide technical, financial and other assistance among themselves.

Most farmers are discouraged to access credit facilities because of the collateral and high interest rates demanded by financial institutions. However, with improvement in their credit facilities by make their credit terms more flexible, more farmers would seek their assistance.

Cocoa extension services should be adequately facilitated by government through the extension Unit of Cocoa Service Division, so as to educate farmers on the best farm practices to improve their production and reduce technical inefficiency. Also, government, through ministry of agriculture, should make provision to employ more officers so as to make their services more accessible to farmers.

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 Stochastic Frontier Analysis.

5.4 Limitations of the Study

A couple of limitations were identified with this study. The first limitation has to do with respondents. Most of them the researcher came across were not able to write. The researcher had to interpret the questionnaire in the local language, and write the response given by the respondents.

In addition the respondents prolonged a simple answer to a question just to impress. These consumed a lot of time allocated for the survey.

Lastly, resource constraint was a major problem in terms of travelling and food expenses to administer questionnaires in the study areas which were very far from the researcher's place of residents. Coupled with that, the survey areas were in different communities of distant places. This to a large extent affected the sample size and the scheduled time intended for the research.

REFERENCES

ABEKOE, M. K., OBENG-OFORI, D. and EGYIR, I. S. (2002) *Technography of Cocoa in the Forest Zone of Ghana.* Unpublished Technical Report, Convergence of Sciences Project. University of Ghana, Legon.

ADEDEJI, I. A., AJETOMOBI, J. O. and OLAPADE – OGUNWOLE, F (2011) *Technical efficiency of cocoa production in Oyo State, Nigeria*. Continental Journal of Agricultural Economics 5(1): 30 – 40

ADESINA, A. A. and DJATO, K. K. (1997) *Relative efficiency of women as farm managers: Profit function analysis in Cote d'Ivoire*. Agricultural Economics 16, 47 – 53.

ADJINA, K. O. and OPOKU, I. Y. (2010)*The National Cocoa Diseases and Pest Control (CODAPEC): Achievements and Challenges.*

AHENKORAH, Y. et al. (1987) *Twenty years' results from a shade and fertilizer trial on Amazon cocoa (Theoborma cacao) in Ghana*. Experimental Agriculture 23:31-39.

AIGNER, D. J., CHU, S. F. (1968) *Estimating the Industry Production Function*. American Economic

AIGNER, D., LOVELL, C. A. K. and SCHMIDT, P. (1977) *Formulation and Estimation of Stochastic Frontier Production Function Models*. Journal of Econometrics.

AJIBEFUN, I. A. and ABDULKADRI, A. O. (1999) *An Investigation of Technical Inefficiency of production of farmers under the National Directorate of Employment in Ondo State, Nigeria*.

ALI, M. & CHAUDRY, M. A. (1990) *Inter-regional Farm Efficiency in Pakistan's Punjab: A Frontier Production Function Study*.

AMOS, T. T (2007) *An Analysis of Productivity and Technical Efficiency of Smallholder Cocoa Farmers in Nigeria*, J. Soc. Sci. 15(2):127-133.

ANEANI, F. et al. (2011) *Analysis of Economic Efficiency in Cocoa Production in Ghana*. African Journal of Food Agriculture Nutrition and Development Vol 11 No 1 February 2011

ANIM-KWAPONG, G. J. and FRIMPONG, E. B. (2005) *Vulnerability of Agriculture to Climate – change impact of climate on Cocoa production*, Cocoa Research Institute: New Tafo Akim, Ghana.

ARMAH, S. E. (2008) *Explaining Ghana's Good Cocoa Karma: A Smuggling-Incentive-Reversal Argument.*

ASAMOAH, M. and BAAH, F. (2003) *Improving Research-Farmer linkages: The role of Cocoa Research Institute of Ghana (CRIG)*. A paper submitted at the 4th international seminar on cocoa Pests and Diseases (NECOPED) Accra, Ghana.

ASHOK, P., ALI, F. & SHAH, M. M. K. (1995) *Measurement of Economics Efficiency in Pakistani Agriculture*. American Journal of Agriculture.

ASUMING-BREMPONG, S. et al. (2007) *Labour practices in cocoa production in Ghana (NPECLC)*, ministry of manpower, youth & employment.

AUDIBERT, M. (1997) *Technical Inefficiency Effects among Paddy Farmers in the Villages of the 'Office Du Niger'*, Mali, West Africa. J. Prod. Anal. 8(4):379-394

AYENOR, G. K. et al. (2007) *Assessing the effectiveness of a local agricultural research committee in diffusing sustainable cocoa production practices: the case of capsid control in Ghana*. IJAS International Journal of Agricultural Sustainability 5 (2–3), 109–123.

BANCO ESPIRITO SANTO, GHANA (November, 2012), International Support Kit of Opportunities.

BATEN, A. MD., et al. (2009) *Modeling Technical Inefficiencies Effects in a Stochastic Frontier Production Function for Panel Data*. African Journal of Agricultural Research, vol 4 (12), pp 1374-1382.

BATTESE, G. E. and COELLI, T. J. (1993) *A Stochastic Frontier Production Function Incorporating a Model for Technical Inefficiency Effects*, Working Papers in Econometrics and Applied Statistics, No.69, Department of Econometrics, University of New England, Armidale.

BATTESE, G. E. (1992) *Frontier Production Functions and Technical Efficiency: A survey of Empirical Applications in Agricultural Economies*.

BENIAM N. J., et al. (2004) *Factors affecting the technical efficiency among smallholder farmers in the slash and burn agriculture zone of Cameroon*.

BENNEH, G. (1987) *Land tenure and agroforestry land use in Ghana*. In, Land, trees and tenure –. In: Raintree J.B. (ed.), Proceed. Of an international workshop on tenure issues in agroforestry, Nairobi, 27–31 May 1985, pp. 163–168.

BINAM, J. N., GOCKOWSKI, J. and NKAMLEU, G. B. (2008) *Technical Efficiency and Productivity Potential of Cocoa Farmers in West African Countries*, Dev. Econ. 46(3):242-263.

BLANKSON, D. P. (2011) *Concentration Of Pesticide Residues In Fermented Dried Cocoa Beans In Asukese And Its Environs In The Tano North District Of Brong Ahafo Region, Ghana*.

BLOCH, H. (1974) *Prices, Costs, and Profits in Canadian Manufacturing: the Influence of Tariffs and Concentration*. *Canadian Journal of Economics* 7(4): 594-610.

BOANSI, D. (2013) *Export performance and macro-linkages: A look at the competitiveness and determinants of cocoa exports, production and prices for Ghana*, MPRA Paper 48345, University Library of Munich, Germany.

BO G, (2007) *Balance of payments, Annual Report, Bank of Ghana (Bo G)*, Accra, Ghana.

BOGETIC, Y. et al. (2007) *Ghana's growth story: How to accelerate growth and achieve MDGs*.

BRAVO-URETA, B. E. and PINHEIRO, A. E. (1993) *Effieciency Analysis of Developing Country Agriculture: A Review of the Frontier Function Literature*, Agricultural and Resource Economic.

BREISINGER C. et al. (2008) *The Role of Cocoa in Ghana's Future Development; Ghana Strategy Support Program (GSSP),* Background Paper No. GSSP 11, International Food Policy Research Institute (IFPRI), Washington, D.C. USA

BRYCE, E. (2012, December 11). Reshaping *the Future of Cocoa in Africa*. [Online] The New York Times Blog. Retrieved fromhttp://green.blogs.nytimes.com/2012/12/11/reshaping-the-future-of-cocoa-in-africa/?

CAVES, R. and BARTON, D. (1990) *Efficiency in US: Manufacturing Industries*. MIT Press.

COCOBOD (2007) *Cocoa Production and Price statistics,* Ghana COCOBOD, Accra, Ghana.

COCOBOD (2009) *Overview of Ghana Cocoa Industry*. Unpublished document, Ghana Cocoa Board.

COCOA RESEARCH INSTITUTE OF GHANA, GHANA COCOA BOARD. COCOA SERVICES DIVISION. (1987) *A guide to cocoa cultivation.*

COCOBOD (2002) *Socio-Economic Study*. Final Report, Cocoa Board, Ghana.

COELLI, T. (1996) A *Guide to DEAP Version 2.1: A Data Envelopment Analysis*, (Computer Program), CEPA Working Paper 96/08, Department of Econometrics,University of New England, Armidale.

COELLI T. J. (1995) *Estimators and Hypothesis Tests for a Stochastic Frontier Function: A Monte Carlo Analysis*. Journal of Productivity Analysis.

COELLI T. J, PRASADA R, & BATTESE G. E. (1998) *An Introduction to Efficiency and Productivity Analysis*. Kluwer Academic Publishers. Boston.

COELLI, T. and S. PERELMAN, (1996) *A Comparison of Parametric and Non- Parametric Distance Functions: with Application to European Railways*.

COELLI, T. J. and S. PERELMAN (1999) *A Comparison of Parametric and Non-Parametric Distance Functions: With Application to European Railways*.

COULOMBE, H. & WODON, Q. (2007) *Poverty, livelihoods, and access to basic services in Ghana.*

CHARNES, A. et al. (1978) *Measuring the Efficiency ofDecision Making Units*, European Journal of Operational Research, 2 (1978), pp. 429–444

DANSO-ABBEAM, G. et al. (2012) *Technical Efficiency in Ghana's Cocoa Industry: Evidence from Bibiani -Anhwiaso-Bekwai District*. Journal of Development andAgricultural Economics, Vol. 4(10), pp. 287-294

DEY, M. M. et al. (2000) *Technical efficiency of tilapia grows out pond operations in the Philippines.* Aquac. Econ.Manag. 4(1-2):33-47.

DONKOH S. A., TACHEGA, M. and AMOWINE, N. (2012) *Estimating technical efficiency of tomato production in Northern Ghana*. Am. J. Exp. Agric. 3(1):56-75.

DORMON, E. N. A., van Huis, A., Leeuwis, C. (2007) *Effectiveness and profitability of integrated pest management for improving yield on smallholder cocoa farms in Ghana*. Int. J. Trop. 433 Insect Sci., 27(1), 27-39.

DWINGER, F. (2010) *Infrastructure for Cocoa: The story of Ghana"s Trade Relationship with China*. [Online] Available from: http://www.consultancyafrica.com/index.php? Retrieved on November 4, 2010.

DZENE, R. (2010) *What Drives Efficiency on the Ghanaian Cocoa Farm?* Working paper, Ghana Institute of Management and Public Administration, Accra, Ghana.

EFFENDY E., et al. (2013)*Characteristics of Farmers and Technical Efficiency in Cocoa Farming at Sigi Regency - Indonesia with Approach Stochastic Frontier Production Function.* Journal of Economics and Sustainable Development:www.iiste.org. ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)Vol.4, No.14, 2013

ESDD, (2002) *Special Report FAO/WFP Crop and Food Supply Assessment Mission to Northern Ghana.*

EZEH C. I. (2004) *A Comparative Study of Fadama and Non-Fadama Crop Farmers in Osisioma-Ngwa L.G.A,* Abia State. Nigeria.

FAO. (2007), [Online] database. Available from: http://faostat.fao.org

FÄRE, R. et al. (1993) *Derivation of Shadow Prices for Undesirable Outputs: A Distance Function Approach.*

FARRELL M. J. (1957) *The Measurement of Productive Efficiency.*

Forsund, F. and E. Jansen (1977) *On Estimating Average and Best Practice Homothetic Production Functions via Cost Functions*, International Economic Review, 18, pp. 463-476.

FORSUND, F. R., C.A.K. LOVELL and P. SCHMIDT (1980) *A Survey of Frontier Production Functions and of theirRelationship to Efficiency Measurement, Journal of Econometrics* 13, pp5-25.

FRIED, H.O., C.A.K. LOVELL, and S.S SCHMIDT, (eds.) (1993) *The Measurement of Productive Efficiency: Techniques and Applications*. New York: Oxford University Press.

GHANAWEB (News of Friday, 13 December, 2013), *Cocoa productivity far below competitors.*

GOCKOWSKI J. et al. (2010) *An empirical analysis of the biodiversity and economic returns to cocoa agroforests in southern Cameroon*. Journal of Sustainable Forestry 29.

GOCKOWSKI, J. and D.SONWA (2011) *Cocoa Intensification Scenarios and Their Predicted Impact on CO2 Emissions, Biodiversity Conservation, and Rural Livelihoods in the Guinea Rain Forest of West Africa.*

GLOBAL AGRICULTURAL INFORMATION NETWORK (GAIN) (2012), *Cocoa Annual Report.*

GNA, (2005). *Ghana Achieves Highest Cocoa Revenue.* [Online] Available from: http://www.modernghana.com/news/71649/1/ghana-achieves-highest-cocoa-revenue.html

GREENE W. H. (2004) *Fixed and Random Effects in Stochastic Frontier Models.*

GRECO, E. (2014) Types of Efficiency in Economics, eHow Contributor, last updated August 12, 2014. [Online] Available from: http://www.ehow.com/info_7896497_types-efficiency-economics.html**.**

GROSSKPOF, S., HAYES L. TAYLOR and W. WEBER, (1996) *Budget Constrained.*

GUMBAU-ALBERT, M. and J. MAUDOS (2002) *The determinants of efficiency: The case of Spanish industry*, *Journal of Applied Economics*, 34, 1941-1948.

HAZARIKA, G. and J. ALWANG (2003) *Access to credit, plot size and cost inefficiency among smallholder tobacco cultivators in Malawi*. *Agricultural Economics*, Volume 29, Issue 1, pp. 99-109.Available from: http://dx.doi.org/10.1111/j.1574 0862.2003.tb00150.x

HAZARIKA, C. & SUBRAMANIAN, S. R. (1999) *Estimation of Technical Efficiency in the Stochastic Frontier Production Function Model: An Application to the Tea Industry in ASAM.*

HEADY E. O. and DILLON J. L (1988) *Agricultural Production Functions*. New Delhi, India: Kalyani Publishers.

HOLLINGSWORTH, B. and PARKIN, D. (2003) *Efficiency and Productivity Change in the English National Health Service: Can Data Envelopment Analysis provide a robust and useful measure?*Journal of Health Services Research and Policy; 2003: **8** 230-236.

ICCO (International Cocoa Organization) (2012) *The World Cocoa Economy: Past and Present.*

IINUMA, M., Sharma, K. R. and Leung, P. S. (1999) *Technical efficiency of carp pond culture in peninsula Malaysia: an application of stochastic production frontier and technical inefficiency model.* Aquaculture 175: 199–213

ISSER (2001) *The State of the Ghanaian Economy in 2000, Institute of Statistical, Social and Economic Research (ISSER)*, University of Ghana, Legon, Accra, Ghana.

ISSER (2003) *State of the Ghanaian Economy*. Institute of Statistical, Social and Economic Research (ISSER), University of Ghana, Legon, Accra, Ghana.

JAFORRULLAH, M. and J. WHITEMAN (1999) *Scale efficiency in the New Zealand dairy industry: a nonparametric approach.*The Australian Journal of Agricultural and Resource Economics, 43: 523-541.

KEBEDE, T. A. (2001) *Farm Household Technical Efficiency: A stochastic Frontier Analysis: A study of Rice producers in Mardi-Watershed in the Western Development Region of Nepal*.

KEEN C. L et al. (2005) *Cocoa antioxidants and cardiovascular health.*

KEEN C. L., HOLT, R. R. and FRAGA, C. G. (2003) *Cocoa antioxidants and cardiovascular health*. Am J Clin Nutr; 81: 298-303.

KENNY, T. et al. (2004) *Pentameric Procyanidins Isolated from Theobroma cacao Seeds Selectively Down regulate ErbB2 in Human Aortic Endothelial Cells*.

KIBARRA, W. B. (2005) *Technical Efficiency in Kenyan's Maize Production: An Application of the Stochastic Frontier Approach*. Colorado State University, Fort Collins, Colorado.

KISHORE, A. (2010) *Cocoa Production in Ghana*.

KUMBHAKAR, S. C., & LOVELL, C. A. K. (2000) *Stochastic Frontier Analysis*. New York, NY: Cambridge University Press.

KYEI, L., FOLI, G., ANKOH, J. (2011) *Analysis of factors affecting the technical efficiency of cocoa farmers in the Offinso District -Ashanti Region, Ghana*. Am. J. Soc. Mgmt. Sci. 2(2):208-216.

LEIBENSTEIN, H. (1966) *Allocative Efficiency Vs. X-Efficiency, American Economic.*

LEIBENSTEIN, H. (1975) *Aspects of the X-efficiency Theory of the Firm*.

LOVELL, C. A. K. et al. (1994) *Resources and Functioning*. In: Eichhorn, W. (ed.), A New View of Inequalityin Australia". Models and Measurement of Welfare and Inequality, Springer,-Verlag, Berlin.

Mansfield, E. (1975) *International Technology Transfer: Forms, Resource Requirements, and Policies*. American Economic Review 65:372–76.

MANU, S. Y. (1989) *The Golden Cocoa Pod*. Ghana: Sedco Publishing Limited.

MEEUSEN, W. & van den Broeck, J. (1977) *Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error*.

MINISTRY OF FINANACE, REPUBLIC OF GHANA. (2013)*Budget Statement and Economic Policy*.

MINISTRY OF FOOD AND AGRICULTURE, Animal Production Directorate. (October 2003) *State Of The World's Animal Genetic Resources Ghana Country Report*,

MOF (1999) *Ghana Cocoa Sector Development Strategy*. Accra, Ghana: Ministry of Finance.

MOFA (2006) *Agriculture in Ghana in 2005, Annual Report of the Ministry of Food and Agriculture*, Accra, Ghana.

MoFA (Ministry of Food and Agriculture) (2011) *Agriculture in Ghana: Facts andFigures (2010)*, Statistics Research and Information Directorate. Accra.

MONITORING AFRICAN FOOD AND AGRICULTURAL POLICIES PROJECT (MAFAP), (2013), *Analysis of Incentives and Disincentivesfor Cocoa in Ghana.*

MOSSU, G. (1992) *The Tropical Agriculturist.*

MURSU, J. et al. (2004), *Dark Chocolate Consumption Increases HDL Cholesterol Concentration and Chocolate Fatty Acids May Inhibit Lipid Peroxidation in Healthy Humans.*

NCHARE, A. (2007) *Analysis of Factors Affecting Technical Efficiency of Arabica Coffee Producers in Cameroon*. African Economic Research Consortium (AERC), Research Paper 163.

NGWENYA, S. A., BATTESE, G. E. and FLEMING, E. M. (1997) *The relationship between farm size and the technical inefficiency of production of wheat farmers in Eastern Free State, South Africa*. Agrekon 36,283-301.

NKAMLEU, G. B., Nyemeck, J. and Gockowski, J. (2010) *Technology Gap and Efficiency in Cocoa Production in West and Central Africa: Implications for Cocoa Sector Development*. African Development Bank, Tunis, Tunisia.

NYAGAKA, D. O., et al. (2010) *Technical Efficiency in Resource Use: Evidence from Smallholder Irish Potato Farmers in Nyandaura North District, Kenya*. Africa Journal of Agricultural Research, 5(11),1179-1186.

OGUNDARI, K and B. BRÜMMER (2011) *Technical efficiency of Nigerian Agriculture: A meta-regression analysis*. Outlook on agriculture, Vol. 40 (2):171-180.

OGUNTADE, A. and FATUNMBI, T. (2012) *Effects of Farmers' Field School on the Technical Efficiency of Cocoa Farmers in Nigeria.* Journal of Biology and Life Science ISSN 2157-6076 2013, Vol. 4, No. 1

OGUNDELE, F. O. and OKORUWA V. O. (2004) *A comparative analysis of technical efficiency between traditional and improve rice variety farmers in Nigeria*. African Journal of Economic Policy. 11: 90-94.

OGUNDARI, K. and OJO, S. O. (2006) *An Examination of Technical, Economic and Allocative Efficiency of Small Farms: The Case Study of Cassava Farmers in Osun State of Nigeria.*

OGUNDARI, K. and OJO, S. O. (2007) *Economic Efficiency of Small Scale Food Crop Production in Nigeria: A Stochastic Frontier Approach*. Journal of Social Science, 14(2),123-130.

Ojo, S. O. (2004) *Analysis of productivity and risk factors in commercial poultry production in Osun State, Nigeria.*

OJO, S. O. and AJIBEFUN, I. A. (2000) *Effects of Training on FAMAN J*

OKORUWA, V. O. and O. O. OGUNDELE (2008) *Technical Efficiency Differentials in Rice Production Technologies in Nigeria.*

ONUMAH A. J, AL-HASSAN, R. M. and ONUMAH, E. E. (2013) *Productivity and Technical Efficiency of Cocoa Production in Eastern Ghana.*

ONUMAH, E. E. and ACQUAH, H. D. (2010) *Frontier Analysis of Aquaculture Farms in the Southern Sector of Ghana*. World Applied Sciences Journal, 9(7), 826-835

ONUMAH, E., HOERSTGEN-SCHWARK, G. and BRÜMMER, B. (2009) *Productivity of hired and family labour and determinants of technical inefficiency in Ghana's fish farms*. Discussion paper Nr.09/07, Department für Agrarökonomie und Rurale Entwicklung, Georg-August-Universität Göttingen.

OPOKU, R. A. et al. (2007) *Communicating brand personality: are the web sites doing the talking for food SMEs?* - Qualitative Market Research: An International Journal, 10, 4, 362-374.

OWENS, T., HODDINOTT, J. & KINSEY, B. (2001) *The Impact of Agricultural Extension on Farm Production in Resettlement Areas of Zimbabwe*. Working Paper CSAE WPS/2001-6. Centre for the Study of African Economies, University of Oxford, UK.

PARIKH, A., ALI, F. and SHAH, M. K. (1995) *Measurement of Economic Efficiency in Pakistani Agriculture*, American Journal of Agricultural Economics, Vol. 77, 243-250

PARK, T. A. and LOHR, L. (2010) *Assessing the Technical and Allocative Efficiency of U.S Organic Producers*. Journal of Agricultural and Applied Economics, 42, 247-259

REDDY, Y. V. (2002) *Monetary and financial sector reforms in India: a practitioner's perspective*. [Online] Bank for International Settlements. Available from: http://www.bis.org/review/r020425d.pdf.

RAHMAN, S. and Rahman, M. (2009) *Impact of land fragmentation and resource ownership on productivity and efficiency: The case of rice producers in Bangladesh*. Land Use Policy 26(1):95-103.

RAHMAN, S. A. and YAKUBU, A. (2005) *The status of commercial poultry egg production in Nasarawa State in Nigeria*. Production Agriculture and Technology.

RAUF, A. A. (1991) *Education and Technical Efficiency during the Green Revolution in Pakistan*. Economic Development and Cultural Change, 39: 651–65

REUTERS, (2013) Update 1-Ghana to fall short of 2013/14 cocoa output target – Ecobank. [Online] Available from: http://www.reuters.com/article/2013/12/17/cocoa-ghana-idUSL6N0JW2WL20131217

SEIDU, A. (2008) *Technical Efficiency of Rice Farmers in Northern Ghana*. African Economic Research Consortium, Research Paper. 2008; 178.

SEINI, A. W. (2002) *Agricultural Growth and Competitiveness Under Policy Reforms in Ghana*: ISSER, P. 61.

SCHMIDT, P. (1986) *Frontier Production Functions,* onometric Reviews 4, 289-328.

Seidu, A. (2008) *Technical Efficiency of Rice Farmers in Northern Ghana*. African Economic Research Consortium, Research Paper. 2008; 178.

STOLL, M., LOVEYS, B., and *P. DRY* (2000) *Hormonal changes induced by partial rootzone drying of irrigated grapevine. J. Exp. Bot.* **51,** 1627-1634.

SQUIRES, D. & TABOR, S. (1990) *Technical Efficiency and Future Production Gains In Indonesian Agriculture.*

THOMPSON, P. B. (2005) *Trend analysis of Cocoa production in Ghana and some selected Cocoa growing district along the Ghana side of the Ghana-Cote d'Ivoire boarder*, Master Thesis. Accra: University of Ghana

TIAN, W. and GUANG H. W. (2000) *Technical Efficiency and Its Determinants in China's Grain Production*. J. Prod. Anal. 13**:**159-174

TUDHOPE W. T. D. (1909) *The Development of the Cocoa Industry in the Gold Coast and Ashanti.*

WEIR, S. (1999) *The effects of education on farmer productivity in rural Ethiopia @*, Centre for the Study of African Economies Working Paper, University of Oxford: Oxford.

WORLD BANK (2011) *Supply Chain Risk Assessment: Cocoa in Ghana*. Ghana Cocoa SCRA Report 2011.

ZEITLIN, A. (2005) *Market Structure and Productivity Growth in Ghanaian Cocoa Production,* Center for the Study of African Economies University of Oxford.

ZHU, Q. et al. (2002) *Inhibitory Effects of Cocoa Flavanols and Procyanidin Oligomers on Free Radical-Induced Erythrocyte Hemolysis*.

APPENDIX

Efficiency, Land Productivity and Labour Productivity Levels of Each Cocoa Farmer

Number of Farmer	Technical Efficiency	Land productivity	Labour productivity
1	0.7259185	320	53.33333
2	0.5617968	640	160
3	0.5294567	160	53.33333
4	0.9448888	80	64
5	0.4211735	256	85.33334
6	0.3104955	96	32
7	0.5690452	192	96
8	0.8311698	384	85.33334
9	0.919372	672	168
10	0.9517394	528	234.6667
11	0.8268337	672	224
12	0.9406624	768	256
13	0.8624122	512	85.33334
14	0.690244	512	85.33334
15	0.8655128	512	51.2
16	0.0665935	64	7.111111
17	0.9272155	182.8571	42.66667
18	0.8018357	544	181.3333
19	0.8545399	704	234.6667
20	0.8507028	800	100
21	0.9214042	537.6	672
22	0.9562823	832	277.3333
23	0.2768736	85.33334	64
24	0.074502	32	2.666667
25	0.6197782	128	26.66667
26	0.8795317	298.6667	71.68
27	0.7872406	128	64
28	0.9135671	120.8889	60.44444
29	0.3797623	106.6667	53.33333
30	0.8497571	512	170.6667
31	0.9387189	336	168
32	0.8820141	512	170.6667
33	0.8688387	672	448
34	0.8771853	592	394.6667
35	0.8167354	704	281.6
36	0.8289413	736	163.5556

Number of Farmer	Technical Efficiency	Land productivity	Labour productivity
37	0.959289	608	243.2
38	0.7916052	1216	152
39	0.9510341	448	186.6667
40	0.1589761	96	21.33333
41	0.6954918	153.6	25.6
42	0.9558396	210.2857	16.35556
43	0.7123004	512	170.6667
44	0.9204603	384	85.33334
45	0.906392	448	149.3333
46	0.8971043	243.2	608
47	0.718416	137.1429	30
48	0.9795263	238.5455	262.4
49	0.9601712	365.7143	853.3333
50	0.8857073	576	1152
51	0.9059189	1088	362.6667
52	0.9335343	857.6	285.8667
53	0.9660756	729.6	1216
54	0.9315214	1056	84.48
55	0.8555933	864	144
56	0.7626628	384	192
57	0.2132237	64	21.33333
58	0.4548106	96	32
59	0.0315175	64	10.66667
60	0.4356914	256	42.66667
61	0.7497849	320	53.33333
62	0.7060319	320	53.33333
63	0.8032296	320	53.33333
64	0.7836905	320	53.33333
65	0.7884869	320	53.33333
66	0.7794778	320	53.33333
67	0.6278247	320	53.33333
68	0.7272857	480	80
69	0.8045198	480	80
70	0.659995	448	112
71	0.9308219	640	192
72	0.8087523	1216	152
73	0.9029239	608	152
74	0.9376189	714.6667	268
75	0.811534	544	136
76	0.9187682	938.6667	563.2

Number of Farmer	Technical Efficiency	Land productivity	Labour productivity
77	0.9177451	1120	224
78	0.8555198	1216	304
79	0.5033754	320	26.66667
80	0.6930686	384	128
81	0.1762926	128	12.8
82	0.8623616	512	85.33334
83	0.9165019	512	85.33334
84	0.3960968	256	42.66667
85	0.330972	192	64
86	0.330972	192	64
87	0.8442604	1920	213.3333
88	0.8385712	512	85.33334
89	0.7171408	320	53.33333
90	0.6928987	298.6667	49.77778
91	0.6244791	448	149.3333
92	0.535271	320	106.6667
93	0.911849	138.6667	46.22222
94	0.2582397	80	10.66667
95	0.5443963	115.2	96
96	0.8026196	137.1429	120
97	0.5387874	128	64
98	0.8942363	144	48
99	0.8514795	864	288
100	0.9063795	832	416
101	0.8928428	522.6667	348.4445
102	0.9599627	384	320
103	0.935975	576	288
104	0.8620085	576	192
105	0.976843	358.4	149.3333
106	0.8461885	992	165.3333
107	0.949652	2026.667	380
108	0.4051489	102.4	25.6
109	0.6070786	170.6667	42.66667
110	0.9355087	400	80
111	0.0902812	96	8
112	0.916212	160	34.28571
113	0.9627622	292.5714	40.96
114	0.7048109	960	160
115	0.7644535	960	160

Number of Farmer	Technical Efficiency	Land productivity	Labour productivity
117	0.8769997	146.2857	56.88889
118	0.1637081	48	12.8
119	0.5284796	320	80
120	0.9445437	240	25.6
121	0.3732836	213.3333	16
122	0.7844455	256	51.2
123	0.9240609	280	112
124	0.9237593	265.1429	123.7333
125	0.688826	240	320
126	0.6584629	230.4	76.8
127	0.7833762	384	96
128	0.7432687	320	64
129	0.7913229	341.3333	85.33334
130	0.8942164	246.8571	86.4
131	0.8178293	336	84
132	0.9217913	182.8571	142.2222
133	0.7848691	341.3333	128
134	0.8444827	614.4	128
135	0.7277623	448	29.86667
136	0.8308954	768	192
137	0.8992952	274.2857	25.6
138	0.3248552	128	25.6
139	0.3309435	106.6667	16
140	0.3262677	149.3333	49.77778
141	0.5974556	115.2	32
142	0.8142953	384	192
143	0.8528485	288	96
144	0.9474266	234.6667	93.86667
145	0.8166338	240	48
146	0.3110124	106.6667	53.33333
147	-	192	144
148	0.958207	300	80
149	0.7557066	336	112
150	0.8668012	384	192
151	0.9753853	266.6667	160
152	0.8527918	384	64
153	0.8495272	210.2857	245.3333
154	0.9741625	179.2	179.2
155	0.8713017	256	204.8
156	0.3779412	160	53.33333

Number of Farmer	Technical Efficiency	Land productivity	Labour productivity
158	0.7076957	256	256
159	0.7949746	384	32
160	0.648634	256	51.2
161	0.116123	32	5.333333
162	0.8666089	137.1429	30
163	0.3607905	160	80
164	0.197927	96	16
165	0.7039844	128	26.66667
166	0.9612761	174.5455	64
167	0.814971	200	100
168	0.9449103	228.5714	80
169	0.2972143	80	53.33333
170	0.9598877	170.6667	64
171	0.4301208	128	35.55556
172	0.8716037	114.2857	133.3333
173	0.6870487	96	96
174	0.8972086	128	112
175	0.9147961	120.8889	90.66666
176	0.8636625	120.8889	72.53333
177	0.7658902	179.2	99.55556
178	0.9233762	121.6	40.53333
179	0.081617	96	24
180	0.717563	115.2	96
181	0.6882824	128	80
182	0.5262204	96	64
183	0.4938853	112	74.66666
184	0.7215307	102.4	85.33334
185	0.8031775	166.4	92.44444
186	0.341248	128	20
187	0.167281	96	21.33333
188	0.8460836	256	45.71429
189	0.8334036	217.6	54.4
190	0.6537285	240	240
191	0.7259888	230.4	192
192	0.610847	170.6667	128
193	0.8969501	217.6	181.3333
194	0.4379432	192	192
195	0.9355339	199.1111	112
196	0.8687547	202.6667	152
197	0.8393884	320	133.3333

Number of Farmer	Technical Efficiency	Land productivity	Labour productivity
199	0.8002576	480	80
200	0.8816867	1024	85.33334
201	0.4356914	256	42.66667
202	0.8275671	512	85.33334
203	0.7608646	512	85.33334
204	0.6963792	448	74.66666
205	0.5509782	384	64
206	0.5483236	384	64
207	0.8191399	426.6667	71.11111
208	0.8646374	426.6667	71.11111
209	0.8431787	640	128
210	0.6323308	224	74.66666
211	0.784609	720	96
212	0.6681737	544	60.44444
213	0.7672499	576	80
214	0.7107254	640	53.33333
215	0.8488017	533.3333	88.88889
216	0.7834361	704	117.3333
217	0.8742968	426.6667	53.33333
218	0.8580818	640	153.6
219	0.906917	416	104
220	0.9162396	365.7143	91.42857