

**PRODUCTION EFFICIENCY ANALYSIS OF PINEAPPLE
FARMERS IN THE AKWAPIM-SOUTH DISTRICT
OF GHANA**

BY

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**THIS THESIS IS PRESENTED TO THE UNIVERSITY OF GHANA, LEGON IN
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DECLARATION

I, Yaw Ofori-Appiah, do hereby declare that except for the references cited, which have been duly acknowledged, this thesis titled: **“PRODUCTION EFFICIENCY ANALYSIS OF PINEAPPLE FARMERS IN THE AKWAPIM-SOUTH DISTRICT OF GHANA”** is the product of my own research work, under the supervision of senior members in the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon from August 2017 to July, 2018. This thesis has never been published or submitted either in whole or in part for any other degree in this university or elsewhere.

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Date

This thesis has been submitted for examination with our approval as supervisors.

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Date.....

Date.....

DEDICATION

I dedicate this thesis to my brother Samuel Ofori-Appiah and my aunt Janet Otubea Mante. This is in recognition of the countless, immeasurable efforts and sacrifices that you made towards my education. May the good Lord continue to bless you.

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ABSTRACT

Pineapple farmers in Ghana are not able to meet their potential yield. Organizations are making conscious efforts to help boost pineapple production by training farmers on topics such as input use and farm management. It is necessary to ascertain if some gaps in production still exist that need to be addressed. The study sought to identify the influence of inputs on pineapple production in conjunction with the production of other crops. It also estimated the technical efficiency score of pineapple farmers and identified the determinants of technical inefficiency levels of the farmers using the one step stochastic output distance function approach. The constraints faced by pineapple farmers in the Akwapim-South District were identified and ranked using the Kendall's Coefficient of Concordance. A total of 135 respondents were selected using the multi-stage sampling technique. STATA version 14 was used for the data analysis. The analysis revealed that all the input variables (fertilizer, labour, planting material and intermediate cost) are significant and have a positive influence on the productivity of pineapple production. The shadow share of other crops is negative relative to the production of pineapple in the output mix. The mean technical efficiency score is estimated to be 86 percent. This implies that pineapple farmers in the Akwapim-South District have the potential to increase their output level further by 14 percent using the current technology available to them. The results indicate that extension visits, education and access to credit significantly and negatively affected technical inefficiency of pineapple farmers. The constraints facing pineapple farmers in the district are identified to be lack of credit, high production cost, high labour cost, marketing problems, lack of storage facilities, lack of extension services and incidence of pests and diseases ranked in order from the most pressing to the least pressing constraint. The farmers agreed to the ranking of the constraints. The study recommends based on the findings that government should make inputs accessible, available and affordable to farmers and policies implemented should help to improve credit facilities for farmers. Policy-makers should also intensify their efforts at providing labour-saving technologies and implementing policy measures that make agriculture more attractive to the youth. Finally, it recommends that there should be regular education of extension agents and extension service delivery should be structured properly to suit the needs of the farmers

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LIST OF ACRONYMS

COLS	-	Corrected Ordinary Least Square
CRS	-	Constant Returns to Scale
DEA	-	Data Envelopment Analysis
DMU	-	Decision Making Unit
DRS	-	Decreasing Returns to Scale
ERP	-	Economic Recovery Programme
EU	-	European Union
FAO	-	Food and Agriculture Organization
FBO	-	Farmer Based Organization
FDH	-	Free Disposable Hull
FFF	-	Flexible Functional Form
FTF	-	Feed the Future
G.A.P	-	Good Agricultural Practices
GDP	-	Gross Domestic Product
GEPC	-	Ghana Export Promotion Council
GSS	-	Ghana Statistical Service
IRS	-	Increasing Returns to Scale
Kg	-	Kilogramme
MD2	-	Pineapple variety developed by Del Monte of Costa Rica
METASIP	-	Medium Term Agriculture Sector Investment Plan
MiDA	-	Millennium Development Authority
MLE	-	Maximum Likelihood Estimation
MoFA	-	Ministry of Food and Agriculture
MRT	-	Marginal Rate of Transformation
MT	-	Metric Tonnes
NGO	-	Non-Governmental Organization
NTE	-	Non-Traditional Exports

PPF	-	Production Possibility Frontier
RTS	-	Returns to Scale
SC	-	Smooth Cayenne
SSA	-	Sub-Saharan Africa
Std. Dev.	-	Standard Deviation
Std. Err.	-	Standard Error
TL	-	Translog Functional Form
UNCTAD	-	United Nations Conference on Trade and Development
VRS	-	Variable Returns to Scale

CHAPTER ONE

INTRODUCTION

1.1 Background to Study

The role of agriculture in Ghana's economy cannot be underestimated as it employs over 60 percent of the working population and contributed about 30 percent of GDP (Ghana Statistical Service, 2010). Ghana has over the years depended heavily on primary commodities like gold, cocoa and timber. This trend continued until the exportation of gold and cocoa contributed about 50 to 65 percent of the total exports (GSS, 2010, Wolter, 2008) and as such the general performance of the Ghanaian economy was solely based on how these primary commodities fared on the global market. Within this period however, timber and wood was ranked as the third major export product after gold and cocoa.

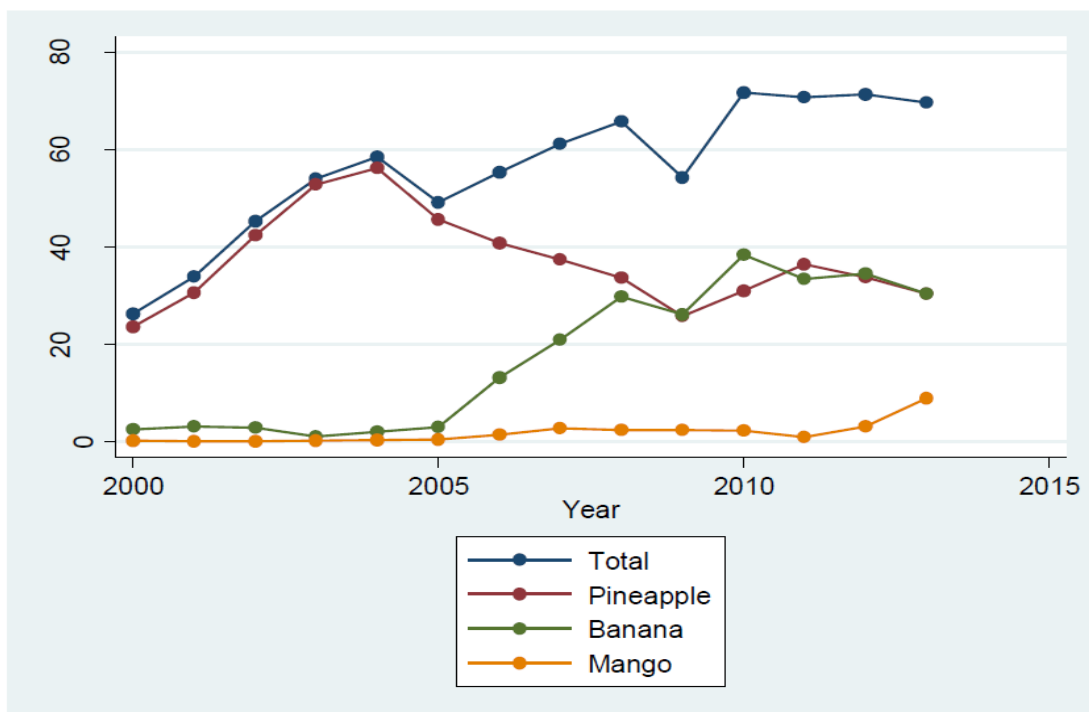
In an attempt to diversify export products in order to lessen Ghana's dependence on its few primary commodities as well as reducing the risks and unexpected events that may affect the economy of the country (example the collapse of cocoa prices in the 1980s), the government introduced a series of export diversification programmes in the 1990s as part of its Economic Recovery Programme (ERP). Part of the key purposes of the ERP was ensuring production shares as well as the competitive nature of Non-Traditional Export Products with the primary focus on products from fruits and vegetables on the global market. Since the introduction of the ERP, the fruit crop sector has contributed tremendously to the development of Ghana's revenue; from the creation of employment, through to the generation of foreign exchange and fiscal revenue. Ghana has comparative

advantage when it comes to the production of pineapple. These advantages are in the form of favourable soil and climatic conditions all year round; suitable geographical location ensuring low sea and air carriage charges to Europe as such ensuring the competitive nature of its export produce and the presence of the abundance of labour force (Jaeger, 2008). These factors give Ghana the superiority to become a paramount producer and supplier of economical pineapple products to the EU markets.

The EU still remains the largest market for fresh pineapples produced in Ghana; especially Switzerland, Italy, France, Germany, Belgium and the UK, among others. The Middle East is the next most important market and recently Turkey is one of the export destinations. These other markets serve as alternatives to the EU market, especially when there is a decrease in demand in the EU during certain periods (Ibrahim, 2015). Kleemann (2011) states that about 63 percent of pineapples produced in Ghana between the periods 2003 to 2007 was largely directed to the EU markets due to higher demands. Between the years 2000 to 2013, the fruit crop industry through its exportation of raw and processed fruits to the EU yielded about €562 million to the economy of Ghana (Eurostat, 2013). The value of the total foreign exchange rose from €26.30 million in 2000 to €58.50 million in 2004. In 2005 however, there was a sudden drop or reduction in the export value from €58.50 million in the previous year to €49.10 million representing 16.1 percent drop. The crisis in the pineapple sector led to the decline in 2005 to a larger extent emphasizing the significant contribution of pineapple as a Non-Traditional Export Product while the drop in 2009 was as a result of the occurrence of fruit flies and unpredictable rainfall patterns (Zakari, 2012).

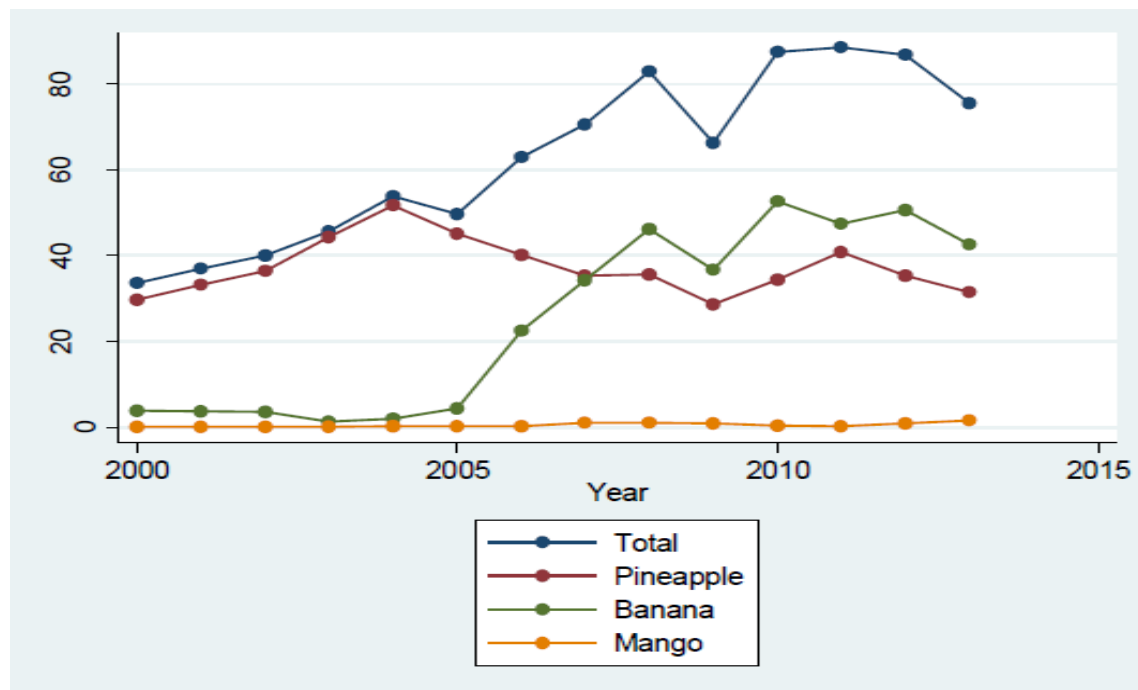
Figure 1.1 and 1.2 show the trend of total and sectoral values and quantities of fruits exported to the EU from 2000 to 2013 respectively. Between the years 2000 to 2004, the amount of foreign exchange derived from pineapple exportation increased rapidly as seen in Figure 1.1. This was due to the rapid rise in the volume of pineapple being exported as seen in Figure 1.2. The subsequent years experienced falls in export values due to the decline in export volumes.

Figure 1.1: Annual Export Values (Mil. of Euro) of Fruits from Ghana to EU from 2000 – 2013



Source: Eurostat, international trade statistics, 2013

Figure 1.2: Annual Export Quantities (Tonnes) of Fruits from Ghana to EU from 2000- 2013



Source: Eurostat, international trade statistics, 2013

There was a major structural transformation of the pineapple industry in Ghana due to the change in varietal preference for MD2 as compared to the Smooth Cayenne (Gatune *et al.*, 2009). Many producers and shippers were greatly affected by this change in varietal preference thus making pineapple production for export come to a virtual collapse. The farmers who successfully managed to switch to the new variety were faced with initial difficulties. These difficulties included lack of planting materials and agronomic practices which led to low exportable yields with a high investment cost. The worst casualties as a result of this structural change were smallholder farmers who were not financially stable to invest in MD2 production (Jaeger, 2008; Kleemann, 2011).

During the peak of this critical period, the favourable comparative advantage that Ghana had was no longer vibrant enough to boost the sector's competitive nature as well as to compete with rival countries particularly Costa Rica in the European markets. Approximately 70 percent of the output in the pineapple sector is dependent on small scale out-grower farmers who are mostly not financially sound. A greater proportion of small-scale pineapple farmers were not able to respond rapidly and adequately to this immediate change. This change meant that small scale farmers had to replace the existing suckers with the new MD2 suckers which required comprehensive and precise chemical usage and agronomic practices in order to obtain the optimum yield (Gatune *et al.*, 2013). Various governmental agencies, NGOs and other stakeholders in an effort to revamp production and restore farmers' confidence interceded to bestow upon the farmers both technical and financial support. Even though the greater part of pineapples that were found on the EU markets a few decades ago were sourced from West Africa particularly Ghana and Cote d'Ivoire, nations which were seen as competitors in pineapple production especially Costa Rica have considerably and substantially increased their efficiency of production while an insignificant or negligible development have been realized in the Ghanaian pineapple production sector (Gatune *et al.*, 2013).

A multi-output feature is observed in agricultural production as a risk minimizing strategy. Pineapple farmers grow other crops such as maize, yam or cassava as well. This can be observed to a large extent in the Akwapim-South District. The study of Kayitesi (2011) also showed that the system of farming for smallholder pineapple farmers in Rwanda is multi-output in nature. Pineapples that are usually cultivated for export and

fruit processing companies are not intercropped with other crops. This is because the farmers have to meet the strict phytosanitary certification requirement such as GLOBAL G.A.P requirement. However, farmers find it difficult to meet this requirement leading to about 65% decline in the number of registered farmers in the Akwapim South District from 2009 to 2010 (MoFA, 2011).

1.2 Problem Statement

In Ghana, smallholder farms dominate the agricultural sector with a farm size of about 1.2 hectares and farming activities characterized by the low use of improved technology. Most crops have low yields with pineapple production yielding as low as 60 percent of its potential yield from 2002 to 2008. The low productivity (an average yield of 60 Mt/Ha out of a potential yield of 100 Mt/Ha) can be attributed to the fact that pineapple farmers do not use improved planting materials in production and also make minimal use of inputs (MoFA, 2010). ISSER (2017) also reports that pineapple production declined from 43,461 tonnes in the 2015 production year to 27,148 tonnes in the 2016 production year. During this period, pineapple farming recorded a deficit of 37.5 percent in production volume. These farmers make minimal use of inputs especially fertilizer due to the high cost of the inputs hence soil fertility levels are low which translates into lower productivity.

A lot of studies have focused on pineapple farming in Ghana in recent years (Suzuki *et al.*, 2011, Conley & Udry, 2010, Kleemann & Abdulai, 2013, Wuepper *et al.*, 2018). This is because it creates a profitable business venture where pineapple farmers export to

the EU. The decision to produce for export has prompted pineapple farmers to learn how to intensify their production (Conley & Udry, 2010).

The shift in the demand for the new variety (MD2) has also necessitated the employment of more inputs in production. This has made pineapple production more expensive (Fold & Gough, 2008). However, there is a shift from providing credit and inputs to the provision of information as a way of helping farmers to produce sufficient quantities (Webber & Labaste, 2009). Both local and external organizations are making conscious efforts to help boost pineapple production by training farmers on topics such as input use and farm management (Wuepper *et al.*, 2018). MiDA (2011) reports that most FBOs have indicated that these trainings have been useful and have led to an increase in their crop yields. An example is the Oboadaka farmers' Cooperative from Akwapim Municipality. However, the extent to which the support services have helped to increase the efficiency levels of farmers is not known. It is therefore necessary to ascertain if some gaps in production still exist that need to be addressed.

In agricultural production in developing countries, the measurement of production efficiency has always been a vital issue from the view of agricultural development since it provides the necessary information for the formulation of agricultural policies and making of good management decisions in the allocation of resources. It is essential that in an attempt to raise the productivity of pineapple production in Ghana, a pragmatic approach is adopted and carried out to establish and measure the relative efficiencies of resource use among pineapple farmers.

In almost all the farming communities in Ghana, a multiple-output production feature is usually a popular characteristic of farming activities. The multi-output feature in the farming communities is largely influenced by the farmers' approach of minimizing risk and at the same time achieving self-sufficiency (Mensah & Brümmer, 2016). The typical Ghanaian farmer generally produces more than one crop. Although the farmer is noted to produce one dominant crop, he/she produces other crops either on subsistence level or to buttress the dominant crop.

Several efficiency studies on agricultural production have been conducted in Ghana, but most of these studies solely focused on the dominant crop produced by the farmer. Examples are Shamsudeen *et al.* (2011), Kyei *et al.* (2011), Onumah, *et al.* (2010) and Alhassan (2008). These studies were therefore conducted using the conventional technical efficiency approach (which involves the usage of multiple inputs to produce a single output) to measure the performance of farmers. However, the conventional method of efficiency measurement used to estimate efficiency of farmers does not reflect the technical inefficiency levels of the farmers. The use of the conventional technical efficiency framework to measure how farmers perform under circumstances in which they produce more than a single output using multiple inputs may tend to bias the estimates that would be obtained from the regression thus the allocative effect is ignored in relation to the inputs and output (Brümmer *et al.*, 2002). A more suitable approach that captures the multi-output nature of pineapple production will provide better estimates on efficiency levels to address issues better. The study is aimed at addressing the following research questions:

1. What are the influences of agricultural inputs on pineapple production in conjunction with the production of other crops in the Akwapim-South District?
2. To what extent are pineapple farmers efficient in the use of available resources for production?
3. What are the determinants of technical inefficiency levels of pineapple farmers?
4. What are the constraints to pineapple production in the district?

1.3 Objectives of the Study

The main aim of this study is to assess the production efficiency of pineapple farmers in the Akwapim-South District in the midst of other crops produced.

The specific objectives of the study include:

1. To identify the influence of inputs on pineapple production in conjunction with the production of other crops.
2. To estimate the technical efficiency score of pineapple farmers.
3. To identify the determinants of technical inefficiency levels of the farmers.
4. To identify and rank the constraints in pineapple production.

1.4 Justification of the Study

Pineapple is an important crop in both the local and domestic markets. It generates high levels of revenue and foreign exchange for the country. Issues relating to pineapple

production need to be addressed to achieve economic growth. The right estimation will give the right technique to tackle issues as this study seeks to address.

The estimates in this study will provide knowledge about the level of importance of inputs employed in production. This will guide the farmer in the allocation of resources and the proportion of budget to allocate to these inputs since resources are limited and farmers are mostly faced with budget constraints.

The study will also provide knowledge of the input substitution combinations that can be done. This will serve as a guide to the farmers and if substitution is rightly done will lead to cost reduction and profit maximization. Farmers rely on returns from their production for their livelihood, therefore activities carried out of the farm must yield the best results.

Conducting efficiency studies will give policy makers ideas on the best policies to implement in order to achieve optimal production efficiency levels. Significant factors affecting efficiency positively or negatively will be addressed. Identification of constraints and provision of possible recommendations will help to boost production of pineapple which will be beneficial to the pineapple sector. This is because efforts and resources will be channeled at solving these constraints.

The study will add to the growing body of literature on pineapple production in Ghana. The study suggests a new and better approach for measuring production efficiency of

pineapple farmers. Researchers and other stakeholders may consult this study when undertaking projects on production efficiency.

1.5 Organization of Thesis

The study is organized into five chapters: Chapter One introduces the background to the study, research problem, objectives and relevance of the study. Chapter Two deals with the review of relevant literature concerning the study. Chapter Three covers the methodology employed, where a discussion is made about the conceptual and theoretical framework, methods of data analysis, the study area, data collection and sampling techniques. In Chapter Four, the results and discussions are presented. Chapter Five presents a summary of major findings, conclusions and policy recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literature relevant to the study. The review highlights pineapple production in Ghana, performance of Ghana's pineapple on the export market, constraints in pineapple production, performance measure of pineapple production, definition of productivity and efficiency, measure of efficiency, approaches to the measurement of productive efficiency. The chapter also reviews production efficiency in agriculture and constraint methodologies.

2.2 Pineapple Production in Ghana

Pineapple like other tropical fruits is mainly grown in less developed countries where about two-thirds (2/3) of rural populace are farmers with a farm size of less than 2 hectares (IFPRI, 2005). The contribution of the fruit crop sector over the past decades to Ghana's national development has been on the rise and as such its significance cannot be ignored. Between the years 2000 and 2013, the pineapple sector played a significant role in the fruit industry in Ghana by generating foreign exchange for the economy (Eurostat, 2013). The pineapple industry is the most structured and well developed sector of the horticultural industry in Ghana. Pineapple production in Ghana is a key contributor to the development of the agricultural sector. Production and exports of pineapples in Ghana is a beneficial sector to the domestic economy, as it provides higher incomes and new employment opportunities to farmers than do other crops grown for the domestic market and consumption (Barrientos *et al.*, 2009).

Ghana's pineapple industry just like many other food industries in West Africa rose with the aim of becoming a major stakeholder on the global market. The fruit sector contributed to Ghana's export and it rose significantly from the early 1990's reaching a value in excess of US\$30 million in the mid 2000's. The successful nature of the pineapple sector during this period created employment and led to poverty reduction (Gatune *et al.*, 2013). The early stages of growth in the pineapple sector via a chain reaction stimulated significant growth in other sectors of the economy (Pay, 2009).

Globally, demand for fresh fruits has been rising with pineapples leading the pack as the most highly demanded horticultural crop. Pineapple production in Ghana has been on the ascendency for the past decade. The horticultural sector is one of the fastest growing sectors in Ghana and crops like pineapple, mango and papaya appear promising as options to diversify sources of income (Afari – Sefa, 2007). Pineapple production is the most important crop activity in the horticultural sub-sector of the Ghanaian economy (Agyare, 2010). Pineapple is the largest contributor to non-traditional export (NTE) in Ghana even though about forty-five percent 45 percent of the total cultivation is performed by smallholder farmers (Bertow, 2007). This re-echoes the assertion of Chamberlin (2007) that agricultural production in Ghana is made of mainly small-scale farmers. Though there are a few large farms involved in the production of pineapples locally, smallholder production still dominates within the sector. In Ghana, the varieties of pineapple cultivated are Smooth Cayenne, MD2 and Sugar loaf.

2.3 Performance of Ghana's Pineapple on the Export Market

The global demand for fresh pineapples levitates round a production volume of between 17.2 million metric tonnes (MTs) and 18 million MTs annually (FAO, 2013). The world market for pineapples has therefore switched towards the exportation of the produce with MD2 variety dominating the global market for fresh pineapple. The introduction of the much sweeter and organic MD2 variety in early 2004, caused Ghana's share of exports of pineapples to reduce considerably. Ghana's production and exports of pineapples is recorded to have reached its peak of about 71,000 MTs in the early 90's when there was a huge demand globally for the produce. However in 2008, the annual volume of pineapples produced reduced to about 35,000 MTs (GEPC, 2005). This is as a result of the switch in the variety of pineapple demanded causing huge declines in revenue from the export of pineapples as the prices also fell on the international market.

The fresh and dried pineapple that are found in the European markets originates from Latin America and Africa with the former contributing about 80 percent while the latter contributes between 10 to 15 percent (Kleemann, 2011). Danielou & Ravry (2005) state that the global production and exports of pineapples is largely divided between Latin America and Sub-Saharan African countries. This fast-growing pineapple market on the EU market consequently presents a magnificent chance for the fruit sector. This is because the bilateral trade agreement between Ghana and the EU that was signed in 2008 opens up the entire EU market to the industry as a result of the removal of all trade barriers for agricultural produce that are from Ghana (Wolter, 2008). UNCTAD (2012)

however estimates that globally, Costa Rica is the leading producer and exporter of fresh pineapples with an annual output volume of 1.5 million MTs worth about \$ 604 million.

2.4 Constraints in Pineapple Production

There are quite a number of literature on constraints faced in pineapple production. These constraints start from the production stage to the postharvest stage and extends even to the distribution stage. A study conducted by Ninson (2012) indicated a number of constraints facing pineapple producers. Among these constraints are difficulty in accessing credit, low fruit price, high cost of inputs, incidence of pests and diseases, lack of extension services and difficulty in accessing farm lands among others. Difficulty in accessing credit was ranked the highest constraint in this study.

Boateng (1999) also noted in his study that poor organization and procurement of production inputs like fungicide, pesticide, fertilizer including urea, sulphate of potash, ammonium and calcium-sulphate are among the major problems that face pineapple farmers. He explained that small-scale farmers are not organized into pineapple cooperatives, which are necessary in order to have access to credits, inputs and transportation systems. These problems decrease yields but could be further improved with strong technical support for cultivation. He recommended that optimum yields will be obtained with consistent use of fertilizer and chemical as well as easy access to credit. Also, poor road network in the production areas, inadequate extension services and limited research base for the industry are among the major problems facing pineapple farmers.

A research conducted by Abbey (2005) adds that out of the 120 respondents interviewed, 43 percent of respondents asserted that they were having problems with financing their farming activities. A significant number of respondents complained about the high cost of labour. 5 percent of respondents complained that land owners prefer to lease out their land for longer periods, however this is accompanied by high price charges which farmers find difficult to pay. Hence, even though there is a vast land available for farming, farmers cannot take advantage of it. They therefore tend to farm on the same stretch of land for longer period which causes the fertility of the land to diminish. Results from the study also indicate that 16 percent of respondents are having problems with marketing their produce. 11 percent of the respondents also cited shorter shelf life of fruits as a major problem they encounter. The results of this study is quite similar to that of Kpare (2016) who found lack of finance, high cost of cultivation, unsuitable land, unavailability of plantlets and exporters' cheating behaviour to be constraints faced in the production of the pineapple variety, MD2.

From literature, it is obvious that access to credit is a very pressing constraint facing farmers and it is common in most findings. Incoom (2008) discussed that farmers find it difficult to assess credit because they mostly do not have current accounts with these financial institutions which is a necessary requirement for credit disbursement. Also, the collaterals (a rural house or farm) they provide are not satisfactory and hence do not merit the credit and do not meet the requirements of these financial institutions.

2.5 Performance Measure of Pineapple Production

Performance measure of firms or any production unit is done by the use of fundamental analysis such as the use of profitability and efficiency analysis (Loukoianova, 2008). Profitability measures include Net Present Value, Net Farm Income, Benefit-Cost Ratio, Gross Margin Analysis. Baseke (2009) used NPV to assess the Profitability of Pineapples while Baruwa (2013) used both Gross Margin and Net profit to estimate profitability of pineapple production. Profitability normally deals with the financial standing of the pineapple farm while Efficiency focuses on using resources to generate optimum production on the pineapple farm. However, increasing the efficiency on the farm improves profitability in the long run.

Some studies used efficiency measures to assess the performance of their pineapple farms (Idris *et al.*, 2013, Lubis *et al.*, 2014). Efficiency measures are more suitable when one wants to assess performance based on resources or inputs used in production. This study will focus on efficiency since our central focus is on assessing the influence of inputs on pineapple production. Both theorists and policy makers are of the view that efficiency is a significant economic concept in assessing a producer's performance. From an empirical perspective, a policy maker's interest may lie in knowing the extent to which a given firm can increase its output without using additional resources by increasing efficiency while from a theoretical perspective; the interest may lie in developing appropriate measures of efficiency and studying its properties. Analyzing efficiency of pineapple production is generally important since it prevents wastage, reduces cost of production and raises profit margin of the farm.

2.6 Definition of Productivity and Efficiency

Productivity is generally defined as the proportion of an output and its factors of production. It is also an indication of how effectively the factors of production are used to produce output. Attar *et al.* (2012) defines productivity as the ratio of output to the resources used to produce that output. He further states that output can be homogenous or heterogeneous and the resources employed to produce output include raw materials, energy, capital, labour et cetera. Productivity measures can therefore be put into two broad groups namely partial productivity measures which relate a particular quantity of output to a single unit of input and total productivity measures which relate a particular quantity of output to a group of inputs employed in the production.

Although the term efficiency and productivity are mostly used interchangeably, they are not exactly the same thing but similar. Some authors use the same definition for both concepts. Cooper *et al.* (2000) define both efficiency and productivity as the ratio of outputs to input. However, some authors distinguish between these two concepts. According to Fried *et al.* (2008), efficiency is defined as how effectively a unit of production does in the using available resources to produce output, taking into consideration the available technology and measuring it against a standard production frontier. Efficiency and productivity are two collaborative concepts but the estimates of efficiency are seen as being more precise than that of productivity. This is because they are juxtaposed or weighed-up against the most efficient frontier. As a result of this, one can compute the estimates of productivity based on the proportion of outputs on inputs.

In economics, the term efficiency is often used in diverse situations; for example efficient markets, efficient prices and efficient farms et cetera. Generally, an organization can attain technical efficiency or allocative efficiency. Technical efficiency assesses how an output can be expanded on a production frontier given a set of inputs while allocative efficiency assesses a firm's ability to choose optimal set of inputs with a given set of input prices (Daraio & Simar, 2007). Kebede (2001) also defines technical efficiency as the highest achievable output level for a given level of production inputs and a set of technologies that are available to the farmers. He went further to define economic efficiency as the combination of both allocative and technical efficiency but however he stressed that technical efficiency may occur without economic efficiency necessarily being achieved.

A firm that has both technical and allocative efficiency does not necessarily possess scale efficiency. Scale efficiency refers to level by which productivity can be expanded till the most productive scale size is obtained. The most productive scale size is obtained where elasticity of scale is equal to one (Coelli *et al.*, 2005). In the classical microeconomics context, efficiency is mostly defined as the ability of a firm or an individual to generate outputs from a specified set of inputs with a least production cost. From the basic definition of efficiency, a person can deduce that the combination of inputs that yields higher levels of output can be classified as an efficient level of production. However, there may be certain factors that may inhibit the realization of these expected higher outputs.

Applied and theoretical economists have focused on the concept of efficiency thereby making it topical. The prevailing or circulating literature on productivity analysis and production has largely been focused on the empirical efficiency estimation.

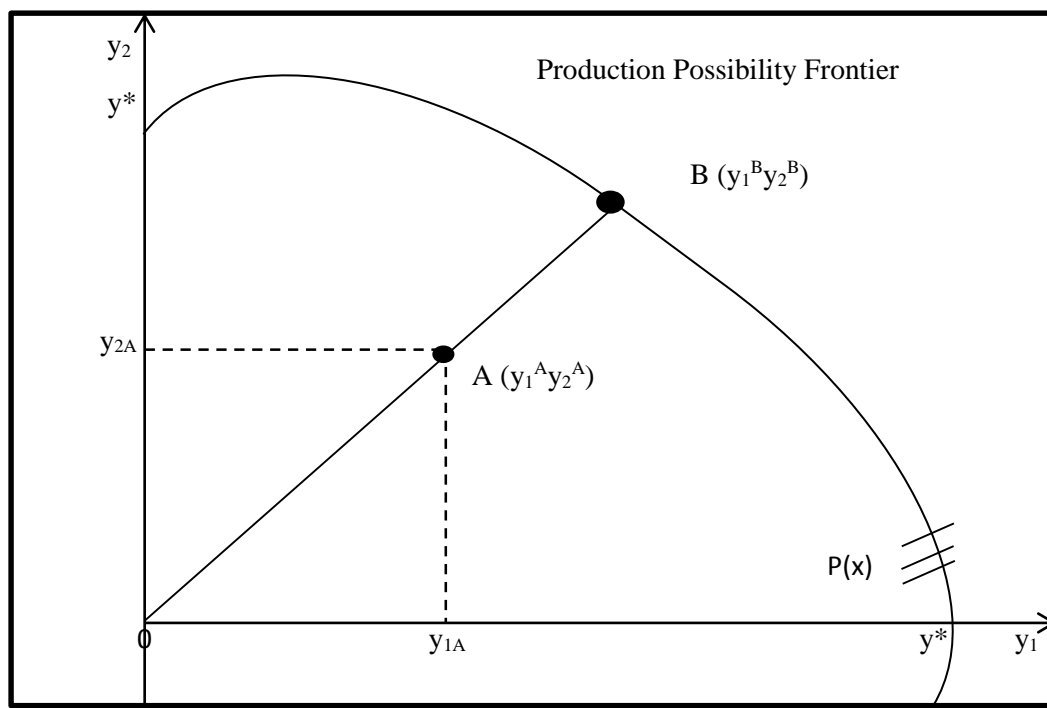
2.7 Concept of Efficiency

The concept of efficiency was first proposed by Farrell in 1957 and this produced a conceptual framework for the measurement of efficiency. Farrell (1957) showed that the efficiency of a production unit is made up of two parts and these are namely technical efficiency (output) and allocative (price) efficiency. Technical efficiency depicts the capacity of a firm to acquire the highest quantity that can be produced from a domain of inputs that are available, or the capacity to reduce the inputs used in producing of a given output vector. In simple terms, a farmer is considered to be more technically efficient than his opposite number if he produces a much higher output from the same set of inputs. Kalirajan & Shand (1999) also suggested that the performance of a firm was measured on the basis of their efficiency levels which are made up of the two distinct components that were proposed by Farrell (1957) in his seminal article namely technical and allocative efficiency. Theoretical models have been developed to explain the differences in the frontier output “efficient levels” and the actual outputs observed based on the definition of production efficiency. Regression and linear programming methods are used to evaluate the achievement of individual firms in relation to an estimated frontier.

The production frontier is therefore linked with the highest attainable level of output, given the least level of inputs that is needed to produce a certain amount of output. In other words, it is the venue or location for maximum achievable output for each input mix. As noted by Farrell (1957) and Debreu (1951), a production unit is considered efficient only if it is found on the production frontier. Technical inefficiency is however accredited with the inability of the firm to produce the frontier level of output, given the amount of inputs available (Kumbhakar, 1994).

From Figure 2.1 below, the conceptualization of a multi-output multi-input production technology for a cross-sectional set of data can be depicted as follows. Supposing a farmer produces two outputs (y_1, y_2) from an input set of vector (x) and where y^* represents the production possibility frontier (PPF) as shown in Figure 2.1.

Figure 2.1: A Diagram Showing Output Distance Function with Two Outputs(y_1, y_2)



Source: Author's own depiction, 2018

According to the production theory, the PPF curve shows all the possible combinations of technically efficient production points of the outputs (y_1, y_2) that could be generated with the input vector (x) and still be found in the feasible production region $P(x)$ which is bounded by the PPF. Based on principles of stochastic frontier production theory, production at any point outside this region (region B) represents suboptimal point. From Figure 2.1, point A is considered inefficient while point B is considered to be efficient. The distance that point A is away from point B (which lies on the frontier) represents their inefficiency level in the production process. Coelli *et al.* (2005) is of the view that a proportional expansion of the output A towards point B which is the efficient production point can be achieved by an upward scaling by a scalar (θ) which must be minimized.

$$D_o(x, y) = OA/OB \leq 1 \quad \text{thus } D_o(x, y) \leq 1$$

$$D_o(x, y) = 1/TE_o \quad \text{thus } TE_o \geq 1$$

The output distance $D_o(x, y)$ gives the reciprocal of the maximum proportional extent of the output vector (y) , taking into account the input vector (x) , and fully characterizes the technology. According to Brümmer *et al.* (2002), the inverse of the distance function can be considered as a performance measure which conforms to the measure of output-oriented technical efficiency (TE_o) proposed by Debreu (1951) and Farrell (1957). B is the point on the the frontier curve where $\theta = 1$ and indicates a point of being fully technically efficiency. At point A, $\theta < 1$ hence there is technical inefficiency. Also any point above point B lies in an infeasible production region. Depending on the particular production technology that is represented, there is the possibility of deriving different decompositions of productivity growth. Brümmer *et al.* (2002) stated that employing the

output distance function approach in a continuous time framework introduces further components which takes into consideration the effects of deviations between the shadow shares for outputs and inputs.

The output distance function proposed by Brümmer *et al.* (2002) was employed for this study. Again, decomposition in the output distance function framework uses the fact that the inverse of the distance function gives the technical efficiency or performance measure (Farrell, 1957).

2.8 Measure of Efficiency

Farrell's (1957) seminal article led to the evolution of different methods for measuring the efficiency of production. Farrell came out with tremendous findings on the measurement of efficiency several years ago and the outcome of his findings has ever since been used for the estimation of efficiency. Other economists including Aigner & Chu (1968) and Meeusen & Van den Broeck (1977) over the years have also worked on such areas and added up to his information. Aigner & Chu (1968) continued the work that was done by Farrell via the application of programming models to evaluate production in deterministic models through which the entire anomaly or deviations from the estimated frontier are one-sided and are as a result of inefficiency.

Winsten (1957) proposed and Greene (1980) demonstrated that for a frontier with one-sided deviations, the Ordinary Least Square (OLS) could be deployed in determining the inefficiency. However, because the parameters of the production function are constantly

being estimated, a person only needs to rectify the intercept term through the addition of the largest residual to the intercept in a production setting. This method is known as the Corrected Ordinary Least Square (COLS). The Corrected Ordinary Least Square (COLS) is however restricted because of the nature of the regression analysis as it only allows a single output in the production function. When it is looked at from an econometrics point of view, assigning the entire deviations to inefficiency in production is wrong as deviations from the frontier apart from inefficiency behavior can also arise from measurement error and statistical noise.

Lovell *et al.* (1994) presented a solution by specifying a distance function to the situation which involves a multiple output case, exploiting homogeneity property and reshuffling the terms in the production process with a single output being considered as the dependent variable while the remaining other outputs are considered as explanatory. This method called the Stochastic Distance Function (SDF) has been made understandable to the general public by Grosskopf *et al.* (1997) and Coelli & Perelman (1999 and 2000). Atkinson & Primont (2002) criticized the asymmetric treatment of a single output by stating that it creates an endogenous problem. Aigner *et al.* (1977) and Meeusen & Van den Broeck (1977) introduced a stochastic production function to differentiate the errors that arise from production inefficiencies from the errors that arise from model misspecification. These papers were of the assumption that the deviation from the frontier composed of an error term that comprised of both inefficiency and statistical noise.

2.9 Approach to Measurement of Productive Efficiency

There are two main approaches in measuring productive efficiency of firms. They are the parametric and nonparametric. These approaches are discussed below:

2.9.1 Non Parametric Frontier Approach

The Data Envelopment Analysis (DEA), is a nonparametric approach to efficiency analysis which originated from a seminal paper written by Farrell in 1957. The DEA is an alternative to the methods that are based on regression. The DEA is a programming model which permits the usage of multiple inputs and outputs. DEA was familiarized and made accessible by Charnes, *et al.* (1978) and subsequently built upon by Banker, *et al.* (1984). This method has been generally accepted and it is used in analyzing the technical efficiency of public sector units. There are two principal advantages associated with the DEA that gives it an edge over the regression-based techniques.

Firstly, the DEA being a nonparametric approach implies that there is no requirement for description of the production function. The method instead estimates the frontier by using the minimum extrapolation principle under the maintained axioms of monotonicity and convexity of the production possibility set (Banker *et al.*, 1984). Chang & Guh (1991), however argued that the DEA is not nonparametric since it employs frontiers (linear production functions) to measure efficiency. Secondly, the main advantage of using DEA is its ability to simply manage multiple outputs and inputs as well as permitting absolute comparisons of production possibilities without needing any additional input price data.

Several studies have been conducted to analyze the achievement of both regression-based techniques and DEA. Distinctively, a data generating process is utilized alongside simulation analysis with the method incorporating a production function with solely one output. Depending on only input prices, Gong & Sickles (1992) compared the stochastic frontier method and DEA with several outputs. Banker *et al.* (1993) used cross-sectional stimulated data to examine the performance of DEA proportional to COLS. The results obtained showed that the DEA fared quite well in correctly modifying the error of measurement whiles the COLS did not. However, as the measurement error enlarged, the two models functioned badly. Ruggiero (1999) using cross-sectional simulated data demonstrated that the deterministic COLS performed well in regulating the error of measurement whiles the stochastic frontier model did not.

2.9.2 Parametric Approach

The parametric programming approach (Aigner & Chu, 1968, Ali & Chaudhry, 1990) encompasses the deterministic and the stochastic frontier approach which uses either cross-sectional or panel data; these approaches are discussed below:

Deterministic Frontier Approach

The deterministic frontier is estimated either by mathematical programming or econometric approach whilst the stochastic uses the econometric technique only. The deterministic frontier model is defined in a cross section perspective as:

$$Y_i = f(X; \beta) \exp(u_i) \quad (2.1)$$

where:

$$i = 1, 2, 3, \dots, N$$

Y_i = denotes the possible production level for the i -th sample farm bounded by a deterministic component $f(X; \beta)$ shown above.

β = refers to the unknown parameters to be estimated

μ_i = the inefficiency component in the production process and it is a non-negative random variable

X_i , = inputs for the i -th farm

N = Sample size

The technical efficiency of individual farm Y_i to the corresponding potential frontier output Y_i^* is given as:

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{f(x_i; \beta) \cdot \exp(-u_i)}{f(x_i; \beta)} = \exp(-u_i) \quad (2.2)$$

In the case of the deterministic frontier technique all deviations in output are attributed to technical inefficiency effects irrespective of the fact that the deviations in output might be contributed by random errors including weather effects and errors of measurement which are beyond the control of the producer.

Stochastic Production Frontiers

The Stochastic Frontier Production model originated from works done by economists such as Meeusen & Van den Broeck (1977), Aigner *et al.* (1977) and Battese & Corra (1977). The model has two error terms present in the model. The error term has a one-sided component that result from unobserved inputs that cause the technical inefficiency error. The two sided error is caused by factors that produce unnecessary noise in the data. This noise may be introduced due to random effects and exogenous shocks beyond the control of the production unit and may include errors from measurements and statistical

noise (Aigner *et al.*, 1977, Meeusen & Van den Broeck, 1977). The model also allows for hypothesis testing and constructing confidence interval is possible (Wadud & White, 2000).

The disadvantages of this approach is that it requires the underlying functional form of the production frontier and the distribution of error term that results in technical inefficiency. The stochastic production frontier is used in multiple input and single output situation but it is limited when the situation involves modelling multi-input and multi-output. This model has the error component which is decomposed into the random noise and inefficiency effect. Hence, this approach to technical efficiency analysis seeks to explain that deviations from the production frontier may not necessarily be completely under the control of the production unit. Other factors which contribute to variations may be external shocks outside the control of the producer (Kebede, 2001). These random or external shocks include effects of weather as well as diseases on the value of output obtained by the producer. These effects can be distinguished from the contribution of variation in technical efficiency using this model.

The stochastic frontier function is given by;

$$Y_i = f(X; \beta) \exp(v - u) \quad (2.3)$$

where:

Y_i = denotes the output

X = input variables

β = is a vector of technology parameters.

The stochastic frontier function employs the use of the one step stochastic output distance function approach to estimate the distance function of the production unit. The technical efficiency level of the multi-output system is then computed by taking inverse of the distance function (Brümmer *et al.*,2002).

Stochastic Distance Function Approach

The stochastic frontier was introduced by both Aigner *et al.* (1977) and Meeusen & Van den Broeck (1977). They specify clearly that external noise affects production by introducing errors, and thus, it necessary to isolate the influence of these exogenous errors events from the errors that cause technical efficiency. They suggested a function which incorporates an error term introduced by external noise and technical inefficiency as discussed above.

The frontier approach employs various functional forms in establishing the relation between inputs and outputs in the analysis of technical efficiency. The most common ones used are the Cobb Douglas and Translog production function and this study discusses these approaches. The choice of a functional form that best fits this study will depend on the results of the hypothesis test conducted.

The Cobb-Douglas specification for the SPF model is expressed as:

$$\ln Y_i = \beta_o + \sum_{i=1}^n \beta_i \ln X_i + \varepsilon_i \quad (2.4)$$

$$\varepsilon_i = v_i - u_i \quad (2.4.1)$$

$$\ln Y_i = \beta_o + \sum_{i=1}^n \beta_i \ln X_i + v_i - u_i \quad (2.5)$$

where:

v_i = noise component is two-sided and have a normal distribution.

u_i = the non-negative technical inefficiency term.

Various studies conducted on efficiency employed the translog stochastic frontier production function specification. The specification is mostly used in production analysis. This specification does not assume homogeneity or separability. An advantage is that the model does not also impose any restrictions on the elasticity of substitution on the put variables in the function. Another advantage is that it allows for the usage of many input variables in the function (Berndt & Christensen, 1973). This functional form is flexible and does not pose any significant parameter restrictions and inputs present in the function. The functional form has some disadvantages such as the presence of multicollinearity between the input variables. Abdulai & Huffman (2000). It also requires larger sample sizes. The translog stochastic frontier production function is specified in the same way as the Cobb-Douglas function.

Inefficiency is further estimated such that for each observation, the u_i gives a technical inefficiency value. The inefficiency term, u_i , can assume a half-normal, exponential, gamma, or truncated normal distribution. The estimate is usually derived from a maximum likelihood, but Kumbhakar & Lovell (2000) propose the moments approach method as appropriate for estimating the stochastic frontier. The stochastic frontier approach has been criticized for its inability to estimate efficiency when the output involved exceed one. The problem of estimating multi-outputs can be solved by using the

distance function approach. The presence of more than one output however presents the potential endogeneity problem (dependent variables on both sides of an equation) and exogeneity. Kumbhakar & Lovell (2000) suggest that the endogeneity problem does not have a significant impact on the model and as such can be overlooked. Coelli & Perelman (2000) agree to this suggestion and provided similar findings.

Since the Cobb-Douglas has some short comings in relation to its specification, the unitary elasticity of substitution between the inputs and the total returns to scale at all input and output levels requires the introduction of the concept of translog specification. The translog is part of the FFF that are usually applied in specifying the production frontier. Generally, the FFF can be expressed as:

$$f(y) = \beta_o + \sum_{i=1}^n \beta_i g_i(x_i) + \frac{1}{2} \sum_{i=1}^n \sum_{n=1}^m \beta_{ij} g_i(x_i) g_j(x_j), \quad (2.6)$$

where:

each g_i is a known twice-continuously differentiable function of x_i , and $b_{ij} = b_{ji}$.

Some commonly used FFF specifications include the quadratic, translog, normalized quadratic and generalized Leontief. The model specified above analyzes a single output and multiple input technology situation.

2.10 Distance Function and Efficiency Decomposition

A production technology can be described by conventional alternative methods such as the production, cost and conceivably the revenue functions and economists usually use these functions in the estimation of efficiency. The larger number of recent studies on distance function has mostly been driven by the desire to estimate the technical efficiency

or shadow prices. The primary benefit of the distance function approach is that it permits the usage of multiple inputs, multiple output technology without the availability of prices information. Even in certain situations where price information is accessible but the representation of its cost and profit functions are impossible due to the violations of the required behavioural assumptions, the distance function approach can still be used (Coelli & Perelman, 2000).

The distance function consists of the same technological information as the cost function does but from an econometric point of view, it may have some advantages over the cost function. A typical example is when the input prices are uniform for all firms but their aggregated output differ across firms (Bauer, 1990). From the sample size (N) of farmers or firms there are five different techniques for estimating distance function technologies and these are as follows:

- i. Using linear programming (DEA) to construct a non-parametric piece-wise linear frontier (Fare *et al.*, 1994).
- ii. Using the FDH to construct a non-parametric frontier (Deprins, Simar & Tulkens, 1984).
- iii. Using linear programming to construct a parametric deterministic frontier (Forsund & Hjalmarsson, 1987, Fare *et al.*, 1993).
- iv. Using the COLS method to estimate a parametric deterministic frontier (Lovell *et al.*, 1994, Grosskopf *et al.*, 1996).
- v. Using MLE method to estimate a parametric stochastic frontier (Hetemaki, 1996).

2.10.1 The Output Distance Function

The output distance function evaluates the proximity of a specific output level to the maximum achievable level of output using the same level of inputs under a technically efficient production (Mawson *et al.*, 2003). The definition of an output-distance function starts by establishing the type production technology used by the firm to produce the output, $P(x)$, which shows the set of all output vectors, $y \in R_+^M$, that can be produced using the input vector, $x \in R_+^K$. This can be expressed mathematically as:

$$P(x) = \{y \in R_+^M : x \text{ can produce } y\} \quad (2.7)$$

The output-distance function is then defined as:

$$D_o(x, y) = \min\{\theta : (y/\theta) \in P(x)\} \quad (2.8)$$

where $D_o(x, y)$ = output distance function

θ = level of efficiency (it shows the extent to which the output vector must be expanded to get to the efficient frontier).

$P(x)$ = the set of vector (y) that can be obtained from the input vector.

y = outputs that are in the output distance function.

x = input vector.

$D_o(x, y)$ is non-decreasing, positively linearly homogeneous and convex in y , and decreasing in x (Lovell *et al.*, 1994). The distance function, $D_o(x, y)$, would assume a value which is less than or equal to one (1) if the output vector, y , is a member of the feasible production set, $P(x)$. Thus, $D_o(x, y) \leq 1$ if $y \in P(x)$. Moreover, the distance function would assume the value of one (1) when y is located on the outer boundary of the production possibility set. That is,

$$D_o(x, y) = 1 \text{ if } y \in Isoq P(x) \quad (2.9)$$

Although the stochastic output distance function (SODF) is different from the stochastic frontier production function (SFPP), there are some similarities between them. For example, they both consider the maximum feasible output from a given set of inputs. The main difference between the stochastic output distance function (SODF) and stochastic frontier production function (SFPP) is that in the case of the SFPP it is simply defined for the case of one output or aggregate outputs and it does not require normalization whiles the SODF is defined in a set of theoretical framework which involves vector of outputs and inputs and can only be implemented empirically by the using one of the outputs.

2.10.2 The Input Distance Function

An input distance function is also described in an almost identical way as the output distance function. However, instead of considering how the output vector may expand proportionally with the input vector being held constant, it rather looks at how the input vector may be proportionally scaled-down in relation to the output vector being held constant. The input distance function may be defined on the input set, $L(y)$, as

$$D_I(x, y) = \max \{ \rho : (x/\rho) \in L(y) \} \quad (2.10)$$

where:

$L(y)$ = the input set and it shows all the set of input vectors, $x \in R_+^K$, that can produce the output vector, $y \in R_+^M$, Thus,

$$L(y) = \{ x \in R_+^K : x \text{ can produce } y \} \quad (2.11)$$

Thus, $D_I(x, y)$ is non-decreasing, positively linearly, homogenous and concave in x and increasing in y . The distance function, $D_I(x, y)$ will assume a value that exceeds or is equal to one (1) when the input vector, x , is an element of the feasible input set, $L(y)$.

Thus, $D_I(x, y) \geq 1$ if $x \in L(y)$

Moreover, when it is found on the inner boundary of the input set, it will assume a value of one (1) or unity.

According to Färe *et al.* (1993 and 1994), under the CRS assumption, the inverse of the output distance function is equivalent to the input distance function.

$$\text{Thus } D_I = \frac{1}{D_O} \tag{2.12}$$

where:

D_I = input distance function

D_O = output distance function

In other words, the magnitude in which a person is capable of radially expanding his output while his inputs are held constant or fixed will be the same as the proportion in which a person is capable of radially decreasing his input usage with a constant output. This condition will however not hold under variable returns to scale (VRS).

2.11 Empirical Literature Review on Production Efficiency in Agriculture

A lot of studies have been done in analyzing production efficiency of various agricultural crops as well as animals. These researchers used various approaches to achieve the objectives of their study. The objectives were mostly based on determining the level of

technical efficiency and the determinants of technical inefficiency. Some of these works are discussed below.

Ahwireng (2014) carried out a research on the determinants of technical efficiency of smallholder pineapple producers. The study examined and estimated the levels of efficiency of resource-use among small-holder pineapple producers and also investigated if farmers' socio-economic characteristics had any effect on their efficiencies and productivity. The stochastic frontier approach was the main methodology employed to estimate the efficiency of farmers' use of resources. The Cobb-Douglas production function was found as the most appropriate functional form hence, the analysis of the estimated coefficients for efficiency were based this functional form. The estimated coefficients of the Cobb-Douglas frontier function showed that, farm size, labour and fertilizer use were the most significant factors that affected farmers' output levels. The determinants of inefficiencies which included age, credit, experience, farm size and educational levels of farmers had negative coefficients and were all found to be statistically significant except farm size. Thus the study concluded that all the significant enhanced efficiency in production.

Ogundari & Brümmer (2011) used an output distance function to estimate technical efficiency, inputs substitution and complementary effects of cassava production in Nigeria. The result of the partial elasticity of production with respect to the inputs showed that, farm size, labour, fertilizer, pesticides, and materials monotonicity are positively relation to output hence will cause an increase in cassava production. An

inefficiency score of about 72% was recorded which indicates implies that an inefficiency level of about 39% is in potential output on the production frontier. Lastly, extension, credit and occupation (farming) were variables that showed a positive correlation with efficiency of the farmers in the sample.

Onumah & Acquah (2010) also applied the one-step stochastic frontier technique to estimate the technical efficiency and the factors that determine efficiency of the aquaculture farms. The findings showed that the expected elasticities of mean output with respect to all input variables considered were positive and significant. Also, these aquaculture farms showed an increasing return to scale based on the production technology and the overall mean technical efficiency was estimated to be 80.8 %.

Kuwornu *et al.* (2013) employed the use of the stochastic frontier model in their study on maize farmers in the Eastern Region of Ghana. Results from the findings indicated that elasticities of mean output for agrochemicals, other inputs and hired labour inputs were positive while the output elasticities of seed, fertilizer and family labour were negative. The technology used on the maize farms is characterized by a decreasing returns to scale. The results also indicate that, the joint effect of operational and farm-specific factors had a significant impact on technical efficiency. The mean technical efficiency score of the farmers was estimated to be 51%. Furthermore, the results from the inefficiency model revealed that extension visit, FBO membership, number of times FBO members meet, training in maize production, cash and in-kind credits were significant determinants of the farmers' technical efficiency level. Lastly, the results of the resource-use efficiency

showed an under-utilization of inputs such that agro-chemicals and hired labour and an over-utilization of other inputs such as family labour, seed, and fertilizer are over-used by maize farmers in the region.

Some studies also show an enormous variation in the levels of efficiency among farmers. A study carried out on the technical efficiency of tomato farmers in the Ashanti Region of Ghana showed technical efficiency variation levels among farmers ranging from 35%-97% (Ayerh, 2015). Results from the study of Antwi (2017) showed a wider technical efficiency gap. The results of the analysis showed that technical efficiencies for soybean farms in the Upper East and Upper West Regions range from 15% to 99% (Antwi, 2017). The findings of Etwire *et al.* (2013) gave a similar technical efficiency range of between 11% and 99% for soybean farms in the Northern Region. In contrast, the results of Mensah & Brümmer (2016) showed the distribution of the efficiency scores where performance scores of farmers were distributed between the range of 66% to 97%. It is obvious that most scores are close to the median efficiency score hence there is a narrow performance variation within the sampled farmers.

Most results from estimation of technical efficiency levels show a high level of inefficiency in Ghana and other developing countries. Results from an agricultural efficiency review in Nigeria from 1999 to 2011 showed that the estimate mean efficiency from all the reviewed studies was about 71%, showing that there was an inefficiency gap of 29% to be filled (Ogundari *et al.*, 2012). As seen in earlier, results from Kuwornu *et al.* (2013) indicated that the mean technical efficiency level of the farmers was found to be

51%, which implies that as high as 49% inefficiency level. Hence, there is the need for farmers in these developing countries to adopt best farming practices in order to produce at optimum production levels.

It is evident from the above review that most studies focused on the production efficiency of a single farm output. This includes the study done on pineapple production. This gives an indication that little consideration has been given to the multi-output nature of farming when analyzing production efficiency of farm output.

2.12 Review on Constraint Methodologies

Several approaches have been employed when analyzing constraints faced by farmers. Some studies used the Kendall's Coefficient of Concordance (Antwi *et al.*, 2017, Ayerh, 2015). Other studies used the Garrett Ranking Technique (Ogundari, 2013, Sedaghat, 2011). Abbey (2005) also used percentages to analyze constraints facing farmers. The commonly used approaches are the Garrett Ranking Technique and Kendall's Coefficient of Concordance.

The Garrett's ranking technique is a simple approach used to identify the most pressing constraint facing respondents. Respondents are asked to assign ranks for a list of constraints which are then changed into percentages. The formula used for the conversion is given as:

$$\frac{100(R_{ij} - 0.5)}{N_j} \quad (2.13)$$

where

R_{ij} = rank given for the i th constraint by the j th respondent

N_j = number of factors ranked by the j th respondent

The Garrett's score table is used to convert the estimated percentage position into scores. Mean scores are computed after adding the individual score for each constraint. The constraint with the highest mean score is the most pressing constraint. This approach is normally employed when analyzing the constraints of a heterogeneous group.

The Kendall's Coefficient of Concordance is another simple approach used to identify and rank constraints facing farmers. A list of constraints are presented to respondents to rank from the most pressing to the least pressing constraints. The mean rank of each constraint is estimated with the least mean rank value being the most pressing constraint and the others following in succession. The Kendall's Coefficient of Concordance (W) is used to measure the degree of agreement among the rankings (Legendre, 2005). The formula is given as:

$$W = \frac{12[\sum T^2 - (\frac{\sum T^2}{n})]}{nm^2(n^2-1)} \quad (2.14)$$

where:

T = sum of ranks for each constraint

m = number of respondents

n = number of constraints ranked

Obtaining the index help to ascertain whether there is an agreement among the rankings or not. The coefficient takes a value between 0 and 1. A coefficient of one means that there is a perfect agreement on the ranking of the constraints while a coefficient of 0 means the highest level of disagreement exists among the respondents (Mattson, 1986).

This approach also allows for hypothesis testing in order to conclude on the agreement among the ranking of respondents. The chi-square test or f-test can be used to test for the agreement. The null and alternate hypotheses are stated as:

H_0 : There is no agreement among the rankings of the constraints by the farmers.

H_A : There is an agreement among the rankings of the constraints by the farmers.

The decision rule is: if $F_{cal} > F_{crit}$, we reject the H_0

In addition, this approach is suitable for a homogenous group who are affected by similar constraints.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

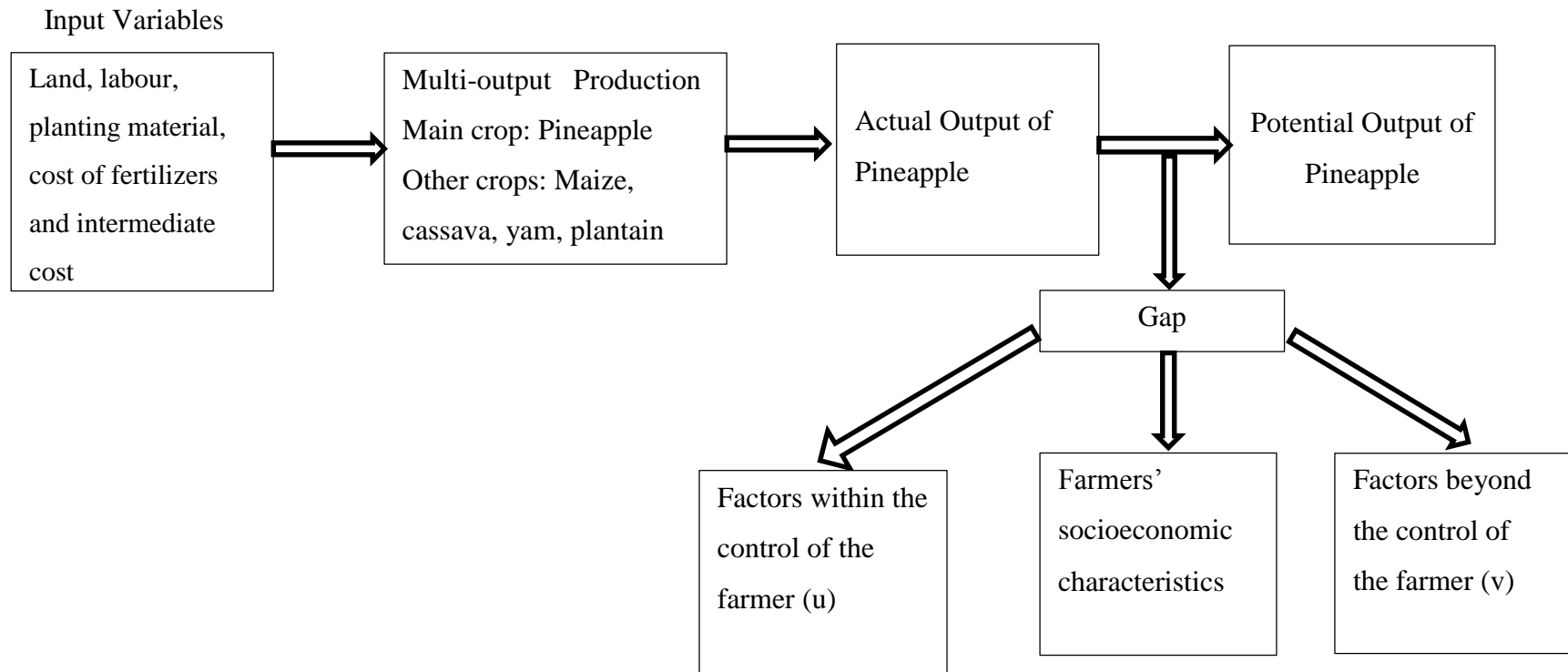
This chapter discusses the conceptual and theoretical framework. In addition, the empirical models that were used to estimate the production efficiency and the factors determining the technical efficiency level of farmers are presented in this chapter. It also explores the methodologies that were used for addressing the various objectives of the study. Lastly, hypothesis testing, definition of variables in the model, assumptions made about the study, data requirements, sampling techniques, data collection methods and geographical area of study are discussed in this chapter.

3.2 Conceptual Framework

Agricultural production involves the conversion of inputs into outputs. Efficient production is associated with good management which entails combination of inputs at the right time. The inputs used in this study include: labour, planting material, fertilizer and intermediate cost. These inputs are expected to improve the production process in order to obtain optimum output given a particular technology. However, lack of these inputs and improper usage of inputs brings about a gap in output levels. The gap in production can also be explained by certain socio-economic inefficiencies such as experience and access to credit. If these determinants are lacking they introduce some inefficiencies in the production process and cause output gaps in the long run. There are other factors that bring about gaps in production. Some factors are within the control of the farmer and can be solved by the farmer. These factors are mostly farming activities such as fertilizer

application and method of land preparation. Applying less than the recommended amount of fertilizer will lead to lower output levels. Also, using the slash and burn method for land preparation is not suitable since rocks and large stones on the plot of land are not properly cleared and this reduces the surface area available for production leading to lower output levels. Some of these factors are also beyond the control of the farmer. These factors include: the effects of statistical noise present in the model and other factors such as bad weather, nature of soil etc. The farmer cannot solve these problems hence they prevent farmers from obtaining their potential output. Figure 3.1 below shows the conceptual framework of the production efficiency of pineapple production together with the production of other crops in the Akwapim-South District.

Figure 3.1: A Conceptual Framework of the Production Efficiency of Pineapple Production in Conjunction with the Production of Other Crops



Source: Author's Own Conception, 2018

3.3 Theoretical Framework

The translog output distance function is the theory applied in this study. For the purpose of estimating the distance from the frontier (distance function in a parametric setting), there is the need to determine the frontier as well as the relationship between inputs and outputs. There is also the need to identify some form of multi-output production function $P(x)$. The commonly used functional form assumed is the translog production function. This is because the incorporation of its squared and cross-product (interactive) terms introduces a high degree of flexibility. Also it does not impose restrictions concerning substitutability between inputs or outputs. The translog distance function with M ($m = 1, 2, \dots, M$) outputs and K ($k = 1, 2, \dots, K$) inputs, and for I ($i = 1, 2, \dots, I$) farmers can be represented in an equation form (equation 3.1) given below.

$$\ln D_{0i} = \alpha_0 + \sum_{m=1}^M \alpha_m \ln y_{mi} + \frac{1}{2} \sum_{m=1}^M \sum_{n=1}^M \alpha_{mn} \ln y_{mi} \ln y_{ni} + \sum_{k=1}^K \beta_k \ln x_{ki} + \frac{1}{2} \sum_{k=1}^K \sum_{l=1}^K \beta_{kl} \ln x_{ki} \ln x_{li} + \sum_{k=1}^K \sum_{m=1}^M \delta_{km} \ln x_{ki} \ln y_{mi} \quad (3.1)$$

As stated by O'Donnell & Coelli (2005) as well as Coelli & Perelman (2000), the parameters of the distance function in equation 3.1 must theoretically satisfy linear homogeneity in terms of output and regularity conditions thus monotonicity and curvature.

Symmetry is then imposed as:

$$\alpha_{mn} = \alpha_{nm}; m, n = 1, 2, \dots, M \text{ and} \quad (3.1.1)$$

$$\beta_{kl} = \beta_{lk}; k, l = 1, 2, \dots, K. \quad (3.1.2)$$

Lovell *et al.* (1994) and Coelli *et al.* (1999) explain that one can impose homogeneity of degree +1 by normalizing the output distance function by one of the outputs. It is

observed that homogeneity implies that setting $\theta = \frac{1}{y_m}$ and substituting it in equation 3.1

implies the distance function can be obtained as seen in equation 3.2:

$$D_o(x, y / y_M) = D_o(x, y) / y_M \quad (3.2)$$

Hence the translog expression for the i^{th} farmer would be expressed in equation 3.3 as:

$$\ln(D_{oi}(x, y) / y_{Mi}) = TL(x_i, y_i / y_{Mi}, \alpha, \beta, \delta), i=1, 2, \dots, N \quad (3.3)$$

The translog expression would be expressed fully in equation 3.4 below:

$$\begin{aligned} TL(x_i, y_i / y_{Mi}, \alpha, \beta, \delta) = & \alpha_0 + \sum_{m=1}^{M-1} \alpha_m \ln(y_{mi} / y_{Mi}) + \frac{1}{2} \sum_{m=1}^{M-1} \sum_{n=1}^{M-1} \alpha_{mn} \ln(y_{mi} / y_{Mi}) \ln(y_{ni} / y_{Mi}) \\ & + \sum_{k=1}^K \beta_k \ln x_{ki} + \frac{1}{2} \sum_{k=1}^K \sum_{l=1}^K \beta_{kl} \ln x_{ki} \ln x_{li} + \frac{1}{2} \sum_{k=1}^K \sum_{m=1}^{M-1} \delta_{km} \ln x_{ki} \ln(y_{mi} / y_{Mi}) \end{aligned} \quad (3.4)$$

By rearranging the terms in equation 3.4, the function (equation 3.5) can then be rewritten as:

$$-\ln(y_{Mi}) = TL(x_i, y_i / y_{Mi}, \alpha, \beta, \delta) - \ln D_{oi}(x, y), i=1, 2, \dots, N \quad (3.5)$$

where $-\ln D_{oi}(x, y)$ is equivalent to the radial distance function from the boundary. Hence by setting $-\ln D_{oi}(x, y) = u$ and in addition capturing the noise effect by adding the term v_i produces Battese & Coelli (1988) kind of the conventional stochastic frontier model that was proposed by Aigner, *et al.* (1977) and Meeusen & Van den Broeck (1977) as seen in equation 3.6 below:

$$-\ln(y_{Mi}) = TL(x_i, y_i / y_{Mi}, \alpha, \beta, \delta) + \varepsilon_i \quad (3.6)$$

$$\varepsilon_i = v_i + u_i \quad (3.6.1)$$

where:

ε_i = is the composed error term.

$-\ln D_{0i}(x, y) = u$ represents the inefficiency (one-sided inefficiency term) of the farmer and it follows some probability distribution. The error term u_i is a non-negative random term

v_i = it represents the occurrence that are beyond the control of the farmer (random noise).

To estimate technical efficiency, the multiplicative translog function is considered and estimated alongside the composite error term; which is comprises noise and inefficiency. However, a technology can be specified by using an output distance function, D_{oi} . In reference to the work of Coelli & Perelman (1996), a translog output distance function with K inputs and M outputs is specified in equation 3.7 as:

$$\begin{aligned} \ln D_{0i} = & \alpha_0 + \sum_{m=1}^M \alpha_m \ln y_{mi} + \frac{1}{2} \sum_{m=1}^M \sum_{n=1}^M \alpha_{mn} \ln y_{mi} \ln y_{ni} + \sum_{k=1}^K \beta_k \ln x_{ki} \\ & + \frac{1}{2} \sum_{k=1}^K \sum_{l=1}^K \beta_{kl} \ln x_{ki} \ln x_{li} + \sum_{k=1}^K \sum_{m=1}^M \delta_{km} \ln x_{ki} \ln y_{mi} \end{aligned} \quad (3.7)$$

When specifying an output distance function, there is the need to impose restrictions on the translog output distance function. This is to ensure linear homogeneity in outputs and the required restrictions are as follows:

For homogeneity of degree +1 in outputs are:

$$\sum_{m=1}^M \alpha_m = 1 \text{ and } \sum_{n=1}^M \alpha_{nm} = 1 \quad m = 1, 2, \dots, M \quad (3.7.1)$$

$$\sum_{m=1}^M \delta_{km} = 1 \quad k = 1, 2, \dots, K \quad (3.7.2)$$

Evidently, the output distance function has outputs which are generally considered as part of the dependent variables and above all, the output distance function has an unobserved value. In addressing these two problems, the output distance function is normalized by dividing all outputs by a reference output (example y_2). The negative of the natural logarithm of D_{oi} can be added to independent variables in the model, which then becomes our inefficiency term. Lastly, in estimating the stochastic frontier, the error term v_i , which has a normal distribution is added. The function (equation 3.8) is then estimated as:

$$\begin{aligned} -\ln y_{li} = & \alpha_0 + \sum_{m=1}^{M-1} \alpha_m \ln(y_{mi} / y_{li}) + 0.5 \sum_{m=1}^{M-1} \sum_{n=1}^{M-1} \alpha_{mn} \ln(y_m / y_{li}) \ln(y_{mi} / y_{li}) \\ & + \sum_{k=1}^K \beta_k \ln x_{ki} + 0.5 \sum_{k=1}^K \sum_{l=1}^K \beta_{kl} \ln x_k \ln x_{li} + \sum_{k=1}^K \sum_{m=1}^M \delta_{km} \ln x_{ki} \ln(y_{mi} / y_{li}) + v_i + u_i \end{aligned} \quad (3.8)$$

Technical efficiency is then estimated by the expected value of u_i or $\ln D_{oi}$. Several authors have argued that the process of normalizing is suitable as this is done to prevent the potential problem of endogeneity that may arise in the specification. Coelli & Perelman (2000) argued that since ratios are being used, they may be assumed to be exogenous. This conclusion seems well accepted now.

3.3.1 Empirical Model Specification

According to Coelli & Perelman (1996), in empirical studies it is assumed that the PPF is known and hence distances of farms or firms away from the efficient frontier can be computed while in reality it is unknown and must be computed by other means. The study employed parametric stochastic frontier using the MLE method for estimating distance function technologies. The stochastic frontier maximum likelihood approach was first proposed by Aigner, *et al.* (1977) in a production function and this method is based on the concept of the composed error term which consists of the symmetric and asymmetric error terms with the former accounting for the statistical noise thus factors beyond the control of the decision making unit (DMU) while the latter accounts for the inefficiencies that arise from production. A functional form that simultaneously estimates the technological parameters and inefficiency parameters of the error term of the inefficiency component is assumed.

According to Coelli & Perelman (1996), in selecting a functional form for an empirical parametric study or analysis, the fundamental decision to make is the choice of a functional form. The functional form for the distance function preferably has to be flexible, simple to compute and also allow for the imposition of homogeneity. Since the translog functional form meets these three requirements it has been used by several authors in the distance function estimation (Lovell *et al.*, 1994, Grosskopf *et al.*, 1996, Mensah & Brümmer, 2016).

3.4 Identifying the Influence of Inputs on Pineapple Production

To identify the influence of inputs on productivity, a translog stochastic output distance function with two outputs, (y_1, y_2) and four inputs, $x_i = (x_1, x_2, x_3, x_4)$ was used and the model is specified as seen in equation 3.9:

$$\begin{aligned}
 -\ln(y_{1i}) = & \alpha_0 + \alpha_1 \ln(y_{2i} / y_{1i}) + 0.5\alpha_{11} \ln(y_{2i} / y_{1i}) \ln(y_{2i} / y_{1i}) + \sum_{k=1}^{K=4} \beta_k \ln x_{ki} \\
 & + 0.5 \sum_{k=1}^{K=4} \sum_{l=1}^{K=4} \beta_{kl} \ln x_{ki} \ln x_{li} + 0.5 \sum_{k=1}^{K=4} \delta_k \ln x_{ki} \ln(y_{2i} / y_{1i}) + v_i + u_i
 \end{aligned} \tag{3.9}$$

where:

y_{1i} = value of pineapple produced in Ghana Cedis (GH¢) per hectare by the i th farmer in the 2017/18 production year.

y_{2i} = value of the other crops produced in Ghana Cedis (GH¢) per hectare.

The input factors (x_i) that are included in model 3.9 are:

x_1 = fertilizer (GH¢)

x_2 = labour (man-days)

x_3 = intermediate cost (GH¢)

x_4 = cost of pineapple suckers (planting materials) (GH¢)

α , β and δ = are the unknown parameters that are to be estimated

Description of Variables in the Translog Distance Function

y_{1i} depicts the value of pineapple produced in Ghana cedis (GH¢) per hectare by the i -th farmer in the 2017/18 production year. The output of pineapple was measured on per

hectare basis because each pineapple output produced by the i -th farm was scaled by their respective farm size and then normalized by its mean.

y_{2i} is the normalized output, thus the value of the other crops that are produced in Ghana cedis per hectare (GH¢ per hectare) in relation to the value of pineapple produced which is equal to the “output ratio” of the value of other crops (the value of cassava + maize + plantain + yam) in relation to the value of pineapple produced by the i -th farmer in the 2017/18 production year.

The shadow share which is the contribution of pineapple in the total output could be obtained by using the homogeneity restriction and is specified in equation 3.10 as:

$$\sum P = 1 - \sum \beta \quad (3.10)$$

where

$\sum P$ = the overall contribution of pineapple.

$\sum \beta$ = the coefficient of other crops.

The input variables were estimated on per hectare basis. They were standardized by dividing through by their respective farm sizes and then normalized by dividing through their respective means. This implies that after taking the logs, the first-order distance elasticities can be interpreted as partial elasticities in relation to the inputs.

Land (farm size) was therefore not included in the list of input variables since the input variables were standardized by their respective farm sizes and therefore it was already incorporated in the model.

X_1 = denotes the cost of fertilizer and it includes both solid and liquid fertilizers. It was measured in Ghana cedis (GH¢) per hectare. The cost of fertilizers that were incurred during the production season was computed and standardized by dividing through by its farm size.

X_2 = denotes the labour component of the input variable and it was measured in man-days and it was then standardized by its farm size. Man-days were computed according to the rule that one adult male, one adult female and one child (≤ 18 years) working for one day (8 hours) was equal to 1; 0.75 and 0.50 man-days respectively. These ratios were adopted from Coelli & Battese (1996) and Battese *et al.* (1996).

X_3 = depicts the intermediate cost component. This refers to the cost of other items and services that were involved in the pineapple production process. Its unit of measurement was in Ghana cedis (GH¢) per hectare. The intermediate cost consists of items such as cost of hired items, cutlass, knapsack spray, hoes, watering-cans, transportation costs etc. of the i -th farm during the 2017/18 production year.

X_4 = depicts the cost of the planting materials and it was measured in Ghana cedis (GH¢). The various costs of planting material (suckers) was then divided by their respective farm sizes to get the unit of measurement as Ghana cedis (GH¢) per hectare.

The summation of the distance elasticities of the input variables gives an indication of the returns to scale of the production function. This shows how output changes with respect to input use. The returns to scale can be increasing, decreasing or constant.

When: $\sum EP > 1$, the production system exhibits increasing returns to scale

$\sum EP = 1$; the production system exhibits constant returns to scale

$\sum EP < 1$; the production system exhibits decreasing returns to scale

Where $\sum EP$ means summation of the distance elasticities of the inputs used.

3.5 Identifying the Determinants of Technical Inefficiency

In investigating how the socioeconomic characteristics of pineapple farmers influence their production, a heteroskedastic corrected inefficiency model was used as suggested by Wang & Schmidt, (2002) and it is expressed in equation 3.11 below:

$$\sigma_{ui} = \exp\{z_{ij}\delta_j\} \quad (3.11)$$

Equation 3.11 assumes that the explanatory variables Z_{ij} thus level of education, years of farming experience, number of extension visits, size of household size, age and gender of pineapple farmers affect the level of technical inefficiency hence produces technical efficiency scores that include these factors.

The parameter estimates of the output oriented technical efficiency and the determinants of its inefficiency were derived by jointly estimating equation 3.9 and 3.11 using the MLE method with Stata Version 14 Statistical Software. Thus the maximum likelihood estimation technique was used to estimate the one-step model which clearly identifies both the stochastic frontier and technical inefficiency model.

Description of Variables and A-priori Expectation

The determinants used in this study include: age, educational level, farming experience, farm size, the number of extension visits and household size. These variables were derived from literature. Table 3.1 presents the variables in the inefficiency models and their expected signs.

Age

Age is measured in years and the age of a farmer represents his actual age. The use of age serves as a proxy for farming experience in the inefficiency model. (Owuor & Shem, 2009). Since farming experience increases with age, it is expected that older farmers will have a positive impact on technical inefficiency. This apriori expectation was confirmed in a study conducted by Ojo (2003) on the productivity and technical efficiency of poultry egg production in Nigeria.

Gender

Gender is a binary variable was incorporated in the model to estimate the effect that the gender of farmers have on technical efficiency thus one (1) if the farmer is a male and zero (0) if the farmer is a female. The anticipated sign is negative since gender is expected to have a positive effect in reducing technical inefficiency. A study by Tewodros (2001) revealed that female-headed households contributed positively to technical efficiency and was also significant. This was because the greater majority of the farmers that were interviewed were females. For this study however, male-headed

household is expected to yield a positive influence on technical efficiency since the greater majority of farm households are male dominated.

Table 3.1: Variables in the Inefficiency Model and Their Expected Signs

Code	Variable	Measurement	A-priori Expectation
Age	Age of respondent	Years	-
Gen	Gender	Dummy (1= Male 0= Female)	-
Hhs	Household size	Number of persons	-
Edu	Educational level	Years	-
FExp	Farming Experience	Years	-
ExtV	Extension workers visits	Number of times	-
AccCredit	Credit Accessibility	Dummy (1= accessible 0= not accessible)	-
FBO	FBO membership	Dummy (1= member 0 = otherwise)	-

Source: Computed from field data, 2018

Experience

This was also measured in number of years thus the number of years that the farmer has been in pineapple production. This is expected to positively influence efficiency since it is believed that experienced farmers may have accumulated more knowledge in pineapple production which will increase their likelihood of adopting improved technologies that will eventually increase their efficiency levels.

Household Size

In this study, a household as defined by Ellis (1993) is a group of social unit sharing the same residence. This variable focuses on the number of people who makes up the household size of the farmer. This includes the farmer, his/her spouse(s), children as well

as any other relative who resides and are being catered for by the farmer. A similar approach and estimation of household size has been employed by several authors such as Alhassan (2008).

Education

Education was measured in number of years that was attained by the farmer. The expected sign for this variable is negative since education is expected to have a positive effect in reducing technical inefficiency. This implies that the higher the number of years that one attains education, the more efficient he/she becomes. This is in line with studies such as Onumah & Acquah (2010), Kuwornu, *et al.* (2013) whose studies revealed that education was found to reduce the level of inefficiency.

Extension Visits

From the onset, extension contact was dummied with one (1) representing when the response was yes and zero if otherwise. However, the extension visits was used for the analyses since it gave a better basis for estimation because farmers who responded yes might record varying frequencies of extension visits. Extension is expected to reduce technical inefficiency since extension agents are expected to advice farmers on the best practices to adopt as well as introducing them to new technologies. A study conducted by (Awunyo-vitor *et al.*, 2013) found extension visits being consistent with this a-priori expectation.

Access to Credit

Access to credit was dummied with one (1) being responding yes and zero (0) as otherwise to the question of if the farmer had access to credit during the 2017/18 production year. Farmers who had access to credit are expected to be efficient since it enables them to purchase the needed inputs that will enhance their productivity.

FBO Membership

FBO membership was dummied with one (1) depicting those who belong to such organizations and zero (0) if otherwise. FBOs are expected to improve efficiency since such associations are able to access extension services, have a stronger bargaining power and also access credit from financial institutions.

3.6 Hypothesis to be Tested

The following hypothesis were investigated in the study in order to establish its appropriateness of the specified models, the presence of inefficiency as well as explain the significance of the independent variables in explaining the inefficiency of the pineapple farmers.

1. $H_0: \beta_{ij} = 0$: the null hypothesis states that the squared and cross-product (interactive) terms in the translog model are zero. This implies that the Cobb-Douglas model best fits the data.
 $H_1: \beta_{ij} \neq 0$: the alternate hypothesis states that the coefficient of the squared and interactive (cross-product) terms in the translog model are not zero.

2. $H_0: \gamma = \delta_0 = \delta_1 = \dots = \delta_8 = 0$: the null hypothesis states that the inefficiency effects are absent from the model at every level.

$H_1: \gamma = \delta_0 = \delta_1 = \dots = \delta_8 \neq 0$: the alternate hypothesis states that the inefficiency effects are present in the model at every level.

The above hypotheses were tested using the generalized likelihood ratio test: $LR = -2[L(H_0) - L(H_1)]$, where $L(H_0)$ and $L(H_1)$ are the values of log likelihood functions under the null and alternate hypothesis respectively (Greene, 1980). The null hypothesis is rejected when the calculated chi-square is greater than the critical chi-square with degree of freedom (the number of restrictions at null hypothesis) at 1%, 5% or 10% level of significance i.e. $LR > \chi^2$.

3.7 Identifying and Ranking of Constraints in Pineapple Production

Literature was reviewed on studies done by Ninson (2012), Abbey (2005) and Obeng (1994) to identify constraints which were pre-tested and presented to the respondents to rank. The weighted average formula was used to find the mean rank of each constraint;

The formula is given in equation 3.12 as;

$$W \text{ average} = \frac{\sum T}{\sum m} \quad (3.12)$$

Where:

W average = Weighted average

$\sum T$ = sum of ranks for each constraint

$\sum m$ = Number of farmers

The mean rank with the least value is the most pressing constraint with others following in succession.

The Kendall's Coefficient of Concordance (W) was used to measure the degree of agreement among the rankings and can be estimated using equation 3.13.

$$W = \frac{12[\sum T^2 - (\frac{\sum T^2}{n})]}{nm^2(n^2-1)} \quad (3.13)$$

Where:

T = sum of ranks for each constraint

m= number of respondents

n= number of constraint ranked

The agreement among the rankings will be tested using the F-test. The F-test ratio is stated in equation 3.14 as:

$$F_{cal} = \frac{\frac{[m-1]}{W}}{1-W} \quad (3.14)$$

Hypothesis

H₀: there is no agreement among the respondents

H_A: there is an agreement among the respondents

Decision rule: if $F_{cal} > F_{crit}$, we reject the H₀

3.8 Method of Data Collection

3.8.1 Types and Sources of Data

Primary data was the main source of data employed in the research. Secondary data sources such as journals, research publications, articles and other relevant materials were also consulted and used to gather relevant information from other researchers and literature works to aid in the research.

3.8.2 Sample Size and Sampling Method

A multi-stage sampling technique was employed to obtain a total of 135 respondents for this study. Pineapple farmers were the target population for the research. A list of farmers was obtained from the extension officers in the district. For the first stage, pineapple farmers were purposively selected from the list. This was followed by a cluster sampling to group the pineapple farmers according to their various communities. This was done carefully to ensure that farmers from all communities in the district were represented. Numbers were then assigned to the list of names provided and respondents were chosen at random from the assigned numbers.

3.8.3 Survey Instrument

A well designed and pre-tested questionnaire was used to acquire significant information from the respondents. A pre-test of the questionnaire was conducted to ensure that the instructions and questions were clear, there were no problems in answering the questions and the duration of the interview was not unduly long. Close-ended questions were posed which enabled the respondent to select a restricted set of answers. Open-ended questions

were also added which gave the respondents the opportunity to express their views on some important aspects. The questionnaire was composed of six sections. The first part described the socioeconomic characteristics of the farmers. In the second section, basic information on pineapple farming were provided. The third section was then designed to collect data on technical services and credit for farmers. Production information on inputs used and land requirements was provided in the fourth section followed by information on multiple output of pineapple farmers and information on farm constraints was captured in the last section.

3.8.4 Method of Data Analysis

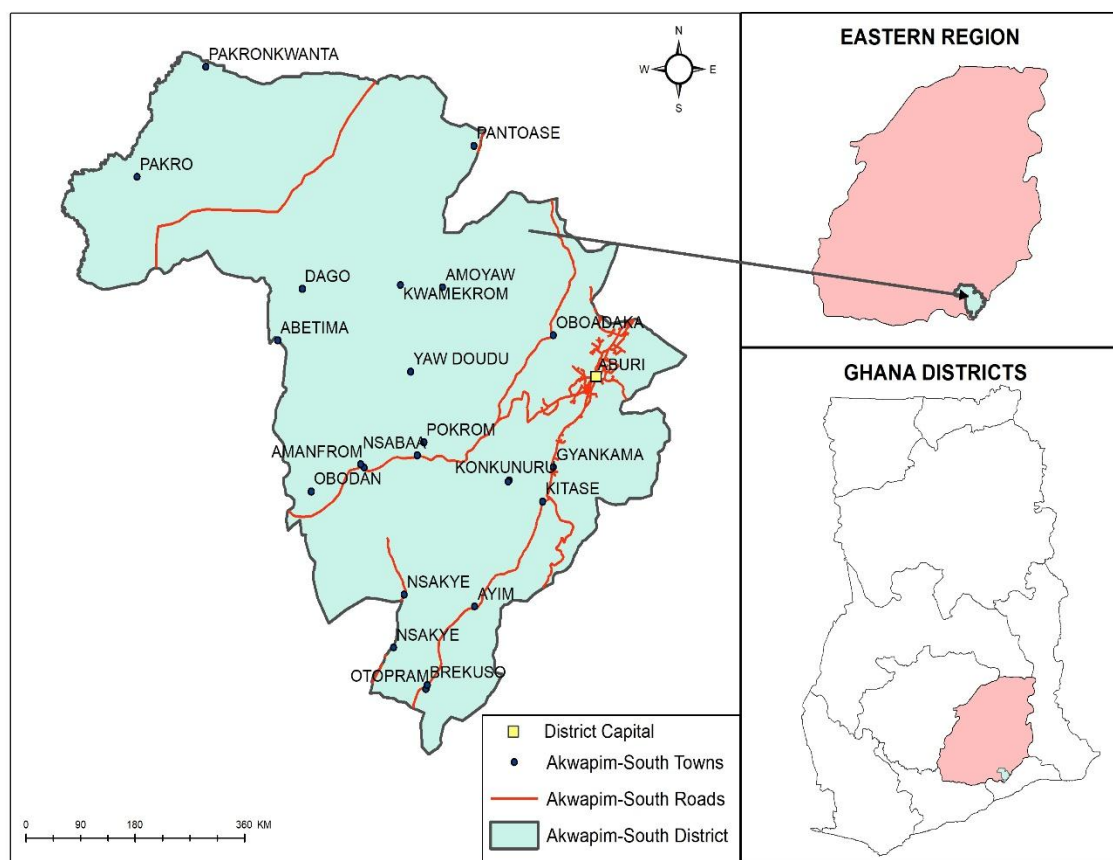
STATA statistical software (Version 14) was used for the data analyses. The use of the distance function estimation technique allowed for the examination of the production performance of farmers that produce both pineapple and other crops in the Akwapim-South District.

3.8.5 The Study Area

The research was conducted in the Akwapim-South District. The Akwapim-South District is located in the south eastern-part of the Eastern Region of Ghana. The district covers towns such as Pokrom, Berekuso, Yaw Duodo, Amanfrom, and others with Aburi as the capital of the district. The number of households that engage in agriculture is 4,475, representing 48.2 percent of the total number of households in the district (GSS, 2014). Majority (94.5 percent) of the households engaged in agricultural activities in the district are into crop farming. The dominant crop cultivated in the area is pineapple

(MoFA 2015). Other crops grown in cultivated in the area are maize, cassava, pawpaw and. It is evident that a significant proportion of the population in the district engaged in some form of farming with pineapple farming being predominant. The communities that were covered in the study were Pokrom, Nsakyi, Amanfrom, Oboadaka, Pepawani, Apatem, Kwasi Doi, Otiakrom and Yaw Duodu with at least ten (10) respondents from each community. Hence, the selection of Akwapim-South District as the study area was appropriate for this study. A Map of the Akwapim-South District is shown in Fig 3.2 below.

Fig 3.2: Map of Akwapim-South District (the Study Area)



Source: Geography Department (University of Ghana), 2018

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents and discusses the results of the study in relation to the specific set of objectives. It describes the socioeconomic characteristics of pineapple farmers in the Akwapim-South District. This chapter also presents and discusses the estimates of the translog distance function. Results of the influence of inputs on the productivity of pineapple production in the district and the constraints to pineapple production as perceived by the farmers are outlined. The constraints that the pineapple farmers faced were identified, ranked and discussed in the last section of this chapter.

4.2 Socioeconomic Characteristics of Respondents

The results for the socioeconomic characteristics of the respondents are presented in Table 4.1. Table 4.1 presents the results of the selected socioeconomic variables which includes gender, age, level of education, marital status, FBO membership and credit accessibility.

Age

The results on farmers' age distribution indicate that about 13.33 percent of farmers were youth (35 years and below). This clearly reaffirms the fact that farming is mostly carried out by adults since most of the Ghanaian youth shy away from farming. The majority (78.52 percent) of the farmers were found to be between the ages of 36 and 60 years with the rest being the elderly. Hence, the cultivation of pineapple is done mostly by the adults

between the ages of 36 and 60 years. This agrees with the study of Baruwa (2013) who also found pineapple farmers to be relatively old. The youth do not venture into pineapple cultivation since they don't see it as attractive and lucrative. The percentage involved is very low and discouraging. Also, the low percentage may result from the youth migrating to the city in search of jobs or they might even be present in the community but are engaged in the cultivation of crops other than pineapple. The elderly constituted 8.15 percent of the total sample size.

Table 4.1: Socioeconomic Characteristics of Respondents

Characteristics	Frequency	Percentages (%)
Age (in years):		
Youth (≤ 35 years)	18	13.33
Adults (36 – 60 years)	106	78.52
Elderly (≥ 60 years)	11	8.15
Total	135	100
Gender:		
Male	118	87.4
Female	17	12.6
Total	135	100
Educational level:		
No education	7	5.19
Basic	105	77.78
Secondary	23	17.04
Tertiary	0	-
Total	135	100
Marital Status:		
Single	6	4.4
Married	124	91.9
Divorced	4	3.0
Widowed	1	0.7
Total	135	100
FBO membership:		
Member	100	74.1
Otherwise	35	25.9
Total	135	100
Credit accessibility:		
Accessible	33	24.4
Non-accessible	102	75.6
Total	135	100

Source: Survey data, 2018.

Gender

The results from Table 4.1 also indicate that the majority (87.4%) of the farmers were males while the females were 12.6 percent. A study conducted by Ahwireng (2014) also recorded sixty-two percent (62%) males and thirty-eight percent (38%) females. This clearly shows that pineapple production is entirely male dominated. Cultivation of pineapple is labour intensive with majority of the farmers leaving their homes very early in the morning and returning late in the evening. As tradition and customs demands, women stay and take care of the homes when the men are away. Although pineapple production in the district is mainly male dominated, females take active part in functions such as gathering of fresh pineapple during the harvesting stage, packing and grading of fruits, transferring of suckers to new sucker plots for cultivation and fetching of water from the borehole sites to the farm. Due to the tedious nature of pineapple production, female farmers only play active roles after the males are done planting the pineapple suckers.

Level of Education

In the case of educational level, the majority of the farmers (94.82%) had at least basic education of which none had tertiary education. This indicates that most of the farmers are educated hence are literates. Hence they can read and know the right quantities of inputs to employ in their production activities. Alhassan (2008) opined that in order to attain the optimal frontier output, it is required that farmers have some of basic education which will enable them to understand and equip them with skills to operate modern technologies in their farming operations. However, farmers with higher educational achievements are not involved in pineapple production. This is quite disappointing since

their vast knowledge and technical skills can be applied to boost pineapple production in the area.

Marital Status

The marital status results indicate that 91.9 percent of the respondents were married. The rest were either single (4.4 percent), widowed (3.0 percent) or divorced (0.7 percent). Marital status is a proxy for the household to pull resources together to increase income and also provide more helping hands on the farm. Asante *et al.* (2013) also found married status to be the highest (84.1%).

FBO Membership

The results for FBO membership indicate that the majority 74.1 percent of the farmers were members of a Farmer Based Organization as seen in Table 4.1. Joining these groups will enable farmers to have access to vital information and other relevant inputs like farm equipment to increase their production. The few who were not members indicated that joining an association is not always favourable since some farmers consider it a waste of time and meetings held were usually unproductive. This suggests the reason for low patronage of these organizations as seen in some studies (Nyangaka *et al.*, 2010, Antwi, 2017).

Access to Credit

The findings also show that 75.6 percent of the farmers had no access to credit. Access to credit is an important factor for farm expansion. The inability of farmers to have access to

credit militated against their expansion and productivity. They also cited the high rate of interest that is charged on credit and collaterals demanded by these financial institutions as a major constraint in accessing credit. The table indicates that a small percentage of farmers had access to credit and these were from diverse sources. These sources include: loans from financial institutions (particularly microfinance and rural banks) and financial assistance from fruit processing companies, friends and relations. Tambo & Gbemu (2010) also states that farmer hardly receive financial assistance from formal institutions and therefore depend on their personal savings to a larger extent. In the study of Nyagaka et al. (2010), farmers faced problems in accessing credit; only 35 percent had access to credit. Trujillo & Iglesias (2013) also found as low as 21% of farmers having access to credit in his study.

Table 4.2 presents other characteristics of the sample data such as household size, farming experience and others.

Household Size

The results indicate that the mean household size is about 6 persons. Results from the study of Ninson (2012) in the Akwapim South District also showed recorded a mean household size of 6 persons. The number is quite high since these farmers live in the same household with their extended relations. These relatives provide sources of labour on the farm even though the use of hired labour is also employed in production. Hence farmers find it necessary to keep large family sizes in order to have more helping hands on the farm.

Farming Experience

The mean for the number of years of farming experience is about 14 years. This agrees with the findings of Nyagaka *et al.* (2010) who found an average farming experience of 14 years in analyzing the technical efficiency of farmers. Farming experience is necessary since it provides the expertise to work and deal with risks effectively. The farmers agreed that they are able to handle farm operations and risks better as they gained more experience. Rahman (2002) showed that farmers with higher levels of farming experience obtained higher efficiency levels. This conforms to the classical economic theory which recognizes the positive relationship between that specialization and efficiency.

Table 4.2: Characteristics of the Sample Data (Number of Observation = 135)

Variable	Unit	Mean	Min	Max	Std. Dev.
Pineapple	GH¢/ha	13,958.67	2,000	32,000	8640.07
Other crops	GH¢/ha	2,082.30	600	6,000	959.46
Labour	Man-days/ha	22.44	10	48	10.67
Fertilizer	GH¢/ha	730	200	1,800	296.93
Intermediate cost	GH¢/ha	1,504.70	500	3,300	682.25
Planting material cost	GH¢/ha	372.37	50	1,500	258.45
Education	Years	7.607	0	12	2.49
Experience	Years	14.081	2	36	6.39
Household size	Number of people in a household	5.66	1	14	2.19
Age	Years	46.81	27	74	9.15
Extension	Number of extension visits	3.96	0	14	3.50

Source: Computed from field data, 2018

Income from Pineapple Production

The minimum income from pineapple production recorded was GH¢2,000.00 per hectare and maximum is GH¢32,000.00 per hectare. This gives an average income of GH¢ 13,958.67 per hectare. A standard deviation of GH¢ 8,758.713 per hectare was obtained from the analysis which shows a high disparity of income among pineapple farmers in the Akwapim-South District. Farmers with lower incomes should be given special attention in order to boost their production activities.

4.3 Testing of Hypothesis

Table 4.3 below presents the various hypothesis tests on the statistical validity of the set of data and the appropriateness of the specified model

Table 4.3: Hypothesis Test for Model Specification and Statistical Assumptions

Null Hypothesis	Test Statistics (λ_{cal})	Critical Value	Decision (Reject H_0 if $\lambda_{cal} > \lambda_{crit}$)
1. $H_0: \beta_{ij} = 0$	82.89125	30.58	Rejected
2. $H_0: \gamma = \delta_0 = \delta_1 = \dots = \delta_8 = 0$	29.52848	26.12	Rejected

Source: Computed from field data, 2018

The generalized likelihood test ratio was used to test for both first and second hypothesis. The first null hypothesis tests the appropriateness of the chosen functional form of the production function. The second order variables in the translog model are zero which implies that the Cobb-Douglas frontier is an adequate representation for the data. The null hypothesis was strongly rejected at 1 percent significance level. Thus specifying the translog stochastic frontier functional form is more appropriate to deduce conclusion from the data. Mensah & Brümmer (2016) and Ogundari & Brümmer (2011) stated in their works that the Cobb-Douglas functional form has a wrong curvature in the (y_1, y_2)

space. The second hypothesis which specified that inefficiency is absent from the model was rejected at 0.001 percent level of significance. This implies that the inefficiency effects are related to the exogenous variables but have a particular distribution which is determined by the exogenous variables.

4.4 Influence of Inputs on Productivity

Objective one was to identify the influence of inputs on the productivity of pineapple production in the district. The results from the parameter estimates of the translog distance function model are given in Table 4.4.

The dependent variable is the total pineapple output which is measured in monetary value (GH¢/ha). The independent variables include the value of other crops (GH¢/ha), fertilizer (GH¢/ha), labour (man-days/ha), planting material (GH¢/ha) and intermediate cost (GH¢/ha). All the input variables possessed the expected sign and therefore the monotonicity condition at the sample mean was satisfied. This was observed in the study of Ogundari and Brümmer (2011) who also stated that all input must conform to the monotonicity condition by possessing the negative sign. A negative sign in front of the distance elasticities results implies a positive contribution to the production of pineapple in the district. All the input variables were found to be significantly different from zero (0); labour, cost of planting material (suckers) and intermediate costs were significant at 1 percent whiles fertilizer was significant at 5 percent. This means that all the input variables contributed significantly to the production of pineapple in the district.

Table 4.4: Parameter Estimates of the Translog Distance Function Model

Variable	Coefficient	P > z
Constant	-0.190	0.000
Ln (Other Crops)	0.024***	0.001
Ln (Fertilizer)	-0.181**	0.016
Ln (Labour)	-0.508***	0.000
Ln (Planting Material)	-0.286***	0.000
Ln (Intermediate Cost)	-0.227***	0.003
Ln (Other Crops Square)	0.747*	0.057
Ln (Fertilizer Square)	0.441	0.517
Ln (Labour Square)	0.646	0.295
Ln (Planting Material Square)	1.110***	0.000
Ln (Intermediate Cost Square)	-1.382**	0.015
Ln (Other Crops*Fertilizer)	1.617***	0.000
Ln (Other Crops*Labour)	-0.360	0.324
Ln (Other Crops*Planting Material)	-0.607***	0.000
Ln (Other Crops*Intermediate Cost)	0.447	0.307
Ln (Fertilizer*Labour)	0.087	0.864
Ln (Fertilizer*Planting Material)	-0.860***	0.000
Ln (Fertilizer* Intermediate Cost)	0.139	0.783
Ln (Labour*Planting Material)	-0.314*	0.071
Ln (Labour* Intermediate Cost)	0.178	0.628
Ln (Planting Material * Intermediate Cost)	-0.315*	0.077

Level of significance 1% *** 5% ** 10% * Log likelihood = 116.69048
 Number of obs = 135 Wald chi2 (20) = 1677.24 Prob > chi2 = 0.0000
 ***, **, * = coefficients are significantly at 1, 5 and 10 percent respectively.

Source: computed from survey data, 2018

As presented in Table 4.4, the marginal productivity of labour was the largest it showed the highest absolute value of the distance elasticity among the input variables. Ogundari & Brümmer (2011) and Amewu & Onumah (2015) also concluded that labour had the highest distance elasticity value in their study on technical efficiency of cassava and cost efficiency of producing households respectively. This shows the importance of labour in the production of pineapple in the district and agricultural production as a whole. In a similar manner, a positive sign in front of other crops distance elasticity depicts a negative shadow share contribution to pineapple production in the output mix. The effect of elasticity on other crops is completely the opposite as a result of the homogeneity constraint in outputs which conforms to the findings of Brümmer *et al.* (2002).

The shadow share of pineapple in the total farm output is calculated as 0.976 (97.6 percent) while that of other crops is 0.024 (2.4 percent). Majority of the farmers interviewed cultivated pineapple mainly for the fruit processing companies, export and local market. This therefore resulted in the large share to total revenue in relation to other crops and was consistent with the data and expectation. The relatively lower parameter estimate of other crops output elasticity shows the low shadow share of crops in the multi-output production set up. The other crops produced were mainly for consumption and local market. The 0.0242 coefficient of other crops can as well represent the slope of the PPF at the sample mean. This means that it captures the MRT between pineapple and other crops produced in relation to the output mix and was significant at 1 percent. The coefficient of the squared terms of other crops from the distance function results was

positive and significant at 1 percent thereby substantiating the evidence of convexity in the output at the sample mean.

On the cross-term effect, there was significant evidence of input substitution effect between labour and planting material, fertilizer and planting material, planting material and intermediate cost, other crops and planting material. The economic explanation for the significant evidence of the input substitution effect between labour and planting material could be attributed to the high cost of labour in pineapple production. The sampled farmers substitute labour for planting materials (suckers) in order to undertake some production activities. In buttressing the above point, it can be clearly seen from the earlier findings in this study that labour had the highest share of output distance elasticities and very necessary in production. A substitution effect was observed between fertilizer and planting material.

Both input variables are production costs thus the allocation of a proportion of the budget for inputs will cater for the costs of these inputs. An increase in the cost of fertilizer would therefore reduce the amount planting materials that can be purchased and vice versa. This economic interpretation can be used to explain the substitution effect between planting material and intermediate cost. The explanation for the relationship between other crops and planting material is that; an increase in the production of other crops will reduce the land area of pineapple under cultivation since land is a fixed variable. A smaller land area will require less planting material during production.

Complementarity effect was however observed between other crops and fertilizer. This implies that as more of other crops are grown, the cost of fertilizer increases. These other crops will require fertilizer at different stages of the production process. The farmer therefore has to purchase fertilizer for both pineapple production and the production of other crops. This will increase the amount and cost of fertilizer used in production.

For the purpose of calculating the RTS, results from Table 4.4 have been simplified and presented in Table 4.5. The coefficients of the inputs were summed up to obtain the scale elasticity of production as seen in Table 4.5. An absolute value of 1.202 was obtained from the summation of the coefficients of the input variables. This implies that at the sample mean, the production system exhibited increasing returns to scale. The result can be economically interpreted as; 1% joint increase of the inputs increases pineapple production by about 1.2%. The RTS is also significantly different from zero.

Table 4.5: Average Distance Elasticities and Returns to Scale

Variables	Coefficient
Pineapple	0.976
Other Crops	0.024***
Fertilizer	-0.181**
Labour	-0.508***
Planting Material	-0.286***
Intermediate Costs	-0.227***
RTS	1.202

Source: Computed from survey data, 2018

An increasing RTS of 1.202 implies that pineapple farmers in the Akwapim-South District are producing at the first stage of the production function and as such output can be increased in the short term if inputs are increased. It is irrational for a producer to

produce at the first stage of the production curve and therefore doubling the amount of inputs that are used in the production process, will lead to more than doubled increase in the output. Farmers should also maintain good agronomic practices in order to increase their total farm output. This will also result in a reduction of the average cost of production per unit of production. Donkoh *et al.* (2013) undertook a study on the Technical Efficiency of Tomato Farmers in Northern Ghana and estimated returns to scale of 1.202.

4.5 Estimated Technical Efficiency Score

The results from Table 4.6 reveal that the farmers produce, on average, 86 percent of the potential output given the current technology available to them. This implies an average increase of 14 percent in output margins is possible if production inefficiency is eliminated.

Table 4.6: Technical Efficiency Score

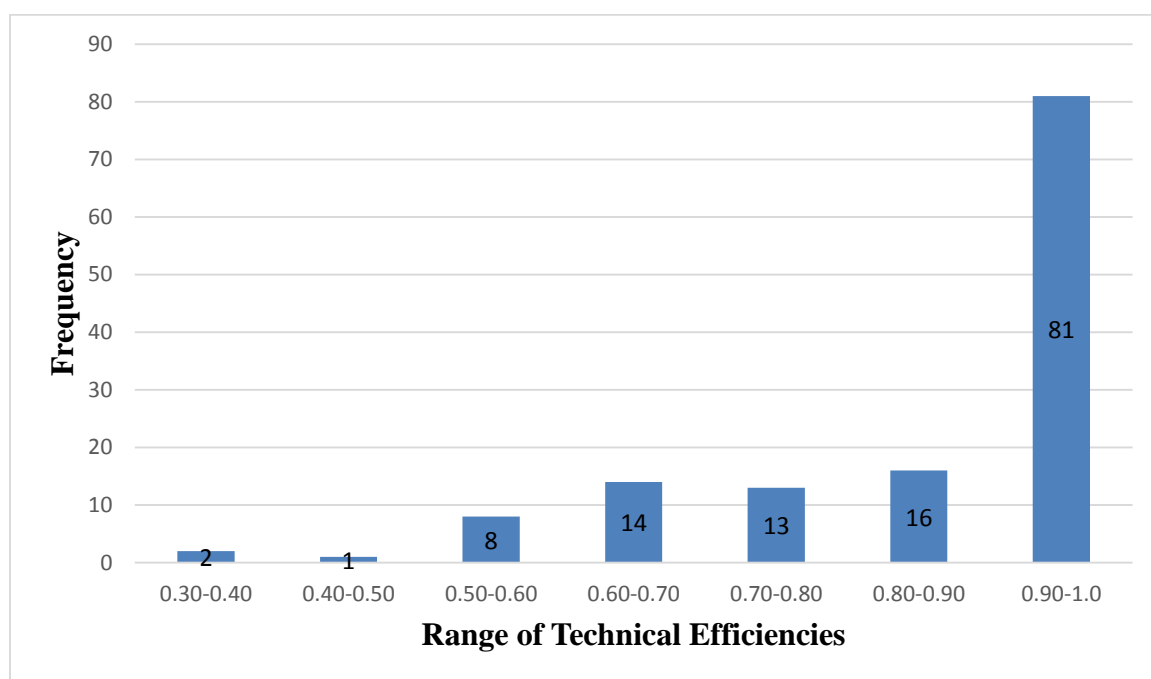
Observations	Mean	Standard deviation	Minimum	Maximum
135	0.8576	0.1501	0.3056	0.9939

Source: Computed from field data, 2018.

The performance score of the farmers is distributed over a range from a minimum of 0.31 to a maximum of 0.99 as seen in Figure 4.1. This conforms to the study done by Kusa (2012) on Agricultural Productivity. This wide variation in technical efficiency scores indicates the presence of varying levels of resource utilization among the pineapple farmers. The district thus demonstrates an uneven distribution of pineapple farmers across the technical efficiency score. Nevertheless, most scores are close to the mean efficiency score. The distribution is moving to the right direction indicating that the graph

is positively skewed. This implies that majority of the farmers have high efficiency scores. The high efficiency scores resulted from farmers receiving assistance in the form of education and training from the fruit processing companies and other NGOs. This is not surprising since the study of Ogundari (2014) also showed that all African countries had a positively skewed distribution with West Africa having the highest mean efficiency score.

Figure 4.1: Frequency Distribution of Technical Inefficiency



Source: Computed from field data, 2018

4.6 Determinants of Technical Inefficiency Levels

The coefficients and significant levels of the determinants of inefficiencies among pineapple farmers in the Akwapim-South District are presented in Table 4.7.

Table 4.7: Determinants of Technical Inefficiency Levels

Variables	Co-efficient	P-value
Age	-0.056	0.163
Gender	0.129	0.841
Extension Visits	-0.336***	0.000
Experience	0.069	0.227
FBO	-0.254	0.552
Education	-0.323***	0.000
Household Size	0.051	0.675
Access to Credit	-0.813*	0.080
Constant	0.872	0.581

*, **, *** significant at the 10%, 5% and 1% respectively

Source: Computed from field data, 2018.

Number of extension visits, level of education and access to credit have significantly positive effects in reducing production inefficiency. The coefficient of extension visit is negative. The frequent extension visits by extension agents is expected to enhance technical efficiency of farmers in the district. FTF (2015) puts forward that effective agricultural extension systems which are characterized by quality and timely delivery of services to farmers contribute significantly to growth and development in the agricultural sector. Extension agents serve as a link between farmers and researchers and are channels through which new innovations in farming methods are introduced and communicated to farmers. Farmers who interact regularly with extension agents are therefore more efficient since regular interactions lead to better rate of adoption. They as well play advisory roles to farmers and engage them in training sessions that will equip them with the requisite knowledge on the best input to employ that which will enhance their productivity. A study conducted by Onumah *et al.* (2009) indicates that output increased by 9% for fish farms who had at least one extension visit during the 2007 production

year. The findings of Antwi (2017) and Ogundari (2013) also conform to the findings of this study.

The study found a negative correlation between education and technical inefficiency. This conforms to the findings of Ahwireng (2014). This suggests that educated farmers are more capable of obtaining new information on inputs and outputs prices, as well as being more willing to use modernized technologies to improve their farm operations as compared to uneducated farmers who are conservative in their production methods. Educated farmers are also able to keep accurate records of farm operations and ensure the optimal utilization of various farm inputs through effective resource allocation techniques. Kalirajan & Shand (1985), however, argue that farmers' education is not necessarily positively related to their yield achievement and efficiency. They stated that though education is an important factor influencing efficiency, illiterate farmers can also understand modern production technologies and put them into practice very effectively. This can be done through effective training and proper communication of the technologies to the farmers. Agricultural extension agents from both the private and public sector should therefore find appropriate and practical means of relaying information on these technologies to farmers.

Access to credit had a negative correlation with technical inefficiency. This implies that farmers who have access to credit rely on them to adopt best farming practices. Credit is also needed to meet the high costs involved in production. This will go a long way to increase their productivity and efficiency. Authors such as Nyagaka *et al.* (2010) and Obwona (2006) also found credit to have a positive influence on technical efficiency.

The rest of the inefficiency variables (Age, gender, farming experience, FBO membership and household size) showed weak correlation and are statistically insignificant. This implies that there is no relationship between these variables and technical inefficiency. Hence, these variables do not affect technical efficiency of farmers in the study area.

4.7 Constraints in Pineapple production

A total of seven constraints were identified from studies by Ninson (2012), Abbey (2005) and Obeng (1994). The constraints were pre-tested and then presented to the farmers to rank from the most pressing constraint to the least. The pressing constraints identified from the study were lack of credit, high production cost, high labour cost, marketing problems, lack of storage facilities, lack of extension services and incidence of pests and diseases as indicated in Table 4.8.

From the results, 68.3 percent of the farmers agreed among themselves in the ranking of the constraints. And since the Asymp. sig is 0.000, which is statistically significant, then, the null hypothesis which says that there is no agreement among the farmers was rejected in favour of the alternate. This means that the farmers agreed among themselves in the ranking of constraints in Table 4.8.

Table 4.8: Ranks of constraints

Constraints	Mean Rank	Rank
Lack of credit	1.69	1
High production cost	2.24	2
High labour cost	3.25	3
Marketing problems	3.84	4
Lack of storage facilities	4.67	5
Lack of extension services	5.73	6
Incidence of pests and diseases	6.57	7
N	135	
Kendall's W ^a	0.683	
Chi-Square	553.004	
Df	6	
Asymp. Sig	0.000	

Source: Survey data, 2018

As indicated in Table 4.8, the highest constraint faced by pineapple farmers was lack of credit. Obeng (1990) explained that the credit problem can be looked at from two points of view. Thus there is a problem of high lending (interest) rate and also the inaccessibility to institutional credit. Very few farmers are able to access long term loans from financial institutions especially banks because they are usually not credit-worthy and also they are not able to meet the collateral requirements. Farmers tend to rely on loans from micro finance institutions which also come with the problem of high lending (interest) rate. Hence their profit from production is eroded after payment of such huge interest rates. Most findings Abbey (2005), Ninson (2012), Obeng (1990) have found lack of credit to be the most pressing constraint affecting pineapple producers. Pineapple cultivation is both labour and capital intensive and therefore requires capital injection. The effect of inadequate capital on farming and farming outputs is very significant. Agricultural inputs

such as fertilizers, weedicides, pesticides, labour are very expensive. These factors result in an inadequate application of inputs which affects yield greatly.

The high cost of cultivation involved in pineapple production is the second most pressing constraint facing farmers. Agricultural inputs such as weedicides, pesticides, suckers etc are very expensive. This coupled with their inability to access credit results in an inadequate application of inputs which affects yield greatly. Most of the producers therefore try to produce assuming all the production and marketing risks which requires huge investment in land equipment. This also tends to reduce their scale of production as well as their productivity. A study done by Kpare (2016) showed that the cost of production of pineapple is indeed very high.

A significant number of respondents also complained about the high cost of labour. Pineapple production is highly labour intensive. Labour is needed for land preparation, planting, weeding, fertilizer, spraying (pest/disease control and fruiting or flower induction), fetching water (especially for dipping) forcing, degreening and harvesting. This requires the employment of hired labour to supplement family labour. The producers indicated that few labourers were available since most residents were also into pineapple production. These labourers therefore charged huge sums of money for services rendered which producers had no option but to pay. This is in line with the study of Ninson (2012) who found labour cost to be the third most pressing constraint of pineapple farmers in the Akwapim-South District.

Results from the study indicate that respondents were having problems with marketing their produce. Most buyers dictate the price to these farmers which they are forced to take due to the perishable nature of the produce. Farmers are not happy with their relationship with exporters as they are of the view that exporters don't always adhere to purchasing agreements and therefore default in payment after they had purchased the produce on credit. Fruits that are also rejected by exporters are bought at unreasonably low prices by local buyers (market queens) which reduces the expected revenue from the fruits. Pineapple fruits are also highly perishable which creates a major problem for farmers. They are even forced to sell their produce at lower prices in order not to make huge losses. Hence the profit they are supposed to enjoy goes to the fruit processing companies and retailers who buy at low prices and sell at higher prices. They therefore do not see the point in expanding their farming activities because they are of the view that increasing output might mean decreasing income if the market is flooded with pineapple. This agrees with the findings of Abbey (2005).

Pineapple fruits are also highly perishable and seasonal in nature. This therefore requires the use of storage equipment to increase their short shelf-life. These inputs will also be beneficial since farmers will be able to store their produce and sell them at high prices when pineapple is out of season. The lack of storage facilities causes farmers to sell their produce at lower prices to avoid losses that will be incurred when the fruits rot. The problem of lack of storage conforms to the study of Ninson (2012). They therefore do not find it necessary to increase the hectares of land under cultivation. This is because excess

supply of pineapple on the market will lead to lower returns from the cultivation of pineapple.

The pineapple farmers in the district are many however the extension agents are not enough to cater for the services needed by these farmers hence obtaining information on new and improved practices is quite difficult. Boateng (1999) also found the lack of extension agents to be a constraint faced by farmers in the District. Farmers need advisory services on production hence their inability to get the needed attention from extension agents is a problem. These extension agents are also there to help them in acquiring certain inputs for their production activities which requires that the extension services should be intensified.

Pests and diseases of pineapple are also key problems affecting pineapple cultivation in Ghana and must not be overlooked. This findings conforms to the study of Obeng (1994) Farmers exercise great care in handling planting materials since they are prone to disease and pest infestation. Most of the chemicals for controlling pests and diseases are imported and therefore very expensive. Farmers find it difficult to purchase and use them in their production activities.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes and presents the major findings of the entire study, draws appropriate conclusions and provides the needed policy recommendations.

5.2 Summary and Major Findings

The pineapple industry is the most structured in the horticultural sector, however, farmers in this sector are not different when it comes to supplementing household incomes and reducing risks. This study seeks to assess of the productivity of pineapple farmers who engaged in multi-output production to give a clearer focus of the nature and dynamics of industry. This study examined the production efficiency of 135 pineapple farmers in the Akwapim-South District.

The main objective of this study is to assess the productivity performance of pineapple farmers in the midst of other crops in the Akwapim-South District. Specifically, the study seeks to identify the influence of inputs on the productivity of pineapple production, to estimate the technical efficiency score of pineapple farmers, to identify the determinants of technical inefficiency levels of the farmers and to identify and rank the constraints in pineapple production. The study employed a translog stochastic output distance function with five inputs namely land, labour, fertilizer, planting material and intermediate costs. The study as well tested for the functional forms and the presence of inefficiencies. The first hypothesis which states that the Cobb-Douglas production best fits the data was

rejected in favour of the translog production model. The second hypothesis indicated the presence of inefficiencies in the model. The constraints faced by pineapple farmers in the Akwapim-South District were identified and ranked using the Kendall's Coefficient of Concordance. Descriptive statistics was also used to analyze the socio-economic characteristics of the farmers and Stata version 14 was used in the data analysis. A well-structured questionnaire was used to guide the data collection.

The findings revealed that the majority (87.40 percent) of the farmers were males and the youth contributed only 13.33 percent of this percentage. The majority (94.82 percent) of the farmers had at least basic education and an average of 14 years of farming experience. Also, the majority of the farmers were married with the average household size being 6. Majority of the farmers were married and were members of a farmer based organization. Most of these farmers did not have access to credit. The analysis also showed that the average income obtained from pineapple production is GH¢ 13,958.67.

The analysis further revealed that fertilizer, labour, planting material and intermediate costs are significant factors and contributed positively to affecting pineapple production. The shadow share of other crops is negative relative to the production of pineapple in the output mix. Also, the mean technical efficiency of the pineapple farmers that were observed in the Akwapim-South District was 86 percent. Analyzing the determinants of technical inefficiency showed that extension visits, education, credit accessibility are the significant factors affecting technical inefficiency. Finally, the constraints facing pineapple farmers in Akwapim-South District are lack of credit, high production cost,

high labour cost, marketing problems, lack of storage facilities, lack of extension services and incidence of pests and diseases arranged in order from the most pressing to least the least pressing constraint. The Kendall's Coefficient of Concordance was also estimated to be 0.683 which implies that the farmers agreed among themselves in the ranking.

5.3 Conclusions

Pineapple farming in the Akwapim-South District is male dominated and carried out mostly by adults. Majority of the farmers have at least basic education indicating that they are literates. Majority of the farmers are members of farmers based organizations but most of the farmers do not have access to credit.

The study concludes that the Cobb-Douglas frontier is an adequate representation for the data. Also, the translog stochastic frontier functional form is more appropriate to deduce conclusion from the data. Fertilizer, labour, planting material and intermediate cost are significant factors and contributed positively to pineapple production. The shadow share of other crops is negative relative to the production of pineapple in the output mix. The indication of increasing returns to scale in the study area suggests that farmers can still increase their output and productivity by improving on their inputs of production. There was significant evidence of input substitution effect between labour and planting material, fertilizer and planting material, planting material and intermediate cost, other crops and planting material. Complementarity effect was however observed between other crops and fertilizer.

Overall, the mean technical efficiency of the pineapple farmers that were observed in the Akwapim-South District was 86 percent of the potential output given the current technology available to them. Thus there is the potential to increase their current output by 14 percent. Analyzing the determinants of technical inefficiency indicated that farmers who have more extension visits are more likely to be efficient. Highly educated farmers are more likely to be efficient. Farmers who have access to credit are also more likely to be efficient.

Finally, the constraints facing pineapple farmers in Akwapim-South District are lack of credit, high production cost, high labour cost, marketing problems, lack of storage facilities, lack of extension services and incidence of pests and diseases arranged in order from the most pressing to the least the least pressing constraint. Hence, lack of credit is the major constraint facing farmers and results from high interest rate and farmers not being able to meet collateral requirements. The Kendall's Coefficient of Concordance was also estimated to be 0.683 which implies that the farmers agreed among themselves in the ranking.

5.4 Policy Recommendations

Based on the findings of this study, the following policy recommendations are made for policy action to be taken in order to help boost pineapple output and eliminate technical inefficiencies in the production process.

The study recommends that pineapple farmers in the study area should increase the use of inputs such as land, labour, fertilizer, planting materials since the farmers are producing in the first stage of the production process and as such increasing these inputs has the potential to increase pineapple output and reduce the average cost. The increase in the usage of these inputs can be made possible if the Statistics, Research and Information Department of MoFA readily make them available, affordable and accessible to the farmers in the Akwapim-South District.

The marginal productivity of labour was the largest as it showed the highest absolute value of the distance elasticity among the input variables. This shows the importance of labour in the production of pineapple. Specific interventions to make labour-saving technologies accessible to farmers and policies should be implemented by the Agricultural Department of the District Assembly. Providing incentives and organizing youth programmes to make the youth actively involved in agricultural related issues will also be a good initiative since the youth are more capable of engaging in labor-intensive activities as compared to adults. This also solves the problem of labour shortage as well as the unemployment issue in the district.

The Extension Service Directorate of MoFA should structure the extension and advisory services properly for pineapple farmers in the district so that its impact can be better felt and in turn translated into higher efficiency of the various pineapple farms. The Extension Service Directorate of MoFA must also ensure the regular training of its extension agents to keep them abreast with the current and best pineapple production

practices. This will influence the quality of information that are relayed to farmers and is likely to translate into less inefficiencies in the production system. Also in planning of the extension services delivery approaches, provision must be made to cater for the different educational groups. This is because the level of education should affect the delivery approach used and will determine its effectiveness. This is important because education and extension visits were found to have a positive effect on reducing technical inefficiencies.

Access to credit is one of the important factors affecting efficiency of pineapple farmers as well as a major constraint facing farmers. Government and the Central Bank must ensure that policies that are implemented help to improve credit facilities for farmers. Loan procedures should be disciplined and simple and banks can run input supply services on credit in place of cash credit. Government can also support farmers in the forms of input supply and hiring machinery services like tractor service which helps to reduce their credit needs. Innovations which solve the issue of a traditional collateral requirement by banks should be promoted by private institutions and development partners to solve the problem of collateral requirement. An example is the warehouse receipt financing.

REFERENCES

- Abbey, A. (2005). The Effect of Pineapple Farming on the Livelihood of Pineapple Farmers in the Ga Districts. (Dissertation, University of Ghana).
- Abdulai, A., & Huffman, W. (2000). Structural adjustment and economic efficiency of rice farmers in Northern Ghana. *Economic and Cultural Change*, 48(3), 503-520.
- Afari-Sefa, V. (2007). The dynamics of horticultural export value chains on the livelihood of small farm households in Southern Ghana. *African Journal of Agricultural Research*, 2(September), 435–440.
- Afari-Sefa, V. (undated). The micro-level distributional effects of horticultural export value chains among smallholders in southern Ghana. Paper submitted to the 4th GARNET conference on "Food Security and Sustainable Development: Challenges for the Governance of International Relations.
- Agyare, E. A. (2010). Technology for improved income of small-holder pineapple producers in Ghana. *SNV Netherlands Development Organization Case Studies*.
- Ahwireng, A. H. (2014). *Determinants of Technical Efficiency of Small-holder Pineapple Producers in the Akuapem South Municipality* (Thesis, University of Ghana).
- Aigner, D. J., & Chu, S. F. (1968). On estimating the industry production function. *American Economic Review* 58, 826-839.
- Aigner, D. J., Lovell, C. A. K., & Schmidt, P. (1977) Formulation and estimation of Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics* 6, 2137.
- Alhassan, S. (2008). Technical Efficiency of Rice Farmers in Northern Ghana. AERC Research Paper 178 African Economic Research Consortium, Nairobi April 2008.
- Ali, M., Chaudry, M.A. (1990). Inter-regional farm efficiency in Pakistan's Punjab: A frontier production function study. *J. Agric. Econ.*, 41: 6274.
- Amewu, S., & Onumah, E. E. (2015). Cost efficiency of NERICA producing households in Ghana: a modified non-neutral stochastic frontier analysis. *Am. J. Exp. Agric*, 9(6), 1-13.
- Antwi, D.E. (2017). Agglomeration Externalities, Productivity and Technical Efficiency of Soybean Farms in the Upper East and Upper West Regions of Ghana. (Thesis, University of Ghana).

- Antwi, D. E., Kuwornu, J. K., Onumah, E. E., & Bhujel, R. C. (2017). Productivity and constraints analysis of commercial tilapia farms in Ghana. *Kasetsart Journal of Social Sciences*, 38(3), 282-290.
- Asante, B. O., Osei, M. K., Dankyi, A. A., Berchie, J. N., Mochiah, M. B., Lamptey, J. N. L., Haleegoah J., Osei K., & Bolfrey-Arku, G. (2013). Producer Characteristics and Determinants of Technical Efficiency of Tomato based Production Systems in Ghana. *Journal of Development and Agricultural Economics*, 5(3), 92-103.
- Attar, A. A., Gupta, A. K., & Desai, D. B. (2012). A study of various factors affecting labour productivity and methods to improve it. *IOSR Journal of Mechanical and Civil Engineering*, 1(3), 11-14.
- Atkinson, S. E., & Primont, D. (2002). Stochastic estimation of firm technology, inefficiency, and productivity growth using shadow cost and distance functions. *Journal of Econometrics*, 108(2), 203-225.
- Awunyo-vitor, D., Bakang, J. A., & Gyan, S. K. (2013). Estimation of Farm Level Technical Efficiency of Small-Scale Cowpea Production in Ghana. *American-Eurasian J, Agric, & Environ, Sci.*,13(8),1080-1087. IDOSI Publications, 2013. <http://doi.org/10.5829/idosi.aejjaes.2013.13.08.11013>
- Ayerh, F. (2015). Technical Efficiency of Tomato Farmers in the Ashanti Region of Ghana. (Thesis, University of Ghana).
- Barrientos, S., Anarfi, J., Lamhauge, N., Castaldo, A., & Anyidoho, N. A. (2009). Stochastic Frontier Models for migrant labour in the Ghanaian pineapple sector. *Development Research Centre on Migration, Globalisation and Poverty. Working Paper T- 30.*
- Battese, G. E., S. J. Malik, and M. A. Gill. 1996. An investigation of technical inefficiencies of production of wheat farmers in four districts of Pakistan. *Journal of Agricultural Economics* 47(1):37-49.
- Battese, G. E., & Corra, G. S. (1977). Estimation of a production frontier model: With application to the pastoral zone of Eastern Australia. *Australian Journal of Agricultural Economics* 21, 169-179.
- Battese, G. E., & Coelli, T. J. (1988). Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. *Journal of econometrics*, 38(3), 387-399.
- Bauer, P. W. (1990). Recent developments in the econometric estimation of frontiers. *Journal of econometrics*, 46(1-2), 39-56.

- Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management science*, 30(9), 1078-1092.
- Banker, R. D., Gadh, V. M., & Gorr, W. L. (1993). A Monte Carlo comparison of two production frontier estimation methods: corrected ordinary least squares and data envelopment analysis. *European Journal of Operational Research*, 67(3), 332-343.
- Baruwa, O. I. (2013). Profitability and constraints of pineapple production in Osun State, Nigeria. *Journal of Horticultural Research*, 21(2), 59-64.
- Baseke, F. (2009). *Profitability of pineapple production in Kayunga District, Central Uganda* (Doctoral dissertation, Makerere University).
- Bertow, K., & Schultheis, A. (2007). *Impact of EU's agricultural trade policy on smallholders in Africa*. Germanwatch.
- Berndt, E. R., & Christensen, L. R. (1973). The internal structure of functional relationships: Separability, substitution, and aggregation. *The Review of Economic Studies*, 40(3), 403-410.
- Bjorndal, T., Koundouri, P., & Pascoe, S. (2002). Multi-output distance function for the North Sea beam trawl fishery.
- Boateng O. G. (1999), *Contribution of pineapple as non-traditional Export Commodity to the growth of Ghana's Economy*
- Bravo-Ureta, B. E., & Pinheiro, A. E. (1993). Efficiency analysis of developing country agriculture: a review of the frontier function literature. *Agricultural and resource economics Review*, 22(1), 88-101.
- Brümmer, B., Glauben, T., & Thijssen, G. (2002). Decomposition of Productivity Growth Using Distance Functions: The Case of Dairy Farms in Three European Countries. *American Journal of Agricultural Economics*, 84, 628-644.
- Chamberlin, J. (2007). Defining smallholder agriculture in Ghana: Who are smallholder, what do they do and how are they linked with markets? *GSSP Background Paper 6, Washington, DC: IFPRI*.
- Chang, K. P., & Guh, Y. Y. (1991). Linear production functions and the data envelopment analysis. *European Journal of Operational Research*, 52(2), 215-223.
- Charnes, A., Cooper, W. W. & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*. 2(6), 429 – 444.

- Coelli, T., & Perelman, S. (1996). *Efficiency measurement, multiple-output technologies and distance functions: With application to European Railways* (No. DP 1996/05). CREPP.
- Coelli, T. J., & Battese, G. E. (1996). Identification of factors which influence the technical inefficiency of Indian farmers. *Australian Journal of Agricultural Economics*, 40(2), 103-128.
- Coelli, T., Perelman, S., & Romano, E. (1999). Accounting for Environmental Influences in Stochastic Frontier Models: With Application to International Airlines. *Journal of Productivity Analysis*, 11, 251–273.
- Coelli, T., & Perelman, S. (1999). A comparison of parametric and non-parametric distance functions: With application to European railways. *European journal of operational research*, 117(2), 326-339.
- Coelli, T., & Perelman, S. (2000). Technical efficiency of European railways: a distance function approach. *Applied Economics*, 32(15), 1967–1976. doi:10.1080/00036840050155896
- Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). *An introduction to efficiency and productivity analysis*. Springer Science & Business Media.
- Conley TG, Udry CR. 2010. Learning about a new technology: Pineapple in Ghana. *The American Economic Review*: 35-69.
- Cooper, W.W., Seiford, L.M., & Tone, K (2000). *Data Envelopment Analysis. A Comprehensive Text with Applications, References and DEA-Solver Software*. Klumer Academic, Boston.
- Danielou, M., & Ravry, C. (2005). The Rise of Ghana's pineapple industry: From successful takeoff to sustainable expansion. *Africa Region working paper. Series No.93. Washington DC: ESSD Africa*.
- Daraio, C., & Simar, L. (2007). *Advanced robust and nonparametric methods in efficiency analysis: Methodology and applications*. Springer Science & Business Media.
- Debreu, G. (1951). The Coefficient of resource utilization. *Econometrica*, 19(3), 273-292. *Development Research Centre on Migration, Globalisation and Poverty*.
- Deprins, D., Simar, L. and H. Tulkens (1984), "Measuring Labor-Efficiency in Post Services", in M. Marchand, P. Pestieau and H. Tulkens (eds.), *The Performance of Public Enterprises. Concepts and Measurement*, North Holland, Amsterdam.

- Donkoh, S. A., Tachega, M., & Amowine, N. (2013). Estimating technical efficiency of tomato production in Northern Ghana. *American Journal of Experimental Agriculture*, 3(1), 56.
- Ellis, F. (1993). Peasant economics: Farm households and agrarian development, 2nd Ed. *Cambridge University Press: Cambridge*.
- Etwire, P. M., Martey, E., & Dogbe, W. (2013). Technical efficiency of soybean farms and its determinants in Saboba and Chereponi Districts of Northern Ghana: a stochastic frontier approach. *Sustainable Agriculture Research*, 2(4), 106.
- Eurostat. (2013). Eurostat international trade data. EU Fruit Import from Ghana (2000 – 2013). (Eurostat is the Official Statistical Office of the European Union). Retrieved from <http://ec.europa.eu/eurostat>
- FAO (2013). Analysis of trade impacts on fresh pineapple sector in Ghana. FAO Commodity and Trade Policy. Research working paper No. 41.
- Fare, R., S. Grosskopf and C.A.K. Lovell (1994), *Production Frontiers*, Cambridge University Press.
- Fare, R., S. Grosskopf, C.A.K. Lovell and S. Yaisawarng (1993), “Derivation of Shadow Prices for Undesirable Outputs: A Distance Function Approach”, *Review of Economics and Statistics*, 75, 374-380.
- Farrell, M.J. (1957). The Measurement of Productive Efficiency. *Journal of Royal Statistics Society*, 120: 253 – 281.
- Fernández, C., Koop G., Steel M.F.J., (2005). Alternative efficiency measures for multiple-output production. *Journal of Econometrics*, 126, 411-444.
- Feed the Future (2015). The U.S. Government’s Global Hunger and Food Security Initiative. Agricultural Extension Policy Forum: Ghana.
- Fold N, Gough KV. 2008. From smallholders to transnationals: the impact of changing consumer preferences in the EU on Ghana’s pineapple sector. *Geoforum* 39: 1687-97
- Førsund, F. R., & Hjalmarsson, L. (1987). *Analyses of industrial structure: A putty-clay approach*. Not Avail.
- Fried, H. O., Lovell, C. K., & Schmidt, S. S. (Eds.). (2008). *The measurement of productive efficiency and productivity growth*. Oxford University Press.
- Gathon, H.-J., Perelman, S., (1992). Measuring technical efficiency in European railways: a panel data approach. *The Journal of Productivity Analysis*, 3, 131-151.

- Gatune, J., Chapman-Kodam, M., Korboe, K., Mulangu, F., & Rakotoarisoe, M. A. (2013). FAO Commodity and Trade Policy Research Working Paper No. 41. "Analysis of Trade Impacts on the Fresh Pineapple Sector in Ghana," (41).
- Ghana Export Promotion Council (GEPC), 2005. Overview of the Ghanaian Non-Traditional Exports. Section 3-2. Accessed October 26, 2005, available at <http://www.exportghana.org>.
- Ghana Statistical Service (2014). 2010 Population and Housing Census. District Analytical Report: Akwapim-South District.
- Ghana Statistical Service. (2010). Ghana Statistical Service (News Brief) New Series of the Gross Domestic Product (GDP) Estimates, 1–5.
- Ghana Statistical Service (2016). Provisional 2016 Annual Gross Domestic Product.
- Greene, W. H. (1980). Maximum likelihood estimation of econometric frontier function. *Journal of Econometric* 13, 27-56.
- Gatune J, Chapman-Kodam M, Korboe K, Mulangu F, Raktoarisoa M. 2013. Analysis of Trade Impacts on the Fresh Pineapple Sector in Ghana, Food and Agricultural Organization of the United Nations, Rome
- Gong, B. H., & Sickles, R. C. (1992). Finite sample evidence on the performance of stochastic frontiers and data envelopment analysis using panel data. *Journal of Econometrics*, 51(1-2), 259-284.
- Grosskopf, S., K. Hayes, L. Taylor and W. Weber (1996), "Budget Constrained Frontier Measures of Fiscal equality and Efficiency in Schooling", *Review of Economics and Statistics*, forthcoming.
- Grosskopf, S., Hayes, K. J., Taylor, L. L., & Weber, W. L. (1997). Budget-constrained frontier measures of fiscal equality and efficiency in schooling. *Review of Economics and Statistics*, 79(1), 116-124.
- Hetemaki, L. (1996), "Environmental Regulation and Production Efficiency: Evidence from Pulp Industry", mimeo, Finnish Forest Research Institute, Helsinki.
- Ibrahim, Y. (2015). Demand for pineapples from Ghana currently exceeds supply. Retrieved July 19, 2018, from <http://www.freshplaza.com/article/146329/Demand-for-pineapples-from-Ghana-currently-exceeds-supply>
- Idiong, I. C. (2007). Estimation of farm level technical efficiency in small-scale swamp rice production in cross river state of Nigeria: a stochastic frontier approach. *World Journal of Agricultural Sciences*, 3(5), 653-658

- Idris, N. D. M., Siwar, C., & Talib, B. (2013). Determinants of technical efficiency on pineapple farming. *American Journal of Applied Sciences*, 10(4), 426-432.
- IFPRI (2005). The future of small farms. *Proceedings of a research workshop. Washington, DC: International Food Policy Research Institute.*
- Incoom S.E. (2008). *The Monetary and Financial System, 2nd Ed.* Prime Applications: Accra.
- ISSER. (2017). The State of the Ghanaian Economy in 2016. Legon: Institute of Statistical, Social and Economic Research, October 2017. Isser, 246.
- Jaeger, P. (2008). Ghana Export Horticulture Cluster Strategic Profile Study Part I – Scoping review. Prepared for World Bank Sustainable Development Network (WB-SDN), The Republic of Ghana Ministry of Food and Agriculture and European Union All ACP Agricultural Commodities.
- Jondrow, J., Lovell, C. K., Materov, I. S., & Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of econometrics*, 19(2-3), 233-238.
- Kalirajan, K. P., & Shand, R. T. (1985). Types of education and agricultural productivity: a quantitative analysis of Tamil Nadu rice farming. *Journal of Development Studies*, 21(5), 232 – 243.
- Kalirajan, K.P., and Shand, R.T. (1999). Frontier production functions and technical efficiency measures. *Journal of Economic surveys*, 13(2): 149-172.
- Kayitesi, R. (2011). *Factors Affecting Small Scale Farmers' Pineapple Production: The Case Study of Ngoma District, Rwanda.*
- 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. *Unpublished MSc Thesis. Agricultural University of Norway.*
- Kleemann, L. (2011). Organic pineapple farming in Ghana - A Good choice for smallholders? *Kiel Institute for the World Economy*. Working Paper No. 1671.
- Kleemann L, Abdulai A. 2013. Organic certification, agro-ecological practices and return on investment: Evidence from pineapple producers in Ghana. *Ecological Economics* 93: 330-41
- Kpare (2016). The Effects of Varietal Shifts in Demand for Pineapple: A Study of Smallholder Farmers Adoption of MD2 in Nsawam-Adoagyiri Municipal Assembly. (Dissertation, University of Ghana; Institute of Statistical, Social and Economic Research).

- Kumbhakar, S. C. (1994). Efficiency estimation in a profit maximising model using flexible production function. *Agricultural Economics*, 10(2), 143-152.
- Kumbhakar, S. C., & Lovell, C. K. (2000). Stochastic production frontier. *Cambridge University Press*. Kumbhakar, S.C., & Sarkar, S.(2003). *Deregulation, ownership and productivity growth in the banking industry: Evidence from India*. *Journal of Money Credit and Banking*, 35(3), 403-424.
- Kusa, M.U. (2012). Farmer's Health and Agricultural Productivity in Rural Ethiopia. (Thesis, Norwegian University of Life Sciences).
- Kuwornu, J. K., Amoah, E., & Seini, W. (2013). Technical efficiency analysis of maize farmers in the Eastern Region of Ghana. *Journal of Social and Development Sciences*, 4(2), 84.
- Kyei, L., Foli, G. & Ankoh, J. (2011). Analysis of factors affecting the technical efficiency of cocoa farmers in the Offinso district – Ashanti region, Ghana”, *American Journal of Social and Management Sciences*, 2(2): 208-216.
- Legendre, P. (2005). “Kendall Coefficient of Concordance Revisited”. *Journal of Agriculture, Biological and Environmental Statistics*, 10(2), 226-245.
- Löthgren M., (1997). Generalized stochastic frontier production models. *Economics Letters*, 57, 255-259.
- Loukoianova, E. (2008). Analysis of the Efficiency and Profitability of the Japanese Banking System. IMF Working Papers, 1-34
- Lovell C.A.K., Richardson, S., Travers, P. and Wood, L.L. (1994). Resources and functioning: a new view of inequality in Australia, in *Models and Measurement of Welfare and Inequality*. (Ed.) W. Eichhorn, Springer-Verlag, Berlin, 787-807.
- Lovell, C.A.K. (1993) “Production Frontiers and Productive Efficiency”, in H.O. Fried, C.A.K. Lovell and S.S. Schmidts (eds). *The Measurement of Productive Efficiency*, New York: Oxford University Press.
- Lovell, C.A.K., Richardson, S., Travers, P., Wood, L. (1994). *Resources and Functioning: A new view of Inequality in Australia. Models and Measurement Welfare and Inequality, Berlin. Springer Verlag Press, Germany* (Vol. 38, p. 225). doi:10.2307/2683664
- Lubis, R., Daryanto, A., Tambunan, M., & Purwati, H. (2014). Technical, allocative and economic efficiency of pineapple production in West Java Province, Indonesia: A DEA approach. *IOSR J Agric Vet Sci*, 7(6), 18-23.

- Mattson, D. E (1986), 'Statistics-Difficult Concept of Understanding Explanations'. Bolchanzy Carducci Publishers Inc.pp.281,283.361,423.
- Mawson, P., Carlaw, K., & McClellan, N. (2003). *Productivity measurement: Alternative approaches and estimates* (No. 03/12). Wellington: New Zealand Treasury.
- Meeusen, W., & Van den Broeck, J. (1977) Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review* 18, 435-444.
- Mensah, A.O., Oehmke, J. F. (2012). Trade and Investment Program for a Competitive Export Economy in Ghana, (January), 1–4.
- Mensah, A., & Brümmer, B. (2016). A multi-output production efficiency analysis of commercial banana farms in the Volta region of Ghana: A stochastic distance function approach. *African Journal of Agricultural and Resource Economics Volume, 11(4)*, 305-316.
- MoFA (2010). Medium Term Agriculture Sector Investment Plan (METASIP) 2011 – 2015. Accra: Government of Ghana.
- Ministry of Food and Agriculture (2011). Year 2010 facts and figures on pineapple production. Ministry of Food and Agriculture, Akuapem South Municipal Directorate of Agriculture, Nsawam.
- Millennium Development Authority (2011). Mid-Term Review Consultancy Mid-Term Review Report .RFP Ref: 4101114/RFP/QCBS/02/10
- Ministry of Food and Agriculture (2015). Republic of Ghana. Accessed on 1st June, 2018. Available at http://mofa.gov.gh/site/page_id=1495
- Ninson, D. (2012). Analysis of Pineapple in the Akwapim-South Municipal Area. (Dissertation, University of Ghana).
- Nyagaka, D. O., Obare, G. A., Omiti, J. M., & Nguyo, W. (2010). Technical efficiency in resource use: Evidence from smallholder Irish potato farmers in Nyandarua North District, Kenya. *African Journal of Agricultural Research*, 5(11), 1179-1186.
- Obeng I. S. (1990). The Impact of Structural Adjustment Program on Ghana's Horticultural Industry: The Case of Pineapple Production in the Nsawam District.
- Obeng I. S. (1994). Effect of domestic policies on production and export of nontraditional Agricultural commodities.

- Obwona, M. (2006). Determinants of technical efficiency differentials amongst small-and medium-scale farmers in Uganda: A case of tobacco growers
- O'Donnell C & Coelli T, 2005. A Bayesian approach to imposing curvature on distance functions. *Journal of Econometrics* 126(2): 493–523.
<http://www.sciencedirect.com/science/article/pii/S0304407604001216>
- Ogundari, K., & Brümmer, B. (2011). Estimating Technical Efficiency, Input substitution and complementary effects using Output Distance Function: A study of Cassava production in Nigeria. *Agricultural Economics Review*, 12(2), 62.
- Ogundari, K., Amos, T. T., & Okoruwa, V. O. (2012). A Review of Nigerian Agricultural Efficiency Literature, 1999–2011: What Does One Learn from Frontier Studies? *African Development Review*, 24(1), 93-106.
- Ogundari, K. (2013). Crop diversification and technical efficiency in food crop production: A study of peasant farmers in Nigeria. *International Journal of Social Economics*, 40(3), 267-287.
- Ogundari, K. (2014). The paradigm of agricultural efficiency and its implication on food security in Africa: what does meta-analysis reveal?. *World Development*, 64, 690-702.
- Ojo, S. O. (2003). Productivity and technical efficiency of poultry egg production in Nigeria. *International Journal of Poultry Science*, 2(6), 459-464.
- Onumah, E. E., Hoerstgen-Schwark, G., & Brümmer, B. (2009). *Productivity of hired and family labour and determinants of technical inefficiency in Ghana's fish farms* (No. 0907). Diskussionspapiere//Department für Agrarökonomie und Rurale Entwicklung.
- Onumah, E. E., & 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. E., Brümmer, B., & Hörstgen-Schwark, G. (2010). Elements which delimitate technical efficiency of fish farms in Ghana. *Journal of the World Aquaculture Society*, 41(4), 506-518.
- Owuor, G., & Shem, O. A. (2009, August). What are the Key Constraints in Technical Efficiency of Smallholder Farmers in Africa? Empirical Evidence from Kenya. In *111th Seminar, June 26-27, 2009, Canterbury, UK* (No. 52807). European Association of Agricultural Economists.

- Pay, E. (2009). The Market for Organic and Fair-Trade Mangoes and Pineapples. Study prepared in the framework of FAO project GCP / RAF / 404 / GER. "Increasing incomes and food security of small farmers in West and Central Africa through exports of organic and fair-trade (September).
- Rahman. S. 2002. Profit efficiency among Bangladesh rice farmers Manchester: University of Manchester. (School of economic studies. discussion paper series No. 0203).
- Reddy, A. R., & Sen, C. (2004). Technical inefficiency in rice production and its relationship with farm-specific socio-economic characteristics. *Indian Journal of Agricultural Economics*, 59, 259-267.
- Ruggiero, J. (1999). Efficiency estimation and error decomposition in the stochastic frontier model: A Monte Carlo analysis. *European journal of operational research*, 115(3), 555-563.
- Schmidt, P., & Sickles, R. C. (1984). Production frontiers and panel data. *Journal of Business & Economic Statistics*, 2(4), 367-374.
- Sedaghat, R. (2011). Constraints in production and marketing of Iran's pistachio and the policies concerned: An application of the Garret ranking technique.
- Shamsudeen, A., Donkoh, SA. & Sienso G. (2011). Technical Efficiency of Groundnut Production in West Mamprusi District of Northern Ghana. *Journal of Agricultural and Biological Sciences*. 2(40), 071-077, July 2011.
- Suzuki A, Jarvis LS, Sexton RJ. 2011. Partial vertical integration, risk shifting, and product rejection in the high-value export supply chain: The Ghana pineapple sector. *World Development* 39: 1611-23
- Tambo, J. A., & Gbemu, T. (2010). Resource-use efficiency in tomato production in the Dangme West District, Ghana. In *Conference on International Research on Food Security, Natural Resource Management and Rural Development. Tropentag, ETH Zurich, Switzerland*.
- Tewodros, A. K. (2001). Farm Household Technical Efficiency: A Stochastic Frontier Analysis. *A Master Thesis submitted to department of Economics and Social Sciences Agricultural University of Norway*, 55-63.
- Trujillo, J. C., & Iglesias, W. J. (2013). Measurement of the technical efficiency of small pineapple farmers in Santander, Colombia: a stochastic frontier approach. *Revista de Economia e Sociologia Rural*, 51, s049-s062.
- UNCTAD, G. (2012). World investment report: Towards a new generation of investment policies. *United Nations. New York and Geneva*.

- Wang, H. J., & Schmidt, P. (2002). One-step and two-step estimation of the effects of exogenous variables on technical efficiency levels. *Journal of Productivity Analysis*, 18(2), 129–144.
- Wadud, A., & White, B. (2000). Farm household efficiency in Bangladesh: a comparison of stochastic frontier and DEA methods. *Applied economics*, 32(13), 1665-1673.
- Webber CM, Labaste P. 2009. *Building competitiveness in Africa's agriculture: a guide to value chain concepts and applications*. World Bank Publications.
- Wiggins, S. (2009). Can the smallholder model deliver poverty reduction and food security for a rapidly growing population in Africa? FAC Working Paper No. 08. Brighton: Future Agricultures Consortium.
- Winsten, C.B., 1957. Discussion on Mr. Farrell's paper. *Journal of the Royal Statistical Society, Series A: Statistics in Society* 120 (3), 282–284.
- Wolter, D. (2008). Ghana Agriculture is becoming a Business. Business for Development. OECD Development Centre
- Wuepper, D., Sauer, J., & Kleemann, L. (2018). Sustainable intensification amongst Ghana's pineapple farmers: the complexity of an innovation determines the effectiveness of its training. *Environment and Development Economics*, 23(1), 98-119.
- Yiadom-Boakye, E., Owusu-Sekyere, E., Nkegbe, P. K., & Ohene-Yankyera, K. (2013). Gender, Resource use and Technical Efficiency among Rice Farmers in the Ashanti Region, Ghana. *Journal of Agricultural Economics and Development*, Vol. 2(3), pp.102-110
- Zakari, A. K. (2012). *Ghana National Mango Study: Support of the PACT II Program and the International Trade Centre (Geneva)*.

APPENDIX

UNIVERSITY OF GHANA, LEGON

DEPARTMENT OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS

**PRODUCTION EFFICIENCY ANALYSIS OF PINEAPPLE FARMERS IN THE
AKWAPIM-SOUTH DISTRICT:A STOCHASTIC DISTANCE FUNCTION**

APPROACH

QUESTIONNAIRE

This research is an academic exercise in partial fulfillment of the requirements for the award of a Master of Philosophy Degree in Agricultural Economics.

I would be grateful if you could provide me with all the necessary answers to the questions stated below. The data is for academic purposes only and information collected here will be treated as confidential. Thank you.

Serial Number:

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Introduction

Name of Enumerator:
...../...../.....

Date of Interview:

District:

Community/Town/Village:

Name of Pineapple Farmer:
.....

Name of Pineapple Farm (if any):
.....

Telephone Number:

SECTION A: Socioeconomic Characteristics of Pineapple Farmer

[Q1]. Gender of Farmer: 01 = Male [] 02 = Female []

[Q2] Age of farmer: years

[Q3]. Marital status of farmer: 01 = Single [] 02 = Married [] 03 =
Divorced []

04 = Separated [] 05 = Widowed []

06 = others (specify) []

.....

[Q4]. Religion: 01 = Christian [] 02 = Muslim [] 03 =
Traditionalist [] 04 = others (Specify) []

.....

[Q5]. What is your level of education? 01 = No schooling [] 02 = Primary
school [] 03 = MSCL/JHS [] 04 = SHS/Technical/Vocational []

05 = Tertiary [] 06 = others (specify)

.....

[Q6]. Number of years spent to attain that (Q5) level of education
.....years

[Q7]. Residential status of farmer: 01 = Indigene [] 02 = Migrant []

[Q8]. What is the size of your household? person(s)

(a) Adult Malesperson(s) (b) Adult Females person(s)

(c) Children (<18)person(s)

[Q9]. Do you belong to any farmer association/ group? 1. Yes [] 2. No []

[Q10]. Why did you join the group? Please indicate the importance of this group to your farm:

01 = Record Keeping Training [] 02 = Agronomic Practices []

03 = Credit Management [] 04 = others (specify):

.....

SECTION B: Basic Information on Pineapple Farming Land Tenure System

[Q11]. Is pineapple farming your major occupation? 01 = Yes [] 02 = No []

[Q12]. If No to [Q11], which of the following is your major occupation:

01 = Other Crops (Farming) [] 02 = Trading [] 03 = Government

Worker [] 04 = Artisan [] 05 = others (specify) []

.....

[Q13]. Have you had any formal training (Formal Pineapple Farming Education) in pineapple farming before?

01 = Yes [] 02 = No []

[Q14]. How long have you been in the pineapple farming business?

..... years(s)

[Q15]. Which varieties do you cultivate? 01 = MD2 [] 02 = Smooth Cayenne

[]

03 = Sugar Loaf [] 04 = others (please specify) [

].....

[Q16]. What is your farm size (in acres)? Acres

SECTION C: Technical Services and Credit for Farmer

[Q17]. Did you ever have any contact with extension agents in the last production season (2016/17)?

01 = Yes [] 02 = No []

[Q18]. If Yes to [Q17], how many times did the extension agent visit you?
..... times

[Q19]. From which institution did you receive the extension service? 01 = Dept. of
Agriculture [] 02 = NGO [] 03 = others (specify) []

.....

[Q20]. What is your perception about the extension agent? 01 = Very Good []
02 = Good []

03 = Poor [] 04 = Very Poor [] 05 = Indifferent []

[Q21]. What kind of information did you receive from the extension agent?

01 = Production Information [] 02 = Marketing Information []

03 = others (specify):

.....
.....
.....

[Q22]. How did you finance your farm? 01 = Through Personal Savings [] 02 =
Through Credit [] 03 = Both [] others (specify) []

.....

[Q23]. Did you have access to credit in the last production season (2016/17)? 01 = Yes []
02 = No []

[Q24]. If Yes to [Q23], then from which of the following sources did you get your credit
from?

01 = Banks [] 02 = Money Lenders [] 03 = Family/Relatives []

04 = Friends [] 05 = others (specify) []

[Q25]. How much did you receive? (GH¢) (b) At what interest rate?
..... per annum

[Q26]. Ownership of the pineapple farm: 01 = Solely Owned [] 02 = Family []
03 = Group Owned [] 04 = others (specify) []
.....

[Q27]. How many months did it take you to plant and harvest the fresh pineapple?
..... Months

SECTION C: Production Information on Inputs Used

Land Requirement

[Q28]. What is the source of your suckers? 01 = Local Sucker Seller [] 02 =
Certified Sucker Dealer [] 03 = Own Stored Sucker [] 04 = others
(specify) [].....

[Q29]. Please indicate the cropping system adopted on your farm:

01 = Mono-cropping [] 02 = Mixed cropping 03 = others (specify) []

[Q30]. How was your farm land prepared? Please indicate as appropriate

01 = Tractor plough [] 02 = Animal plough [] 03 = Manual plough
(cutlass and hoe) [] 04 = others (specify) []
.....

[Q31]. For each of the following, please indicate the number of acres and the amount
paid as appropriate

PINEAPPLE			OTHER CROPS	
Mode of Land Preparation	Number of Acres	Amount Paid	Number of Acres	Amount Paid
Tractor plough				
Animal plough				
Manual plough				
Total				

[Q32]. Please provide information on the following:

Planting Material Type	Variety	Quantity used per acre or Planting Rate	Cost per planting material type (GH¢)

Agrochemicals

[Q33]. Did you apply any of the following agrochemicals on the **pineapple farm** in the last production year 2016/17? Please indicate (tick) as appropriate;

- 01 = Fertilizer [] 02 = Pesticide [] 03 = Herbicide []
 04 = Compost [] 05 = others (specify) []

[Q34]. Please state the quantity and cost of the chemicals used on **the pineapple farm** in the table below:

Chemicals	No. of times applied /crop life	Quantity used (kg or litre) per crop life	Cost per kg or litre (GH¢)	Total cost per crop life (GH¢)
Fertilizer (Solid)				
Fertilizer (Liquid)				
Herbicide (Weedicide)				
Pesticide				
Others (specify)				

[Q35]. Please state the quantities and cost of the chemicals used in producing the other crops in the table below:

Chemicals	No. of times applied /crop life	Quantity used (kg or litre) per crop life	Cost per kg or litre (GH¢)	Total cost per crop life (GH¢)
Fertilizer (Solid)				
Fertilizer (Liquid)				
Herbicide (Weedicide)				
Pesticide				
Others (specify)				

Labour Requirement

[Q36]. Please indicate the information in the table below:

Farm Activities	Family Labour		Hired Labour		Number of days worked	Cost (charge) per activity (GH¢)
	Number of Persons		Number of Persons			
	Male	Female	Male	Female		
Land Preparation						
Planting/ Sowing						
First Weeding						
Fertilizer Application						
Second Weeding						
Third Weeding						
Harvesting						
Total (GH¢)						

[Q37]. (a). How many days do you spend in your pineapple farm per week?

.....days

(b). How many hours a day do you spend working in your pineapple farm?

..... hours

[Q38]. (a). How many days do you spend per week working on the other crops other

than pineapple? days

b) How many hours per day do you work on the other crops other than

pineapple? hours

[Q39]. Other operational cost in pineapple production:

Item	Total cost per year (GH¢)	
	Number of times	Charge per trip
Transportation cost incurred during farming activities		
Cost of transporting harvested pineapple to processing company		
Cost of transporting harvested pineapple to market centres		
Sold at farm gate		
Hired Items		
Fuel		
Harvesting and Marketing (if applicable)		
Total		

[Q40]. Operational cost in other crops production (excluding pineapple):

Item				
Transportation cost during farming activities				
Transportation cost to processing company				
Transportation cost to market centres				
Hired items				
Harvesting and Marketing (if applicable)				
Total cost per year (GH¢)				

[Q41]. Please provide information about your farm in the table below (Fixed and Variable Assets)

Item	Value (GH¢)
Cutlass and Hoes	
Knapsack Spray	
Basket	
Vehicles	
Farm Machinery and Equipment	
Land	
Buildings	
Animals/Breeding Stock	
Poultry	

SECTION D: Information on Multiple Output of Pineapple farmers

Harvesting and Marketing

[Q42]. Where do you market your harvested pineapple? 01 = Local Market [] 02 = Export []

03 = Fruit Processing Companies [] 04 = Wholesalers and Retailers (Market queens) []

05 = others (specify) []

.....

[Q43]. Where do you market your **other crops** (excluding pineapple)? 01 = Local Market []

02 = Export [] 03 = Wholesalers and Retailers (Market queens) []

04 = others (specify) []

.....

[Q44]. Do you have access to ready market for the harvested pineapple? 01 = Yes [] 02 = No []

[Q45]. If Yes to Q44, state the distance from your farm to the market centre (source):

..... Km

[Q46]. What was the total amount received from the sale of pineapple and the other produce from these farms? GH¢

[Q47]. Sales made from the crops

Crops	Allocated Land Size (acres)	Amount Eaten/Given out as gift	Amount Harvested	Crop Output (unit)	Output Price (GH¢)	Total Value of Output (GH¢)
Pineapple						

SECTION E: Farm Constraints

[Q48]. Please kindly tick where applicable and rank in order of decreasing severity the constraints that you face in pineapple production (farming).

Constraints	Rank (1-7) with 1 = most severe and 7= less severe
Lack credit	
High production cost	
High labour cost	
Marketing problems	
Lack of storage facilities	
Lack of extension services	
Incidence of pests and diseases	

THANK YOU!!!