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DEPARTMENT OF AGRICULTURAL ECONOMICS, AGRIBUSINESS AND EXTENSION

EMPIRICAL ANALYSIS OF PRODUCTIVITY AND RESOURCE-USE-EFFICIENCY IN GHANA'S COCOA INDUSTRY: EVIDENCE FROM BIBIANI-ANHIAWSOBEKWAI DISTRICT.

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN AGRICULTURAL ECONOMICS

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DECLARATION

I, Gideon Danso-Abbeam, author of this thesis do hereby declare that apart from the references of other peoples work, which has been duly acknowledge, the research work presented in this thesis was done entirely by me at the Department of Agricultural Economics, Agribusiness and Extension, Kwame Nkrumah University of Science and Technology, Kumasi from August 2009 to August 2010.

I do hereby declare that, this work has neither been presented in whole nor in part for any degree at this University or elsewhere.

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DEDICATION

This thesis is entirely dedicated to Mrs Grace Mensah, Africa Hall Bursar, Kwame Nkrumah University of Science and Technology, Kumasi.

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If it had not been the Lord who was on our side, now may Isreal say (Psalm 124:1)? It is he that had made me and not me myself; may his name be glorify.

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ABSTRACT

This study analyses the production and resource use efficiency in Ghana's cocoa bean industry. The study area (Bibiani-Anhiawso-Bekwai district) was particularly chosen for this study because of its prime place in cocoa production. The productivity and technical efficiency involved in cocoa production was estimated using the stochastic frontier production function analysis and the direct or primal approach was used in estimating the resource allocation efficiency. Cocoa farming was mostly on small scale level as most of the farmers (70%) had less than 5 hectares producing about 20 bags of cocoa per cocoa season. Moreover, about 90 percent spray their farms with insecticides and fungicides whilst just about 41 percent apply fertilizer on their farm. The stochastic analysis showed that farm size, mean age of cocoa trees, labour, frequency of weeding and pruning, intensity of insecticides and frequency of insecticides application exerts significant effects on cocoa production whilst intensity of fertilizer application, frequency and intensity of fungicide application had no influence on cocoa production. The results further revealed that, cocoa farm operation had positive increasing return to scale (RTS=1.26) indicating that cocoa production was in the irrational stage of production (Stage III). The efficiency level ranged between 0.03 and 0.93 with a mean technical efficiency of 0.49. The major contributing factors to efficiency were farmer's years of experience, farmers benefiting from CODAPEC programme and family size. However, cocoa farmers were not fully economically efficient in the allocation of their resources. The study observed that there was an opportunity for increase in farmers' efficiency and concluded that policies that would directly affect these identified variables should be pursued vigorously.

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LIST OF ACRONYMS

BAB	Bibiani-Anhwiaso-Bekwai
CIIG	Compton's Interactive Information Guide
CIV	Cote d'Ivoire
CODAPEC	Cocoa diseases and pest control
CSSVD	Cocoa swollen shoot and virus disease
ERP	Economic Recovery Programme
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
ICCO	International Cocoa Organization
IMF	International Monetary Fund
ISSER	Institute of Statistical, Social and Economics Research
MFC	Marginal Factor Cost
MOA	Ministry of Agriculture
MOFA	Ministry of Food and Agriculture
MPP	Marginal Physical Product
MVP	Marginal Value of Product
MVP	Marginal Variable Product

OLS	Ordinary Least Square
RUE	Resource Use Efficiency

CHAPTER ONE

INTRODUCTION

1.1 Background

In West Africa, agriculture has continued to play a dominant role in the provision of food, raw material for industries, employment for the majority, and foreign earnings, which are used in financing development activities. Industrial tree crops, notably cocoa, coffee, oil palm, and rubber, have dominated the export agriculture. Among the perennial tree crops, cocoa sector is of particular interest for some parts of West Africa, and for the global chocolate industry. In Africa, cocoa production is dominated by four West-African countries. Côte d'Ivoire and Ghana produce approximately 41 percent and 17 percent of the world output respectively. The other two important producers are Cameroon and Nigeria, each contributing approximately five percent of the world cocoa production (Binam *et.al*, 2008). These countries derive a large proportion of their foreign income from cocoa. For example, in 2001, Côte d'Ivoire exported more than 1.4 million tons of cocoa. This contributed about 40 percent of exports, 14 percent of GDP, and more than 20 percent of government income (Nkamleu and Kielland, 2006).

Moreover, in terms of sector growth, Ghana's Agriculture has in recent years been propelled by the strong performance of the cocoa sector (ISSER, 2003). In 2002, cocoa beans sales contributed 22.4 per cent (463 million US$) of total foreign exchange earnings and constituted 63% of the foreign export earnings from the Agricultural sector compared to 25% and 12% contributed by timber and other non traditional export sector

respectively (ISSER, 2003). Cocoa contributes about 70 per cent of annual income of small-scale farmers and stakeholders like licensed cocoa buyers (LCB's) also depend largely on their products for market, employment and income (Asamoah and Baah, 2002). The cocoa sector in Ghana employs over 800,000 smallholder farm families. The number of cocoa owners is estimated at 350,000. Cocoa farm sizes are relatively small ranging from 0.4 to 4.0 hectares with an estimated total cultivated area of about
1.45million hectares (COCOBOD, 2002).

With more than doubling of cocoa production between 2002 (340, 562 metric tones) and 2006 (740,458 metric tones), the cocoa sector in Ghana has done well, contributing significantly to the over all economic growth of the country (COCOBOD, 2006). However, surveys carried out by the Government of Ghana Task force and COCOBOD estimated annual production per hectare to be less than 250kg (COCOBOD, 1998). This is very low compared to countries like Indonesia and Cote d'Ivoire with annual yield rate of 1000kg and 600kg respectively (ICCO, 2003).

Within the cocoa bean industry, one of the objectives is to increase production on a sustainable basis at the farm level. Linked to the intensification and structural changes in cocoa production is the potentially increased use of chemical pesticides (insecticides and fungicides) and fertilizers. To policy makers, the increased use of inputs like pesticides and fertilizers often seems to be one of the most effective ways to increase production, since a good part of produce is lost through diseases, pests and weeds on the field. The swollen shoot caused by virus and the black pods caused by fungus are the major cocoa diseases and pest of economic significance. Losses of cocoa yields due to black pod disease vary from place to place and from variety to variety. Adegbola (1972) put the average to 40 percent over several parts of West Africa and up to 90 per cent in certain places in Nigeria. Crop loss due to this disease was estimated at about 29 per cent in the 1950s and 1960s (Wharton, 1962). Capsids which causes the swollen shoot disease were first identified as serious cocoa pests in the early part of the cocoa beans industry's history in 1910 (Asomaning *et al.*, 1971). Replacement of soil nutrients that are being mined through cocoa pod harvest annually cannot do without application of fertilizer. Appiah *et al*. (1997) reported a doubling of yields of cocoa in Ghana from the applications of 4.94bags of triple superphosphate and 2.47 bags of muriate of potash per hectare over 4 year period.

The scope of agricultural production can be expanded and sustained by farmers through efficient use of resources available to them (Ali, 1996 and Udoh, 2000). For these reasons, efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of the farmers are resource-poor. The traditional concept of efficiency, as defined by M. J Farrell (1957), has three components: technical, allocative and economic**. Technical efficiency** is defined as the ability to achieve a higher level of output given similar levels of inputs. '**Allocative efficiency'** deals with the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to production value is equal to the factor costs. Technical and allocative efficiencies are components of **economic efficiency.** The main aim of resource use efficiency is to find ways of increasing output per unit of input and attaining desirable inter-firm, intra-firm and inter-sector transfer of production resources in order to provide the means of raising our economic level of living.

Cocoa is mainly produced by small-scale farmers in the rural areas, hence the welfare of vast number of people in the rural areas are tied to cocoa production and marketing. In the past, it was assumed that, output growth would create plentiful non-farm incomeearnings opportunities in the rural economy through linkage effects; however, this assumption is no longer tenable as many poor rural families farming on their own are unable to provide sufficient means of survival (Ofori, 1998). Government must therefore create incentives to boost production of important crops like cocoa. As part of the Structural Adjustment Programme (SAP) implemented in Ghana in April 1983, subsidies on agricultural inputs were gradually withdrawn, this stimulated steep increase in factor inputs prices which may have served as a disincentives to cocoa producers, inter alia, and hurt the welfare of the rural farm families.

It is likely that the higher the producer price of cocoa and the lower the relevant cocoa factor input prices, the higher the supply of cocoa and vice-versa. Moreover, quantity of fertilizer, insecticides and fungicides applied per hectare, inter alia do affect cocoa production. It is also likely that efficient use of resources especially the variable resource can have a significant effects on cocoa production. This gives an indication that, changes in input prices and its application are likely to result in changes in output growth as captured by Cocoa production function (that's the combination of factor inputs to produce an output) and resource-use efficiency.

1.2 Problem Statement

To many people, cocoa is a different thing. To the farmer in developing countries like Ghana, Nigeria and Cote d'Ivoire, it is a life line to his/her dead line in that it serves as an important tropical tree for income earning which is used for the upkeep of his family and himself. To the government, cocoa is a prominent cash crop whose contribution to socioeconomic growth cannot be over-emphasized. Cocoa is, therefore, an important crop not only to the producer but to the economy of Ghana as a whole. If this is the case, then cocoa productivity should be expanded and sustained.

Cocoa productivity levels can be enhanced either by improving technical efficiency and/or by improving technological application. A relevant question for agricultural policymakers is whether to pursue a strategy directed towards technological change (bringing new technologies) or a strategy towards efficiency (improving the use of existing technologies) (Nkamleu 2004; Nkamleu 2004b). The presence of shortfalls in production efficiency means that output can be increased without requiring additional conventional inputs and without the need for new technology. If this is the case, then empirical measures of efficiency are necessary in order to determine the magnitude of the gain that could be obtained by improving performance with a given technology (Binam *et.al*, 2008). Cross country studies (Heady *et. al*, 1987) and location specific studies like Audibert (1997) in Mali, Tian *et a. al* (2000) in China and others show that there are rooms for increasing agricultural productivity in developing countries by improving technical efficiency of agricultural production. This means that there is a high potential of increasing cocoa productivity. In that case, every factor of production should be efficiently and effectively mobilized to reduce the gap between actual and potential outputs. Therefore any attempt at studying efficient allocation of resources on the farm represents a veritable source of achieving growth in the cocoa industry and the economy as a whole.

Generally, yields of cocoa are lower in Ghana than in other major producing countries. Whilst the average cocoa yield in Malaysia is 1800 kg ha–1, and 800 kg ha–1 in Ivory Coast, it is only 360 kg ha–1 in Ghana (Anonymous, 1999). Reasons for the low productivity include poor farm maintenance practices such as weeding and pruning, planting low-yielding varieties, and the incidence of pests and diseases (Anonymous., 1999; Abekoe *et al.*, 2002).This tends to support the work of Binam *et.al* (2008) who indicated that Ghana is the least efficient compared to other cocoa producing countries in West Africa notably; Nigeria, Cote d'voire and Cameroun. Cocoa yields are dependent on how farmers combine their resources optimally to maximize output. For cocoa to continue to play its key role in the economy, producers ought to optimize resource use in the industry. Studies on current level of resource use efficiency and output determinants in the Ghanaian cocoa industry are quite limited. Therefore, an empirical study to investigate these issues is a necessary first step in our national effort to improve resource use efficiency, boost production and to improve the overall contribution of the cocoa sector to national development. This raises the following questions of this study:

1. What are the effects of the determinants of cocoa output growth in Ghana?
2. What is the level of efficiency in cocoa production in Ghana?
3. What factor(s) influence the efficiency of resource of cocoa production in Ghana?

4. Do cocoa farmers allocate the resources available to them efficiently?

1.3 The Objectives of the Study.

The main objective of the study is to determine the quantitative effects of the factors that affect cocoa output and to estimate the Resource-Use-Efficiency in Ghana's cocoa industry. The specific objectives include the following:

1. To quantify the effects of the determinants of cocoa output growth in Ghana's cocoa industry

2. To estimate the level of technical efficiency in cocoa production in Ghana.

3. To identify the main factor(s) that influences the level of efficiency in cocoa production in Ghana.

4. To estimate the resource use efficiency of Cocoa production in Ghana.

1.4 Statement of Hypotheses

For meaningful results, the hypotheses of the study are;

- Farm sizes and input factors are strongly associated with cocoa output growth in Ghana.

- Cocoa farmers are efficient in the use of their resources and have no room for efficient growth

- Policy variables such as CODAPEC and/or socio-economic and demographic variables have no significant influence on the efficiencies of cocoa farmers in the study area.

1.5 Relevance of the Study

Cocoa has dominated the political economy of Ghana since 1920. Local farmers and their families responded very successfully to the world demand for new cash crop created in the industry. According to Dennis Austin (Politics in Ghana) (Annin, 2003) "Cocoa build roads, harbours, railways, schools, hospitals and universities, it capitalized the domestic trade and its local market; it gave impetus to the nationalist movement….. It has continued to finance the state its civilian and military rulers". In 2005, Ghana produces around 18% of the world's cocoa production, which makes it the world 2nd largest producer of cocoa and Cote d'ivoire leading the table with 40% of the world cocoa production (World Cocoa Foundation, 2005). It is estimated that there are around 3.2million Ghanaians involved in cocoa production in Ghana out of total population of almost 19million people (World Fact Book, 1999). Cocoa is mainly produced by several small-scale farmers in the rural areas; hence, the vast number of people in the rural areas is tied to cocoa production and marketing. The use of agrochemical and other factor are likely to affect the cocoa production significantly. However, the magnitudes and the directions of the actual effects of the potential determinant of cocoa production especially at the district level (farm-level) in the cocoa bean industry in Ghana are largely unknown. Hence, the findings of this study will inform policies makers on quantitative effects of the determinants of cocoa production and how resources are used by our cocoa farmers.

The efficient allocation of resources at the farm levels has great implication for overall national development. The following could be some of the important of measuring efficiency on the farm. Firstly, it is a success indicator, and a measure of performance at micro level. Secondly, it is only by measuring efficiency and separating its effects from the effects of the production environment that one can explore hypotheses concerning the sources of efficiency differentials (Ajibefun and Daramola, 2003). When the sources of inefficiency are identified, policy formulations to improve farmers' performance can be effectively done. Thirdly, the ability to quantify efficiency helps decision-makers monitor the performance of the farmers under study. In most cases, theory does not give clear picture of the impact of some factors on the performance level. The use of empirical measurement will provide both qualitative and quantitative evidence (Coelli, 1995). Knowledge of resource use efficiency of farmers is important in understanding farmer behavior and managerial decisions and will aid stakeholders involved in agriculture to develop strategies for reducing the level of economic inefficiencies in our farming practices.

Many researchers have been able to show that small farms are desirable not only because they provide a source of reducing rural unemployment, but also because they provide a more equitable distribution of income as well as an effective demand structure for other sectors of the economy (Bravo-Ureta and Evenson, 1994; Domer, 1975). This has lead many researchers to focus attention on the impact of the adoption of new technologies on farm income and productivity (Hayami and Ruttan, 1985; Kuznets, 1966). In Ghana, there is paucity of rigorous research on the theme of the present study although there are volumes of research on cocoa in Ghana. Given the importance of cocoa in the Ghanaian economy, the formulation of policy measures have been hampered by the lack of relevant empirical studies at the farm level in cocoa production. Hence, this work will bridge the gap in knowledge.

There are six cocoa growing regions in Ghana namely Ashanti, Brong-Ahafo, Central, Eastern, Western and Volta region. The main cocoa production region is presently the Western, which stands at more than 50 per cent total annual production (COCOBOD, 2006). The growth in the Western region is concentrated in north-western part of the region (Sefwi areas). Over 70 per cent of the indigene populace in the Bibiani-AnhiawsoBekwai district are engage in cocoa production (BAB District Assembly, 2008), hence the focus of this study on cocoa in the district. Finally, the present study focuses on Ghana because, in spite of the numerous problems faced by the cocoa bean industry, Ghana was the world's leading producer of cocoa until the 1970's (Nyanteng, 1978). Even with the loss of the first position, Ghana is the 2nd largest producer of cocoa in the world and produces the finest quality of cocoa beans in the world.

1.6 Scope of the Study

The study covers the Bibiani-Anhiawso-Bekwai district of Ghana. Cocoa producers are considered for the study because of their major role in the socio-economic development of Ghana. The emphasis of this study is on factors that significantly affect cocoa productivity and how resources are used efficiently in Ghana's cocoa bean industry. The study relies on data collected in the cocoa production season (August-June) of the year 2008/09 season for the analysis.

1.7 Organization of the Study

This study is organized in five chapters. Chapter one opens with the background of the study which is followed with problem statement with research questions relevant to the study. Moreover, chapter one contains the objectives of the study followed by the need of undertaking the study. Chapter one also contains the scope as well as the organization of the study.

In chapter two, relevant literature based on critical scrutinization and review of the empirical and theoretical prepositions and generalization on the subject matter are the main focus. This is important in understanding the work of others and gaps that could be filled in already completed works in order to add more to knowledge.

The third chapter contains the methodology employed in this study. Here, the choice of the study area and sampling procedure as well as the data collection method are elicited. It also includes the conceptual framework and the empirical model employed. Chapter four deals with the analysis pertaining to the data collected and discussion of the outcome. The study therefore concludes with chapter five, and it is concerned with summary of the major findings of the study and the main recommendations.

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews the literature relevant to the theme of this study. First, the history on the origin and the spread of cocoa is reviewed. Secondly, it describes briefly the structure of cocoa production and the role of cocoa in the economy of Ghana is reviewed. Third, the set of literature on the determinants of cocoa output in Ghana is well touched. Finally, the brief concept of resource use efficiency is also presented.

2.1 The Origin and Spread of Cocoa cultivation in Ghana.

Cocoa, ***theobroma cacao***, originated around the headwaters of the Amazon in South America (COCOBOD, 1998). Its cultivation and value spread in ancient times throughout Central and Western Amazonia and northwards to Central America. Large scale cultivation of cocoa was started by the Spanish in the 16th Century in Central America. It spread to British, French and Dutch West indies (specifically, Jamaica, Martinique and Surinam) in the 17th Century and to Brazil in the 18th century. From Brazil, it was taken to Sao Tome and Fernando Po in 1840 (COCOBOD, 2000). From there, it spread to other parts of West Africa, notably the Gold Coast (now Ghana), Nigeria and Cote d'ivoire. Records show that Dutch missionaries planted cocoa in the coastal areas of Ghana as early as 1815, whiles in 1857, Basel missionaries also planted cocoa at Aburi (COCOBOD, 2000). However, these did not result in the spread of cocoa cultivation until Tetteh Quashie, a native of Osu, Accra who travelled to Fernado Po to work as a blacksmith, returned in 1879 with Amelonado cocoa pods and established a farm at Akuapem Mampong. It later spread to other parts of the Eastern, Western, Ashanti, Brong Ahafo and Volta Regions.

The seriousness with which the people of the Gold Coast took cocoa farming was phenomenal. Knap (1920), for instance, observed that the enthusiasm and seriousness with which cocoa was cultivated in the Gold Coast shattered the stereotype image of the "indolent" native, and showed the World that the "native" was capable of building a strong economy by their own initiative and industry. As a result of its high demand in the European and American, it quickly became the main traditional export commodity in Ghana.

2.2 Cocoa Production in Ghana

2.2.1 The Structure of Cocoa Production

The *Amelonado* cocoa was the first cocoa type to be introduced into Ghana. It takes not less than five years to bear fruit. The Amazonian type which takes three to four years to mature was introduced into the country in the 1950s. Almost all the cocoa farms established in the 1960s and 1970s were sown to the Amazonian type. Recently, the hybrid cocoa variety (called *"akokora be di"* in Akan) was introduced. This is high yielding and early maturing. Cocoa is a perennial tree crop with a life-cycle of twentyfive to thirty years. In the initial stage of land cultivation (two to three years from planting depending on the tree variety) it is intercropped with staple food crops like maize, plantain, cassava and cocoyam, which provides shades to the young trees until they grow and form a closed canopy, at which point they are left to stand alone. Cocoa trees typically take between three to six (depending on the variety) years from planting before they start bearing the first pod, and full production capacity is only reached after ten years from first planting. The ideal climatic zone under which the crop is grown is the tropical rainforest zone.

Cocoa trees grow under shaded conditions with a climate characterized by relatively high temperatures (between 18-32 degrees Celsius) and plentiful rainfall. Cocoa production also depends heavily on the pattern of rainfall; the average distribution of monthly rains throughout the year is more important than the annual total. Annual rainfall in excess of 2500mm may lead to a higher incidence of fungus diseases, the most common known as *phytophtora* pod rot which causes the black pod disease, and the cocoa swollen shoot virus

(ICCO, 2000; Wood and Lass, 1985). Cocoa needs deep, well-drained soils adequately supplied with nutrient and moisture and containing little or no coarse materials (Dickson and Benneh, 1985). The cocoa belt in Ghana generally coincides with the semi-deciduous forest zone. Land preparation for the cultivation of cocoa is done in the same way as for foodstuffs. The forest vegetation is first cleared, but with some of the trees left standing. The litter is burnt during the height of the dry season. Traditionally, foodstuffs like cocoyam and plantain are first planted at the start of the rain in March, and the cocoa seedlings are planted among them to shelter under their broad leaves. Cocoa farms only need occasional weeding and brushing to control weeds (personal communication with farmers). Depending on the variety of cocoa seedlings planted, it may take three to six for the tree to bear fruits.

Cocoa trees typically have two harvest seasons in the year, the main crop (which begins in October and ends in March) and the smaller or mid crop season (between May and August). Harvesting or picking of the ripe cocoa pods starts from about September and may continue till late December or mid-January, depending on the size of the crop (Personal communication with experienced cocoa farmer in Sefwi-Bekwai). It is done by means of a cutlass or a metal hook which is so constructed that it serves the pod neatly from the stem by a thrust or a draw. Labour is mainly supplied by family. The women collect the harvested pods into heaps and carry them in baskets to a spot selected for breaking which is done communally. The men cut open the pods with cutlass and women and children scoop out the wet cocoa with their hands. The beans are fermented for a period of 6 -7 days in the wrapped, airtight container made of banana or plantain leaves. Sometimes, it is heaped under the multi-storey canopy of the cocoa trees and well covered with broad leaves, usually plantain leaves. The fermented beans are then transferred to raise drying

platforms made of sticks and covered with mats of split bamboo. The dried beans are then collected into mini or maxi bags of 30 kgs and 62.5 kgs respectively, and are sold to local buying agents who are distributed throughout the cocoa growing regions. They are then weighed, graded, and bought at prices fixed by
COCOBOD.

2.2.2 The Role of Cocoa in Ghana's Economy

In the role of cocoa in Ghana's future development Breisinger *et al.* (2007), describe the recent performance of the sector as an example of what "*favorable external conditions and internal reforms"* can do to renovate traditional exports. Ghana has maintained overtime a leading position among cocoa producing countries, despite the criticism by economic commentators that its continued dependence on traditional export crops might push the economy into the dependency trap from raw commodities (of which cocoa contributes the bulk of the country's foreign exchange earnings together with gold and timber). Serous concerns also arise over the future sustainability of the sector, as recent research findings clearly indicate that past and present cocoa growth have been driven by land expansion and by the intensive use of labor, rather than by rise in land productivity (Gockowaski, 2007 and Vigneri, 2005).

Cocoa contributes about 70 per cent of annual income of small-scale farmers and stakeholders like licensed cocoa buyers (LCB's) also depend largely on their products for market, employment and income (Asamoah and Baah, 2002). Knudson (2007) shows that income from cocoa is still the determining factor for most households' income and thereby for the demand for non-farm foods and investment in the non-farm sector. Many researchers have been able to show that small farms are desirable not only because they provide a source of reducing rural unemployment, but also because they provide a more equitable distribution of income as well as an effective demand structure for other sectors of the economy (Bravo-Ureta and Evenson, 1994 and Dorner, 1975). The cocoa growing industry also provides employment to many Ghanaians. It occupies well over one-third of Ghana's cultivated land and well over 55 per cent of farm families are directly and indirectly engaged in the production of cocoa (Dickson and Benneh, 1995). The cocoa sector in Ghana employs over 800,000 smallholder farm families. The number of cocoa farm owners is estimated at 350,000. Moreover, in 1960, when population census was taken, there were as many as 552,350 people directly engaged in the industry, including 312,510 cocoa farmers, 500,080 caretakers, 908, 040 family workers and 68,920 hired laborers (Dickson and Benneh, 1995). Moreover, there were numerous cocoa purchasing clerks, drivers and others involved in the purchase and shipping of cocoa to the European and American markets. In addition other stakeholders like chemical companies, input distributors and licensed cocoa buying companies also depend largely on cocoa for markets for their products, employment and income.

The fact that agriculture (including cocoa) is the driving force of the economy simply means a decline in this sector is likely to lead to a decline in the growth of the economy as a whole. Ghana produced one-seventh of World cocoa in the late 1980s and early 1990s as compared to one-third in 1965. This tremendous decline was partly attributed to inadequate credit supply, inappropriate control of disease and pest and poor macroeconomic policy, just to mention few (Opoku, 2003). Between 1986 and 1992, a decline in cocoa production led to a decline in foreign exchange earnings by 41 per cent; that's, decreasing from US $503.3million to US $302.5million (Compton Interactive Information Guide, 1995). This led to a high nominal producer price to boost production, but that was not enough to sustain increased real producer price of cocoa and cocoa exports due to huge inflation (Compton interactive information Guide, 1995). Between 1970 and 1982, Ghana Gross Domestic Product (GDP) declined by 0.5 per cent per annum, real export earnings fell from 21 per cent of GDP in 1970 to 4.0 per cent in 1989 (UNCTAD, 1990). This, among other factors, led to the launching of the Economic Recovery Programme (ERP) in April 1983 as one of the government interventions to reshape the economy. This programme, inter alia, was to increase the incentives for food production, raw material production and traditional export crop production of which cocoa was an important component.

Sales of cocoa beans have been one of the major foreign exchange earners to Ghana throughout the years. In 2002, cocoa made up for 22.4 per cent (463 million US $) of the total foreign exchange earnings (ISSER, 2003). Cocoa constituted 63% of the foreign export earnings from the agricultural sector (ISSER, 2003). Cocoa is the only traditional export commodity whose export is taxed; in 1998, it contributed 14.5 per cent of total tax revenue in the country (ISSER, 2000). The total export receipts from cocoa (beans and products) in 2002 amounted to US$463.4million compared to US$381.1million in 2001, representing an increase of 17.8 per cent (ISSER, 2002). The cocoa sub-sector exhibited the most impressive performance in recent time. For instance, the cocoa sector grew at an outstanding rate of 16.4

per cent in 2002. This has been attributed to both increase in cocoa output and relatively better border price for the commodity (ISSER, 2003).

2.4 Determinants of Cocoa Production

Although models of cocoa supply in Ghana are found more frequently in the literature than models of other perennials in the economics literature, the sum total of models of perennials in general including cocoa models remains unimpressive (Bulir, 2002). The biological lag between the planting decision date and output date presents unique challenges for econometric modeling not only for cocoa, but also for all perennials. Empirical problems also arise because of incomplete, unrecorded or missing data pertaining to plantings, removals and re-planting, yield variations and yield composition (King *et al.,* 1985). The cocoa supply modeling literature has therefore evolved as different analysts have tried to obtain more accurate forecast models by taking into account not only the lag but also other exogenous factors that affect output; for example, cocoa output price instability, cocoa production variability, probably caused by bad weather and also the availability of inputs into production (or rather the lack thereof) have all received considerable attention in the literature (King *et al.,*1985 as cited in Armah, 2008).

According to Bluir (2002), studies on cocoa modelling can be divided into three broad categories. First, some studies model the supply of cocoa as a *"technological"* function of the stock of cocoa trees and fertilization effects resulting in long-run or a short-run function that takes into account price and weather shocks. Second, a traditional partial-Adjustment supply model has been used with properly defined elasticity of domestic producer prices. Finally, few studies have estimated the supply response to changes in producer prices in neighboring countries. These studies have generally found that smuggling explains supply fluctuations better than most other variables. Bateman (1974), made an important contribution to the first group (technological capacity model). As a first step, he estimated a long-run production capacity for Ghana based on tree yields among several variables measuring the chemical spraying of cocoa trees that had a built-in ratchet effect (Bateman, 1974). As a second step, his short –run function included the previously estimated production capacity, real producer price and rainfall variables. Both equations were estimated separately for the three major cocoa producing regions in Ghana, and the shortterm price elasticities of supply were found to be of similar magnitudes, ranging between 0.14 and 0.22.

The second and the largest group of empirical studies has concentrated on the traditional partial-adjustment model using several domestically determined explanatory variables (Abbey and Clark, 1974; Yeung *et al.,* 1979; Berthelemy and Morrison, 1987 and Stryker *et al.,* 1990). In these studies, the estimated equations and the results of those estimates are similar. As a representative example, Stryker *et al.* (1990) have regressed the actual production on its lagged value, an estimate of cocoa production capacity, producer prices of cocoa, and the producer prices of competing food crops. The estimated own short-run and long-run producer price elasticities were 0.22 and 0.62, respectively, and the cross-price elasticities estimated at -0.14 and -0.40 respectively.

The third group of authors focused on the price incentives to smuggle to explain why the officially recorded cocoa production stayed for several years above or below its estimated production capacity. These authors realize that cocoa is a ***Golden Cash Crop*** that can be easily smuggled, because the borders with Cote d'Ivoire and Togo are practically unguarded. As early as 1982, Akiyama and Ducan (1982) regressed cocoa output on real prices (both in first-order differences) and a rainfall variable; in addition, their equation included three variables lagged one year: cocoa output, real producer prices, and the Ghana-Cote d'Ivoire price differential (all in level). Both short-run and long-run domestic producer price elasticities were low and statistically insignificant. However, their models showed the strong impact of price development in Cote d'Ivoire: raising the price differential by 1 per cent lowered the Ghanaian supply of cocoa by one-quarter of 1 percent. In other words, the official sales of cocoa to COCOBOD/Ghana might have fluctuated because of smuggling rather than changes in cocoa output growth. Fosu (1992), supported these findings, he estimated the short-term elasticity of Ghana's cocoa export with respect to the Ghana-Cote d'Ivoire price differential at about 0.17. May (1985), in estimating the regional motivation to smuggle cocoa to neighboring countries, found that as much as 50 percent of the crop in some regions may have been smuggled either to Cote d'Ivoire or to Togo. As a result, he found that virtually all new cocoa plantings in Ghana in the 1970s and 1980s were made in areas adjacent to Cote d'Ivoire and Togo in order to minimize the cost of transporting smuggled cocoa. Azam and Besley (1989) formulated and tested a general equilibrium model of Ghana's economy that features parallel foreign exchange and consumer good markets, and cocoa smuggling.

2.4.1 Control of Diseases and Pests of cocoa

The high incidence of pest and disease infestation is considered by many farmers to be the major cause for low cocoa yields (Nyanteng, 1980). Three major diseases and pest of economic significance exist: (i) swollen shoot caused by virus, (ii) black pod caused by fungus and (iii) capsid, which feed on plant tissues (shoot and pods), eventually killing them. Many diseases affect cocoa on the field. Some of them are *phytophtora* black pod disease, *phytophtora* canker, *phytophtora* seedling blight, *Theilaviopsis* pod rot, cocoa swollen shoot virus (CSSV) disease, *Cherelle wilt*, *charcoal pod rot* and *Collar crack* disease (Adegbola, 1972).

Black pod disease probably appeared as soon as cocoa was introduced in Ghana and it is considered to be the most destructive among all cocoa diseases which attack the developing cocoa pod. It is caused by soil-borne fungus *phytophtora* and is most prevalent during the wet season. The disease is worse in the areas of heavy rainfall. The disease can cause severed damage, rotten both small and large pods. Coupons, seedlings (in the nursery) and leaves of cocoa can be attacked and destroyed under conditions of long periods of cool and rainy weather. Losses of cocoa yields due to black pod disease vary from place to place and from variety to variety. Adegbola (1972) put the average to 40 percent over several parts of West Africa and up to 90 per cent in certain places in
Nigeria. Crop loss due to this disease was estimated at about 29 per cent in the 1950s and 1960s (Wharton, 1962). Deduction from analysis of data from the Cocoa Research Institute of Nigeria (CRIN) indicates that pod loss due to black pod diseases infection varies with variety of cocoa. The average per cent pod loss over the years 1962-1993 was 7.56 for Amazon I, 6.56 for Amazon II, 7.01 for Amazon III and 13.03 for Amelonado.
This is not quite different from the rest of West African countries (Tijani, 2005). In Ghana, the black pod disease is caused by two *phythophthora* species: *P. palmivora* and

P. megakarya (Opoku *et al.*, 1999). Generally, losses due to *P. megakarya* range from 60-80 per cent in newly affected farms to about 100 per cent in old affected farms in the black pod season (May to mid June). Losses for *P. palmivora* are estimated at 4.9 per cent to 19 per cent (Dakwa, 1984). This deadly disease, through yield reduction, also reduces farmer's revenue and the country's export earnings. The recommended method of control was to remove the affected pods and also to harvest the matured pods at short intervals. However, harvesting at short intervals does not meet the requirements for proper fermentation to obtain quality dry beans. Farmers therefore, prefer harvesting at long intervals, which unfortunately promotes a high incidence of the disease. Since the mid-1980s fungicides have been recommended for the control of the disease (Nyanteng, 1980). Babcock *et al.* (1992) noted that those yield loss could be reduced through the use of chemical control agents (synthetic pesticides) which have been favored because of their effectiveness (it diminishes with time in many cases), their relative shelf life (when properly stored), and the ease with which they can be transported, stored and applied. It should however not be forgotten that cocoa farm families spent huge amount of money in the procurement and application (labour cost) of these chemicals thus draining the income of these poor small-scale farmers.

Oluyole *et al*. (2008) estimates the determinants of the occurrence of black pod disease of cocoa. He uses the probit analysis approach to determine the influence of some explanatory variables such as availability of fungicides, price of fungicides, price of cocoa beans, labour availability among other things. The parameters of the probit model were estimated by maximum likelihood estimation rather than by Ordinary Least Square. Price of fungicides was a significant determinant of the probability of cocoa farm having black disease (P< 0.05). This simply means that the higher the price of fungicides, the higher the probability of occurrence of black pod disease. In addition, price of cocoa beans was significant determinants (P< 0.1) of the probability of the occurrence of black pod disease. That is, the higher the price of cocoa beans, the lower the probability of the occurrence of the disease. It can therefore be inferred from Oluyole's analysis that increase in the producer price of cocoa can help reduce the probability of occurrence of black pod disease. However, none of these studies focus on the effects of fungicide application on output and how efficient the chemical is used in controlling the disease, hence this study bridge that gap of knowledge.

Capsids which causes the swollen shoot disease were first identified as serious cocoa pests in the early part of the cocoa beans industry's history, 1910 (Asomaning, 1971). In the mid-1950s, it was estimated that about 50 per cent of the total cocoa area was severely damaged by capsids, serous attempts to control the insects were made in the late 1950s and directed by government who organized two mass spraying campaigns. The first covered only the western part of the Ashanti Region (Nyanteng, 1980). Following mass spraying campaigns, responsibility of capsid control was then transferred to farmers. It was reported that by early 1960s, capsid damage had been brought under control (Addo *et al.*, 1979). Since then, the supply of insecticides and spraying machines has not been adequate to meet estimated requirements for effective spraying of all cocoa farms. A country-wide mass spraying campaign was designed and implemented to cover only the Ashanti and Brong Ahafo Regions during the 1978/79 season; it was subsequently terminated without achieving the target. In the 1970s, capsid damaged accounted for an estimated 50,000 to 75,000 tonnes in the production loss each year (World Bank, 1980).

In respect of the application of fungicides against black pod disease and insecticides against swollen shoot disease, various suggestions have been made. Opeke (1987) suggested early spraying in the season and application repeated every three weeks until rains ceased. Cocoa Research Institute of Ghana also recommends an average of seven to eight times of spraying fungicides per season and three to four times of insecticides spraying per cocoa season. The foregoing presupposes that chemical control of cocoa diseases (mainly black pod and swollen shoot diseases) is feasible, acceptable and desirable, that's, technically possible, practically feasible, environmentally acceptable, economically desirable and politically advantageous (Norton, 1993). However, in the face of escalating costs of agricultural input (insecticides and fungicides), economic desirability appears very questionable. Nyanteng (1980), found the following to be some of the reasons for farmer's inability to spray their farms as often as recommended: lack of adequate quantities of insecticides, lack of funds to buy insecticides and unavailiabity of motorized spraying machines. It follows that, given that these constraints persist, an increase in the usage of insecticides resulting from low cost (subsidization) of insecticides would increase output per hectare and hence increase farmers revenue. The studies on cocoa insects and diseases and their control reveals that there is a knowledge gap concerning the magnitudes and the directions of the effects of the application of fungicides and insecticides as well as their frequencies of application on the output of cocoa in Ghana's cocoa bean industry.

2.4.2 Fertilizer Application

Low soil fertility has been identified as one of the major causes of decline in yield of cocoa. The significance of fertilizer in ameliorating this problem will go a long way to boost cocoa production. Replacement of soil nutrients that are being mined through cocoa pod harvest annually cannot do without application of fertilizer. Adequate application of fertilizer has been found to increase agricultural output. Traditionally, Ghana's cocoa was grown with minimum purchased inputs, although it has long been recognized that soil nutrients reserves would become exhausted (Charter, 1953). Recently, Appiah, *et al.* (1997) argues that soil nutrients availability has indeed become limiting to cocoa yields. Appiah, *et al.* (1997) reported a doubling of yields in Ghana from the applications of 4.94bags of triple superphosphate and 2.47 bags of muriate of potash per hectare over 4 years. According to Olson (1970), fertilizer could increase food production by at least 50 per cent. Opeyemi *et al.* (2005) in their recent work noted that, an effective use of fertilizer on cocoa would help not only to improve yield but also has the advantages of profitability, product quality and environmental protection. FAO (1987) noted that tremendous increase in fertilizer use has the highest potential of increasing productivity.

Ogunlade *et al.* (2009), use regression analysis to asses the determinants of the quantity of fertilizer usage on cocoa production. The quantity of fertilizer used was regressed on explanatory variables like farm size, fertilizer availability, and rate of fertilizer application and the price of fertilizer. They showed that the farm size as well as the price of fertilizer was much more critical in determining the quantity of fertilizer to be used. However, the fertilizer availability as well as rate of fertilizer application has no influence on the quantity of fertilizer used by cocoa farmers. However, these authors did not quantify the effects of fertilizer quantity and its usage on annual cocoa production and, hence this work seeks to fill that gap.

2.4.3 Rainfall

Cocoa, just-like any other crop; is responsive to rainfall and highly susceptible to drought and the pattern of cropping of cocoa is correlated to rainfall distribution. There is a significant correlation between cocoa output yield and amount of rainfall over varying interval prior to harvesting. In Ghana, a year with high rainfall is followed by a year with larger crop output, though the correlations not applicable in all years (Brew, 1991). Ali (1969) reported both positive and negative correlations between rainfalls in certain months with the mean of yield crop in Ghana. The annual total rainfall in the cocoa growing regions of Ghana is less than 2000mm. The rainfall distribution is bi-modal from April to July and September to November. Cocoa as a tropical crop can only be profitably grown under temperature between 30-32C mean max and 18-21C mean minimum and absolute minimum of 10C, Temperature has been related to light use efficiency with temperatures below 24 ^{o}C having a decreasing effect on the light saturated photosynthesis, (Wood and Lass, 1985).

Anim-Kwapong and Frimpong (2008) estimated the impact of climate changes on the supply of dry cocoa beans. Their work sought to determine the effect of changes in total annual rainfall, total rainfall in the two driest months and sunshine duration. They used multiple regression analysis to show that over 60 percent of variation in dry cocoa beans could be explained by the combination of the preceding total annual rainfall, total rainfall in the two driest months and the total sunshine duration. Oyekale *et al*. (2009) also showed that about 82 percent of cocoa farmers in Nigeria depend heavily on rainfall and could be more in the rest of West African countries. They estimated the impact of climate change on the production of cocoa. It was stated that, the main climate was rainfall and has a very significant impact on cocoa growth. Rainfall failure therefore has the ability to increase the cost of controlling diseases and pest and reduce the quality of the cocoa beans. Excess cost and reduce quality were significant at 1 per cent and 5 per cent respectively.

2.4.4 The Producer Price of Cocoa

One of the key economic policies in Ghana each year is the setting of the producer price of cocoa. Farmers, as any other rationale producers, respond to price by changing the intensity with which they tend their farms. If prices are not enough to cover their normal average variable costs including maintenance, the farmer's first response will be to reduce maintenance of the farm and stop new planting activities. If prices do not even cover harvesting, fermenting and drying, then harvesting is most likely to cease. Conversely, if prices cover or exceed variable costs, farmers will intensify farm. The short-term price elasticity of supply is estimated at 0.3 and the price elasticity of production for period 5 and 10 years later are 0.9 and 1.8 respectively(COCOBOD, 1998). This means that a 10% increase in real price will result in a 3% increase in production in the short term. In the longer term increases in production resulting from new plantings will be about 18% higher after 10 years (COCOBOD, 1998).

The volume of Ghana's cocoa exports has expanded significantly in the last several years after many years of decline followed by a mediocre performance recovery (ICCO 2005, IMF Country Report, 1995). Not surprisingly, cocoa prices paid to Ghanaian cocoa farmers have also appreciated both in nominal and real terms; The nominal price per bag of cocoa beans paid to farmers by Ghana Cocoa Marketing Board (COCOBOD) which was Gh¢7 in 1995, topped Gh¢90 by 2004, representing an astronomical increase of 1186% although after exchange rate effects and inflation are accounted for this increase is less impressive (Ministry of Agriculture, 2005). To explain the severe contraction in Ghanaian cocoa supply from 1960s to the 1995s (a 60% decline) Bulir (2003) appealed to the reversal in price-incentive to smuggle Ghana cocoa to Cote d'voire using cointegration model and a single equation error correction model. He explained that distortionary effect of domestic taxes in Ghana widened the gap between the Cote d'voire and Ghanaian domestic prices, and ultimately created incentives to smuggle Ghana cocoa to the CIV (Bulir, 2003). Bulir argued that the monopoly position of Cote d'voire enabled that country to pay better domestic prices to its farmers. Rational Ghanaian farmers therefore smuggled their cocoa to Cote d'voire when the expected gain from smuggling Ghana cocoa to Cote d'voire outweighed the transportation and transaction costs that this risky adventure entails. Armah (2008) also showed that the smuggling incentive was statistically significant at 5% and that the international cocoa price is positively statistically significantly related to cocoa supply in the long run while the cocoa producer price correlated to supply response in the short run. So as the producer price of cocoa increases, Ghanaian cocoa farmers respond by supplying more cocoa both in the short and long run.

Some studies have estimated the effects of input supply of cocoa and its use (Bateman, 1994; Nyanteng, 1980 and Okyere, 1989). These authors looked at how increases in the real producer price of cocoa encourage the establishment of new cocoa farms, rehabilitation, replanting and maintenance of existing cocoa farms. They did not however quantify the effects of the trends of input cost (for example, fertilizer cost and insecticides cost) on the supply of cocoa beans with regards to resource use efficiency. Fosu (1992) indicated that most of the factors postulated to influence cocoa export supply in Ghana are directly or indirectly related to the real exchange of the domestic currency. He further stressed that it is in fact a major factor in the decline of cocoa exports.

Bateman (1973) estimated the effects of the domestic real cocoa producer price and weather on cocoa supply. His work sought to determine the effects of changes in producer price, insecticides usage and government extension programmes on cocoa yield in Ghana. He first specified cocoa base capacity as a function of past planting, tree yields and insecticides (gammalin 20) application. The average capacity estimate from this function was then introduced into a short run supply fluctuations equation. The equation allowed deviation of prices and rainfall to either increase or decrease relative to average capacity.

2.4.5 Labour and Other Socio-economic Factors

According to pilot survey conducted by Ministry of Employment and Manpower Development in 2006, the age range of adult workers in cocoa farms in the cocoa growing regions in Ghana is between 18 years and 70 years, but most of the workers (76.3 percent) belonged to the younger age grouping of 18 years to 35 years, indicating that most of the workers were relatively young. Labour constraints constitute an important determinant of cocoa supply (see for instance, Okali and Rouke, 1974; Manu, 1974 and Robertson, 1987).

Studies on labour constraints relating to cocoa production have tended to concentrate on ways to improve the standard of living of cocoa producers, since family labour was largely used in the cocoa production process in Ghana. Other labour issues addressed included how labour shortages affected cocoa output and the importance of labour in cocoa production as well as the advantage effects of the deportation of illegal immigrants who were a source of their labour, the organization of labourers into society, social security and insurance scheme, making land available and improving health facilities in cocoa communities.

Surveys conducted by Ministry of Finance (1998) on cocoa farms show that about 25% of current cocoa tree stocks are over 30 years old. Behrman (1968) showed that if cocoa were allowed to reach maturity, there would be large output response to the cocoa real producer price. He indicated that the estimated average long-run elasticity was about 0.9. The long run elasticity is the response after newly planted trees have come into full bearing and all other adjustments have been made.

2.5 The Concept of Efficiency in Agricultural Production

The concept of efficiency is defined as the index of the ratio of the value of total farm output to the value of the total inputs used in farm production (Olayide and Heady, 1982). The main aim of resource use efficiency is to find ways of increasing output per unit of input and attaining desirable inter-firm, intra-firm and inter-sector transfer of production resources in order to provide the means of raising our economic level of living. Three main types of efficiency are identified in literature: These are technical efficiency, allocative efficiency and economic efficiency (Olayide and Heady, 1982; Farrell, 1957). Technical efficiency is the ability of a firm to use a minimum quantity of inputs under a given technology to produce a given level of output. Allocative efficiency is defined as the firm's ability in achieving the best combination of different inputs in producing a specific level of output considering the relative prices of these inputs. Economic efficiency is a product of technical and allocative efficiency (Olayide and Heady, 1982). In other words, the efficiency of a firm is its success in producing as large an amount of output as possible from given sets of inputs. Maximum efficiency of a firm is attained when it becomes impossible to reshuffle a given resource combination without decreasing the total output. Since the seminal work of Farrell in 1957, several empirical studies have been conducted on farm efficiency

However, a variety of statistical tools for determining or analyzing resource use efficiency have been identified by many economists and researchers. Hawksworth (1984) indicated that human resources could be studied through the use of descriptive statistics, questionnaire, surveys and in-depth researches. Kay (1987) also stated that measurement of land efficiency is in terms of yield per hectare of land while capital efficiency, for instance, tractor efficiency, is determined in terms of power for productive man work unit and could be used to measure the relationship between capital input and labour. Adesinmi (1981) also identified three major methods of measuring labour efficiency. These include labour efficiency determination in terms of output and amount of labour used, value of the total output and total wage bill as well as total wage bill cum cropped hectarages. However, Upton and Anthonio (1975) also affirmed that labour efficiency could be improved by spreading the labour needs more evenly throughout the year. Therefore, efficiency of labour resource utilization involves optimal utilization of time efficiency profile of work load. It is worth noting that labour supply at busy period could be increased by using communal labour, share cropping or by hired labour.

Measures of efficiency have been classified into three categories namely: deterministic parametric estimation, non-parametric mathematical programming and the stochastic parametric estimation. There are two non-parametric measures of efficiency. The first, based on the work of Chava and Aliber (1983) and Chava and Cox (1988) evaluates efficiency based on the neoclassical theories of consistency, restriction of production form, recoverability and extrapolation without maintaining any hypothesis of functional form. The second, first used by Farrell (1955) decomposed efficiency into technical and allocative. Fare *et al.* (1985) extended Farrell's method by relating the restrictive assumption of constant returns to scale and of strong disposability of inputs (Llewelyn and Williams, 1996; Udoh and Akintola, 2001). Several approaches, which fall under the two broad groups of parametric and non-parametric methods, have been used in empirical studies of farm efficiency. These include the production functions, programming techniques and recently, the efficiency frontier. Several empirical applications have followed the stochastic frontier specification. These studies are basically based on CobbDouglas function and transcendental logarithmic (translog) functions that could be specified either as production or cost function (Udoh and Akintola, 2001). The first application of the stochastic frontier model to farm level data was by Battese and Corra (1977) who estimated deterministic and stochastic Cobb-Douglas production frontiers for the grazing industry in Australia. Studies relating to allocative efficiency in most parts of African agriculture can be classified into two categories depending on weather a direct (primal) or indirect (dual) method is used. In the primal approach, the production function, in most cases Cobb-Douglas, is directly estimated by OLS technique. After obtaining the parameter estimates, marginal product (MP) of each endogenous input is calculated. The presence of allocative efficiency is then tested by equating the value of MP of inputs with their respective prices (Akinwumi, 1970; Ogunfowora *et al.*, 1975; Umoh and Yusuf, 1999). The dual approach involves estimating the profit function along with the input share (in profit) equation derived from Hoteling's lemma (Udoh, 1999 and Umoh, 2003).

Several studies have sought to estimate Technical Efficiency (TE) and its potential determinants in the Agriculture sector, Tchale (2009); Chirwa (2007); Heshmati and Mulugeta (1996); Helfand (2004); Chomitz and Thomas (2001); Shanmugam and Venkataramani (2006)). Binam *et al*. (2004) in examining the factors influencing technical efficiency of groundnut and maize farmers in Cameroon observed an average efficiency of 73%and 77% for the two crops, after controlling for environmental effects.
Heshmati and Mulugeta (1996) observed a mean TE of 65% for Ugandan matoke producing farms

In the cocoa sub-sector, Amos (2007) estimated the productivity and technical efficiency of small holder farmers in Nigeria cocoa industry by employing the famous CobbDouglas production frontier. The results of his analysis showed that the efficiency of Nigerian cocoa farmers ranged between 11 percent and 91 percent with mean efficiency of 72 percent and that there is a scope of increasing cocoa production by about 28% in the short run. He indicated that age of farmers, their level of education and family size are major factors contributing significantly to the farmers efficiency level; while age of farmers reduce the efficiency level educational level and family size increase their efficiency level. Binam *et al.* (2008) employed stochastic frontier metaproduction to estimate the technical gap and efficiency gap in cocoa production in West and Central Africa. The cocoa producing countries studied were Ghana, Cote'dvoire, Nigeria and Cameroun. For the studied countries, he estimated that, the technical efficiency scores ranged from 0.44 to 0.74, with a weighted average of about 0.61, indicating that the cocoa sector in West and Central Africa produces on average, only 61 percent of the potential output given the technology available in each country. However, he showed that, Nigeria is the relatively most efficient country with a mean technical efficiency of 0.74 while Ghana is the least efficient country with an average efficiency of 0.44. Binam *et al.* indicated that imperfect competition, financial constraints etc., may cause a farmer not to be operating at optimal level. However, these studies fail to study how efficient cocoa farmers are in allocating the resources available to them, hence; this study intends to close the gap in knowledge.

CHAPTER THREE

METHODOLOGY

3.1 Study Area

Bibiani- Anhwiaso-Bekwai(BAB) District is located between latitude 6° N, 3° N and longitude 2° W, 3° W. BAB is one of the thirteen administrative districts in the Western Region of Ghana. Its geographical size is about 73 sq.km. The district is bounded on the North by the Atwima Mponua District in the Ashanti Region, South by the Wassa Amenfi in the Western Region, West by the Sefwi Wiawso District in the Western Region and East by the Denkyira North and Amansie East in the Central Region and Ashanti region respectively. The total land area of the district is 873 km square.

The district is located in the equatorial climate with the annual rainfall average between 1200mm and 1500mm.The pattern is bimodal, falling between March – August and September- October. The dry season is noticeable between November- January and the peak periods are June and October. The average temperature throughout the year is about 26°C.There is a high relative humidity averaging between 75% in the afternoon and 95%

in the night and early morning. The implication here is that the climate of the area is suitable and can facilitate the growing of most traditional and non- traditional crops for exports. Some of the traditional crops are cassava, yam and plantain. The non-traditional crops also include pineapple and cashew. The natural vegetation is moist-deciduous forest, with the Celtie- Triplochiton Association dominating. In this area the tree species, examples Odum, Mahogany and Sapele form the basis of the flourishing Ghana Timber Industry. Hence, the district is a suitable location for the establishment of timber firms.

Total population is estimated to be about 120,869 with 47.5% male and 52.5% female (www.ghanadistrict.com). The agricultural sector is the most important sector employing more than half of the district's labour force. Specifically, the agriculture sector alone employs about 65.4 % of the labour force with 34.6 % female participation in the year 2000 and 61% of the labour force with 34% female participation in the year 2005 (www.ghanadistrict.com). Although the district has both rural and urban settlements, the rural settlements accounts for 63%. The implication here is that the district is basically rural; therefore agriculture can be used as a development focus in order to reduce poverty in the district. The district has three urban centers; Bibiani, Sefwi Bekwai and Awaso. These towns account for 37% of the total population, with the district capital alone constituting 22.1% of the total population in the district.

3.2 Choice of Study Area, Crop of Concentration and Data Source

In an attempt to achieve the various objectives of the study, the primary data used in this study were collected from a sample of cocoa farmers in Bibiani-Anhiawso-Bekwai District of the Western Region. The Cocoa crop is considered because of its major role in income generation for the rural farm families. Cocoa contributes about 70 per cent of annual income of small-scale farmers and stakeholders like licensed cocoa buyers (LCB's) also depend largely on their products for market, employment and income (Asamoah and Baah, 2002). It is cultivated as non-consumption crop and therefore much attention is attached to the revenue that will be derived. In the early stage of production, the cocoa plant is inter-cropped with some traditional staple crops like cassava, cocoyam, plantain and yam. The area was considered because of its recent increase in the trend of cocoa output in the Western Region of which most is concentrated in the district.

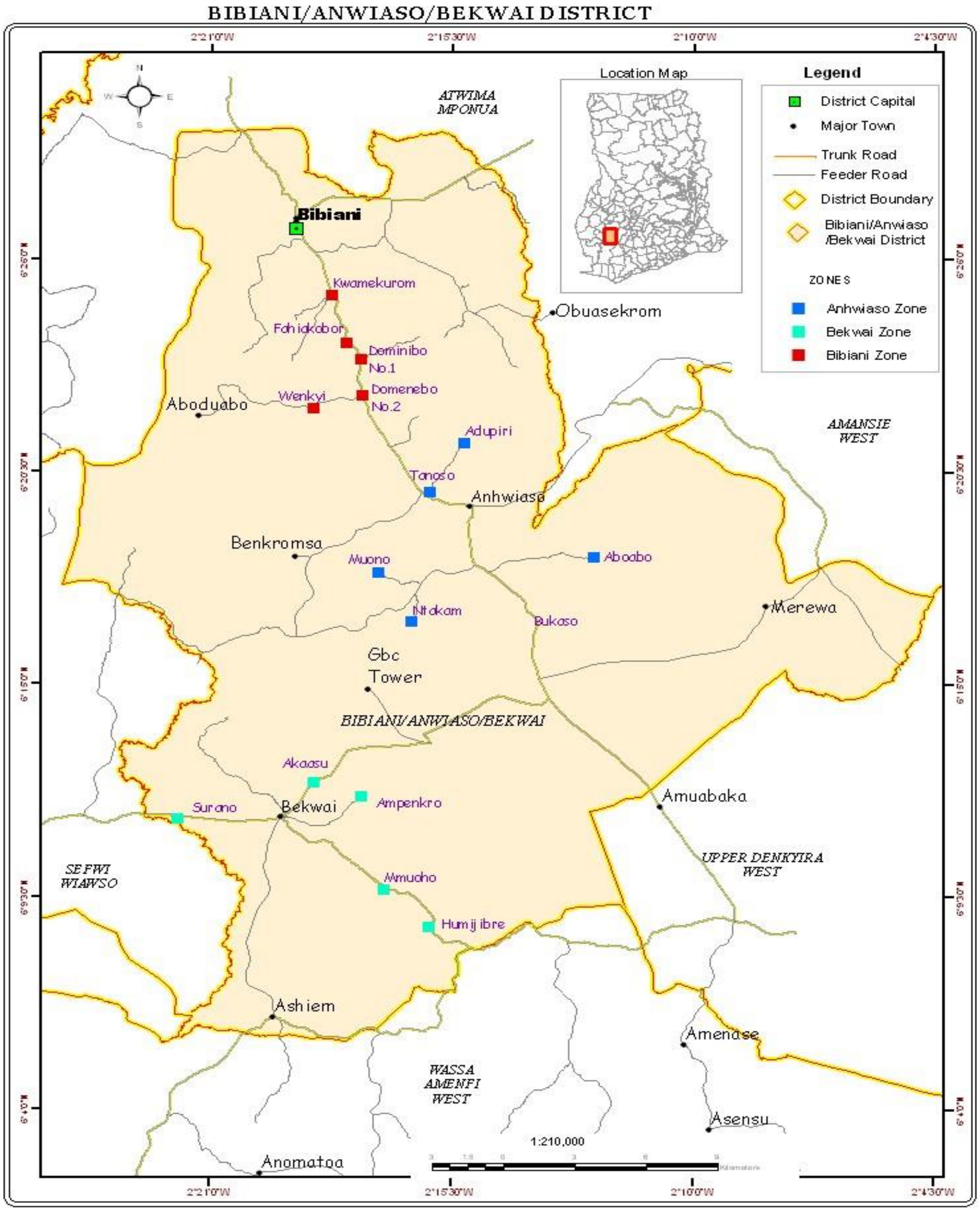
3.3 Sampling Design and Method of Data Collection

The aim of research is to produce, explore and identify the new information, scattered in the field, in front of the researcher, but may not have been recognized and identified before (Aase, 1997). Moreover, Aase contends that production of data and information is a never-ending process. It is because the inexhaustible social interaction every minute produces events and new information in the society. According to Kitchen and Tate (2005), in addition to contributing to knowledge, a piece of research contributes to policy issues and at the very least makes clear to the groups being researched or associated agencies that there might be a need for a greater understanding of an issue. Similarly, Marshall and Rossman (1995) outline five reasons for undertaking a study, viz exploration, explanation, description, understanding and prediction.

Both primary and secondary data were used for this study. In the case of the primary data, a multistage sampling technique was followed. Peil (1982) asserts that sampling is the selection of a part to represent the whole. The first stage involved purposive sampling where the Bibiani-Anwiaso-Bekwai district in the Western region was chosen due to its economic importance as the main farming activity undertaken by the majority of farmers in the area. About 50% of the volume of cocoa produced in Ghana was from the Western Region of which majority is concentrated in the ***Sefwi areas*** of the western region. In the second stage, a cluster sampling were used, where the district was divided into three zones namely, zone A (Bibiani zone), Zone B (Anhiawso zone) and Zone C (Bekwai Zone). Each of these zones was identified as a cluster. Kish (1967) points out that when individual selection of elements seems too expensive, survey tasks can be facilitated by selection of clusters. Simple random sampling was employed to select five communities from each zone, with this; all the communities in each zone get equal chance of selection. In each community, respondent's households were selected using simple random sampling techniques. Data was then obtained from 20 cocoa farmers who are household heads and/or wives (or household members responsible for cocoa production) from each of the five communities in each zone. According to Patton (1980), random sampling is an appropriate strategy when one wants to generalize from the sample studied to some large population. Through random sampling there is increased likelihood that the data collected are a representative of the whole population of interest (*ibid)*. The random sampling technique was preferred over others to select the individual farm owners because with this method the probability of selection becomes the same for every case in the population. Another reason random sampling was used is to avoid bias by giving all units in the target population equal chances of being selected, as emphasized by Nichols (1990).

Fig 3.1. A Map indicating the various communities where survey was conducted in

Bibiani-Anwiaso-Bekwai



A list of the cocoa producers in the villages was obtained from the cocoa purchasing clerks (PC's) of the various cocoa buying companies in the district. The final selection principle was that the sample size from each cluster was a representative of the total sample size which stood at 300 cocoa farmers. Previous studies suggest that a sample size of 25 to 30 is sufficient when variation within micro-area is not large (Officer and Halter, 1968; Hamal and Anderson, 1982). However, this study used a sample size of 300 to improve the probability of capturing variation existing in the information gathered from the respondents. Farmers interviewed were farm household heads and/wives (or household members responsible for cocoa production) and not farm labourers or workers. Data was collected with the use of structured questionnaire through interviews. The data collected covered inputs (fertilizer usage, insecticides and fungicides usage, labour and acreage of farms owned); outputs (total out of cocoa produced by each participant in kilograms) and some important socio-economic variables (age, sex, years of formal education and marital status) of farmers were also collected.

3.4 Theoretical Framework

3.4.1 Concept of Production Function

The production function is a technical relationship depicting the technical transformation of inputs into outputs. This could be represented as $Q=f(X_1, X_2 X_3....X_i)$

Where Q represents a firms output, X_1 may represent the amount of labour, X_2 represents quantity of pesticides (insecticides and fungicides) used in production of Q while X_3 represents the amount of fertilizer applied, among other determinant X_i The objective of the producer is to maximize profit either by increasing the quantity of Q produced or by reducing the cost of producing *Q*. The production function shows the maximum amount of the good that can be produced using alternative combinations of labour, insecticides and fertilizer. *Q* is also referred to as the total physical product (TPP). This production relationship can be expressed in several forms such as: Cobb-Douglas functional form (named after its inventors Cobb and Douglas; Cobb and Douglas, 1928), linear functional forms and polynomial functional forms. The Cobb-Douglas is modified into the transcendental and translog functional forms. The marginal physical product (MPP) of an input is the additional output that can be produced by employing one more unit of that input, *ceteri paribus*.

Example, the MPP for labour (X_1), $MP_{X_1} = \frac{\partial Q}{\partial X_1} = f_{X_1}$

This is derived from the first derivative of the production function. However, if labour is employed indefinitely while holding all the other inputs of production indefinitely, this results into diminishing marginal productivity where the rapid increase in use of additional input results to lower productivity. Therefore the second derivative is less than zero:

$$\frac{\partial MP_{X_1}}{\partial X_1} = \frac{\partial^2 Q}{\partial X_1^2} = f_{X_1 X_1} < 0$$

The average physical product (APP) is a measure of efficiency. The APP depends on the level of other inputs employed. $AP_{X_1} = \frac{Q}{X_1} = \frac{f(X_1, X_2, X_3)}{X_1}$

The concept of returns to scale shows how output responds to increase in all input together. Returns to scale can either be constant, decreasing or increasing.

The elasticity of supply of an input measures how an output responds to changes in inputs. This is derived by dividing the MPP by the APP (i.e. MPP/ APP). In addition, the total variable product (TVP) is derived by multiplying TPP by the output price (i.e.TPP*output price). Given the output price (P_y), its marginal value product (MVP) can be computed by multiplying (MPP*P_y). To determine if the inputs are used at optimum level, the MVP is equated to the unit factor price or marginal factor cost (MFC). If MVP equals MFC, then resources are used efficiently, if MVP is greater than MFC or less than MFC, it simply indicates overutilization or underutilization respectively. It is important to note that in the traditional production function, social economic characteristics and management are not considered as explanatory variables and are thus put together in the error term. The stochastic frontier production functions deals with the analysis of socioeconomic characteristics of the household that are assumed to be in the composed error term.

3.4.2 The Proposed Stochastic Frontier Production Function

The stochastic frontier production function was independently proposed by Aigner, *et al*., (1977) and Meeusen and Van den Broeck (1977). The stochastic production function is defined by;

$Y_i = f(x_i, \beta) + \varepsilon_i$ where $i = 1,2,3...,n$ (1)

$\varepsilon_i = v_i - u_i$

Where Y_i represents, the output level of the *i*th sample farm; $f(X_i;\beta)$ is a suitable function such as

Cobb-Douglas or translog production functions of vector, X_i of inputs for the *i*th farm and a vector,

$ß$, of unknown parameters. ε_i is an error term made up of two components: V_i is a random error having zero mean, N(0; σ^2v,) which is associated with random factors such as measurement errors in production and other factors which the farmer does not have control over and it is assumed to be symmetric independently distributed as N (0; σ^2v,) random variables and independent of u_i.

On the other hand, u_i is a *non-negative* truncated half normal, N (0; σ^2u) random variable associated with farm-specific factors, which leads to the ith farm not attaining maximum efficiency of production; u_i is associated with technical inefficiency of the farm and ranges between zero and one. However, U_i can also have other distributions such as gamma and exponential. N represents the number of farms involved in the crosssectional survey of the farms. Technical efficiency of an individual farm is defined in terms of the ratio of the observed output to the corresponding frontier output, conditioned on the level of inputs used by the farm. Technical inefficiency is therefore defined as the amount by which the level of production for the firm is less than the frontier output;

$$\hat{TE}_i = \frac{Y_i}{Y_i^*}, \text{ whrer } Y_i^* = f\,x(_i;\beta), \textit{ highest predicted for the ith farm}$$

$$TE = Exp(-u_i)$$

$$\textit{Technical inefficiency} = 1 - \hat{TE}_i \quad (2)$$

In their article Bravo-Ureta *et al*. (1993) suggested that the stochastic frontier production function could be established in two ways. First, if no explicit distribution for the efficiency component is made, and then the production frontier could be estimated using a stochastic version of corrected ordinary least squares (COLS). However, if an explicit distribution is assumed, such as exponential, half-normal or gamma distribution, then the frontier is estimated by maximum likelihood estimates (MLE). According to Greene (1980), MLE makes use of the specific distribution of the disturbance term and this is more efficient than COLS.

Previously, TE was estimated using a two-stage process. First, was to measure the level of efficiency/inefficiency using a normal production function. Second, was to determine socio-economic characteristics that determine levels of technical efficiency. This was done by using a probit model, with TE as the dependant variable and the socioeconomic characteristics as the independent variables. However, since 2000, the stochastic frontier and inefficiency models are jointly estimated using Limdep (Green, 2002) or Frontier computing packages, which apply MLE. Green (2002) outlines the Log likelihood estimation of the normal-truncated half-normal model.

The log likelihood for the normal-truncated normal model is

$$\log L_i = -\frac{1}{2}\log 2\pi - \log\sigma - \log\varphi\left(\frac{\alpha}{\sigma\lambda}\sqrt{1+\lambda^2}\right) + \log\varphi\left(\frac{\alpha}{\sigma\lambda} - \frac{\varepsilon_i\lambda}{\sigma}\right) - \frac{1}{2}\left(\frac{\varepsilon_i + \alpha}{\sigma}\right)^2 \quad (8)$$

Where $\varepsilon_i = y_i - \beta' x_i$

$$\lambda = \frac{\sigma_u}{\sigma_v}$$

$$\sigma^2 = \sigma_u^2 + \sigma_v^2$$

$$\sigma = (\sigma_u^2 + \sigma_v^2)^{\frac{1}{2}}$$

$$\alpha = \left(\frac{\mu}{\sigma}\right)\lambda$$

3.4.3 Allocative Efficiency of Inputs

The question of efficiency in resource allocation in traditional agriculture is not trivial. It is widely held that efficiency is at the heart of agricultural production. This is because the scope of agricultural production can be expanded and sustained by farmers through efficient use of resources (Ali, 1996 & Udoh, 2000). For these reasons, efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of the farmers are resource-poor. This study follows the neoclassical theory of production to examine allocative efficiency of inputs, using the farm specific production function that has the highest associated Iso-profit line. The Iso-Profit line according to Yotopoulos and Lau (1973), implies that the farm was able to equate the marginal value product (MVPx) of each resources employed to its unit cost (Px). However the MVPx is obtained, when the slope of the production function (Marginal product (MPx)) is equal to the slope of Iso-Profit line which is the ratio of the price of the factor inputs to the price of output (Px/Py),* (Kalirajan and Obwona , 1994) as derived below:

$$MP_x = \frac{P_x}{P_y} = MP_x \cdot P_y = P_x, \text{ but } MP_x \cdot P_y = MVP$$

$$This \Rightarrow MVP = P_x \quad (4)$$

3.5 The Empirical Model

Following the Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977) method of estimating a stochastic frontier production function, a Cobb-Douglas function was fitted to the stochastic frontier production and estimated. This functional form has been employed consistently in related efficiency (Chirwa, 2007; Donkor *et.al,* (2008); Ogundari, (2008) and Aneani, (2011)). The Cobb-Douglas function is employed because it is commonly used in the literature, making estimates comparable with previous studies.

The specified multiplicative production function was:

$$Y = AX_1^{\beta_1}.X_2^{\beta_2}.X_3^{\beta_3}.X_4^{\beta_4}.X_5^{\beta_5}.X_6^{\beta_6}.X_7^{\beta_7}.X_8^{\beta_8}.X_9^{\beta_9}.\varepsilon \quad (5)$$

The linear transformation of (5) is achieved by taking the natural logarithm of both sides of the equation to obtain (6). $\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9 + \varepsilon_i$ (6)

Where Y = output of cocoa beans in Kg

X_1 = Land input in hectare (ha) (+)

X_2 = Labour input in man days (+)

X_3 = Mean age of cocoa tree (+/-)

X_4 = Farm management (Frequency of weeding and pruning) (+)

X_5 = Frequency of insecticides application (+)

X_6 = Frequency of fungicides application (+)

X_7 = Intensity of insecticides application (quantity/ha) (+)

X_8 = Intensity of Fungicides application (quantity/ha) (+)

X_9 = Intensity of Fertilizer application (quantity/ha) (+)

Ln is the natural logarithm, β_j 'sare the parameters to be estimated (they are elasticity coefficients in the case of a Cobb- Douglas specification of the production function); and the disturbance term $\varepsilon_i = v_i - u_i$ is composed of two components, a symmetric error term accounting for deviation because of factors which are out of the farm (Vi) and error term accounting for the deviation because of inefficiency effects (Ui), and i= 1, 2,….n farms.

Vi - is *independently and identically distributed (i.i.d)* $N(0;\sigma_V^2)$;

Ui - is a non-negative and is assumed to be i.i.d. $N(0;\sigma_u^2)$ truncated at zero or exponential distribution independent of V_i. For this study the parameters of equation (1) were estimated using the Maximum Likelihood (ML) method, following the likelihood function estimation by Battese and Corra (1977).

Where $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\lambda = \sigma_u / \sigma_v$

And σ_u^2 is the variance of U_i and σ_v^2 is variance of V_i, σ^2 is the sum of the error variance and γ is defined as the total variation of output from frontier which can be attributed to technical (in) efficiency. It is theγ, that is used in the estimation of the technical efficiency level and the frontier function by the FRONTIER 4.1 (Coelli,1996) software or frontier computing packages like STATA 11.0 which is used in this study. where if $\gamma=0$, inefficiency is not present, hence the deviation from the frontier is entirely due to random noise and if $\gamma=1$, indicates that the deviation is due entirely to inefficiency (Battese & Coelli, 1995) However, according to Coelli *et al.* (1998), γ does not equal the ratio of the variance of inefficiency to total residual variance. The reason is that the variance of μ equals:

$$\frac{[(\pi\ \sigma - 2)]^{2}}{\pi} \qquad (7)$$

And not σ^2 ; thus, the relative contribution of variance inefficiency to total variance σ^2 equals:

$$\frac{\gamma}{[\gamma+(1-\gamma)\pi/(\pi-2)]} \qquad (8)$$

The technical efficiency level is estimated as:

$$TE_i = \frac{Y_i}{f(x_i,\beta)\exp(V_i)} = \frac{f(x_i,\beta)\exp(\varepsilon_i)}{f(x_i,\beta)\exp(V_i)}$$

$$TE_i = \exp(-U_i) \qquad (9)$$

However, it is the ε_i which is observed not its components. But following Jondrow *et al.* (1982), the farm-specific technical efficiency (TE) of the i[th] farm was estimated by using the expectation of U_i conditional on the random variable ε_i.

3.5.2 Determinants of Technical Efficiency

After the technical efficiency level at which cocoa bean is produced was calculated, the TE level is explained based on some farm level factors following the model of Battese and Coelli (1995). This model specifies technical inefficiency effects in the stochastic frontier model that are assumed to be independently (but not identically) distributed, nonnegative random variables as truncations at zero of the normal distribution (Coelli *et al.*, 1998). Specifically,

$$U_i = Z_i\phi + W_i \quad (10)$$

Where Z_i is a (1x M) vector of explanatory variables, in this study: age of the cocoa farmer, number of years spent in school, years of experience in cocoa farming, marital status (dummy; 1 if married and 0 if otherwise), gender (dummy; 1 if male and 0 if female), cocoa disease and pest control project (CODAPEC) (dummy; 1 if farmer receives CODAPEC and 0 if otherwise) and household size. ϕ is an (M x 1) vector of unknown parameters to be estimated; and W_{it} are unobservable random variables, which are assumed to be independently distributed, obtained by truncation of the normal distribution with mean zero and unknown variance, σ^2, such that U_{it} is non-negative (i.e., $W_{it} \geq U_{it}$).

Two routes are possible in investigating the determinants of technical efficiency variation among cocoa farmers in the sample. The two stage approach is the most intuitive and involves the estimation of the technical efficiency effects from both models by regressing these on a set of unit farmers' specific characteristics. This, though widely used, implies that the inefficiency effects which are assumed to be independently and identically distributed in the estimation of stochastic frontier are a function of farmers' specific effects in the second stage, thus violating the assumption that the efficiency effects are identically distributed (Battese and Coelli, 1995). The inefficiency effects would only be identically distributed if the coefficients of the farmer specific factors are simultaneously equal to zero (Coelli, 1995). It is possible to overcome this problem by using a single stage maximum likelihood approach (Battese and Coelli, 1995). The technical inefficiency effects are specified to be a function of a vector of farmer specific variables and a random error as in (14) and a single stage maximum likelihood estimation technique is used to estimate the parameters of the production frontier and of the technical inefficiency variables simultaneously.

3.7.2 Rationality and Resource-use Efficiency of Inputs

Rationality of cocoa farmers with regard to variable input usage is measured by the scale of elasticity and the resource-use efficiency is measured by the ratio of marginal value productivities (MVPs) for each resource to their respective prices. Elasticity of scale is defined as the change in output as all variable inputs changes. In order to evaluate the resource use efficiency of cocoa farmers as users of resources, this study adopted the method used by Oladeebo and Ezekiel (2006), Oladeebo and Ambe-Lamidi (2007) and Gani and Omonona (2009) where the marginal value productivities (MVPs) for each resource used were computed and such computed MVPs were then compared with their respective acquisition cost, marginal factor (MF).

The MVP of particular resources was computed thus;

$$MVP = MPP_{xi} \cdot P_Q \quad (11)$$

For Cobb-Douglas production frontier as used in this study,

$$MPP = \beta_i \cdot Q / X_i \qquad MVP = \beta_i \cdot Q / X_i \cdot P_Q \quad (12)$$

Where β_i = Regression coefficient

Q = Mean output of cocoa beans

x_i = Mean value of resource used

$\partial Q / X_i$ = Partial derivative of Q_i and x_i

P_Q = Price of output per unit

The elasticity of production is measured as the summation of all the marginal physical products of each resource, thus;

$$\varepsilon = \sum_{i}^{n} MPP_{xi} \quad (13)$$

Where ε denotes return to scale.

When $\varepsilon = 1 \Rightarrow$ constant return to scale; this implies that output increases the same proportion as the increase in factor inputs. That's doubling factors of production doubles output as well.

When $\varepsilon > 1 \Rightarrow$ increasing return to scale; this implies that output increases more than proportionate increase in factor input. That's doubling factor inputs more than doubles output. When $\varepsilon < 1 \Rightarrow$ decreasing return to scale; this implies that output increases less than proportionate increase in factor inputs. That's doubling factor inputs less than doubles output.

Resource-use-efficiency (*RUE*) of each of the factor inputs is estimated by the ratio of *value of marginal product (VMP) to marginal factor cost (MF or* P_x*)*, thus;

$$RUE = MVP / P_x \quad (14)$$

Where *RUE* denotes resource use efficiency and P_x is the price of factor inputs at their geometric mean.

I. When $RUE = 1 \Rightarrow$ Efficient use of resources.

II. When $RUE > 1 \Rightarrow$ Under-utilization of resources and increasing the rate of use will increase productivity.

III. When $RUE < 1 \Rightarrow$ Over-utilization of resources and decreasing the rate of use will increase productivity.

The relative percentage change in MVP (as developed by Mijindadi; 1980) of each resource required so as to obtain optimal resource allocation that is r = 1 or MVP = MFC, was estimated using the equation (19) below:

$$R = \left(1 - \frac{MFC}{MVP}\right) 100 = (1 - RUE_{-1})\,100 \qquad (15)$$

where R is the relative percentage change in MVP .

CHAPTER FOUR

RESULTS AND DISCUSIONS

This chapter presents the empirical results of the present study. First, the socio-economic factors that explicitly or implicitly affect productions are described. The empirical results of the estimated econometric stochastic cocoa production equation are also presented.

Finally, determinants of technical inefficiency, frequency distribution of technical efficiencies as well as resource-use efficiency are also quantified.

4.1 Socio-Economic Characteristics of the Respondents

To set the study in the right frame, it is important to understand the socio-economic characteristics of cocoa farmers in the study area. This was done with the hope of identifying those characteristics that may help to explain the farming activities of the area. The characteristics considered are sex, age, educational attainment, marital status, farming experience and farm output sizes.

4.1.1 Gender

Table 4.1(a) shows that majority (91%) of the respondents were males whilst the proportion of female respondents was 9%. This signifies that males dominate in cocoa farming as an occupational business in the study area.

4.1.2 Marital Status

Table 4.1(b) below also shows that high proportions (86.67%) out of total respondents were married whilst 10.33% were single and 3% were widowed.

Table 4. 1: Distribution of Respondents by Socio-economic Characteristics

Socio-economic Variable	Frequency	Percentage (%)
(a) Sex		
Male	273	91
Female	27	9
Total	300	100
(b) Marital Status		
Married	260	86.67

Single	31	10.33
Widow/Widower	9	3
Total	300	100
(c) Age 20-30	36	12
31-40	65	21.67
41-50	81	27
51-60	86	28.67
61-70	27	9
>70	5	1.67
Total	300	100
(d) Educational Level		
No Formal Education	34	11.3
Primary Education	207	69
Secondary Education	46	15.3
Technical/Vocational	3	1
Tertiary Education	10	3.33
Total	300	100
(e) Farm Experience		
< 10	63	21.00
10-20	71	23.67
21-30	101	33.67
31-40	45	15.00
>40	20	6.67
Total	300	100

Source: Field Survey, 2010

Since the majority of the respondents were married, it indicates the possibility of availability of more family labour for cocoa farming activities.

4.1.3 Age of Farmer

Table 4.1(c) shows the age classification of farmers in the study area. The results revealed that the age of the respondents range between 20 and 70 years. The mean age was 48 while the modal age class was 51-60 years age bracket. One could infer from this result by implication that cocoa farmers in the study area are in their economic active age. Most cocoa farmers been relatively young (about 60.67% are between 20-50 years) implies that quality of labour is good and this may positively affect productivity of the farm business since it will be very easy for the young to adopt new innovations. However, the findings of this study are contrary to that of the Ministry of Manpower and Development which indicates that about 76% of farmers in Ghana are between 18 – 35 years.

4.1.4 Educational Level

The educational level of farmers is known to affect their farming activities. Table 4.1(d) reveals that majority (88.6%) of cocoa farmers in the study area have had formal education. The results indicates that 11.3% have no formal education, while 69%, 15.3%, 1% and 3.33% had primary, secondary, technical/vocational and tertiary respectively. These findings tend to contradict the often reported illiterate status of farmers from many previous studies. These findings indicate high level of literacy among cocoa farmers in Bibiani-Anhiawso-Bekwai District. A high level of literacy will significantly and positively influence productivity and for that matter cocoa farm business. High literacy levels will enable farmers to understand the intricacies of factor and product markets and also predispose them to adopt and use improved farm practices (Oluyole, 2005).

4.1.5 Years of Farming Experience

Table 4.1(e) indicates that about 72.34% of farmers in the study area had between 10 – 40 years of cocoa farming experience. Farmer's years of experience contributes significantly in cocoa production in the study area. It is of general opinion that experienced farmers would be more efficient, have better knowledge about climatic conditions and market situations and are thus expected to a run more efficient and profitable enterprise. According to Nelson and Phelps (1966), experience is a measure of human capital and it reflects the ability to adopt new technology. This was corroborated by Feder *et al*. (1984) who identified experience as human capital and they increase the value of human resources. Hence, experience is expected to increase farmer's the knowledge and output of the farmers.

4.1.6 Farm Size

About 12% of the total respondents had a cocoa farm size of less than 1 hectare whilst a very small proportion (1.67%) had just a little above 10 hectares of cocoa farm. However, 16% of the respondents had their cocoa farm size measured between 5.5-10 hectares whilst the high proportion of the respondents (70.33%) had between 1-5 hectares of cocoa farm. This result however indicates that the majority of cocoa farmers in the study area are small-scale farmers and is in line with the claims by many publishers on cocoa production that "*the golden tree is mainly produced by several small-scale farmers in the rural areas"* and that smallholder farmers are responsible for roughly seventy percent of the total global cocoa production (Clay 2004; Donald 2004).

Table 4. 2: Distributions of Respondents by Farm Size (ha) and Output (bags)

Socio-economic Variable	***Frequency***	***Percentages (%)***
(a) Farm size (in hectares)		
< 1	36	12
1-5.	211	70.33
5.5-10	48	16
> 10	5	1.67

Total	300	100
(b) Output(in 64kg/bag)		
< 10	124	41.67
10-20.	84	28
21-30	36	12
31-40	26	8.67
41-50	13	4.33
> 50	16	5.33
Total	300	100

Source: Field survey, 2010

**The output indicates the cocoa output produced per cocoa season, 2008/2009 cocoa production season.*

Moreover, COCOBOD (2002) indicates that, cocoa farm sizes are relatively small ranging from 0.4 to 4.0 hectare with an estimated total cultivated area of about 1.45 million hectares.

4.1.7 Cocoa Output

It could also be observed from the Table 4.2(b) above that about 41.67% of the respondents produce less than 10 bags of cocoa (64kg per bag) per the season under study while the proportion of farmers producing over 50 bags was 5.33%. Moreover, 28% of cocoa farmers in the study area produces between 10 and 20 bags of cocoa, 12% produces between 21 and 30 bags and the lowest proportion of farmers(4.33%) in the study area produce between 41 and 50 bags of cocoa. However, the average yield per hectare stands at about 378.81kg per hectare. This is greater than what was published by Ghana COCOBOD (1998) and ICCO (2003) and Annon, 1999; undated, that the average yield per hectare was 250kg/ha and 360kg/ha respectively. However, this is very low compared with some major cocoa producing countries in the world. Average cocoa yield per hectare in Indonesia and Ivory Coast are 1000kg/ha and 800kg/ha respectively.

4.2 Use of Agrochemical for Cocoa Production.

4.2.1 Fertilizer Usage

The results below show that 59% of cocoa farmers in the study area do not use fertilizer in the production of cocoa whereas 41% indicated that they use fertilizer (see table 4.3) The result is in agreement with Ogunlade *et al.* (2009) who indicated that majority (78.2%) of cocoa farmers do not apply fertilizer on their farms but in sharp contrast to Chude (1999) who claims that fertilizer is an agricultural technology that is widely adopted by farmers. Meanwhile, different reasons were given for non-usage of fertilizer by the farmers in the studied communities; while some believe their farm lands are fertile enough and therefore fertilizer application is unnecessary, others attribute it to unavailability of the input. However, some farmers in the study area claim that the fertilizer is too costly for them and they do not have enough money to purchase the commodity.

Agrochemical	*Frequency*	*Percentage*
(a) Insecticides Application		
Use of Insecticides	293	97.67
Non-user of Insecticides	7	2.33
Total	300	100
(b) Fungicides Application		
Use of Fungicides	269	89.67
Non-user of Fungicides	31	10.33
Total	300	100

(c) Fertilizer Application		
Use of Fertilizer	123	41
Non-user of Fertilizer	177	59
Total	300	100

Source: Field Survey. 2010

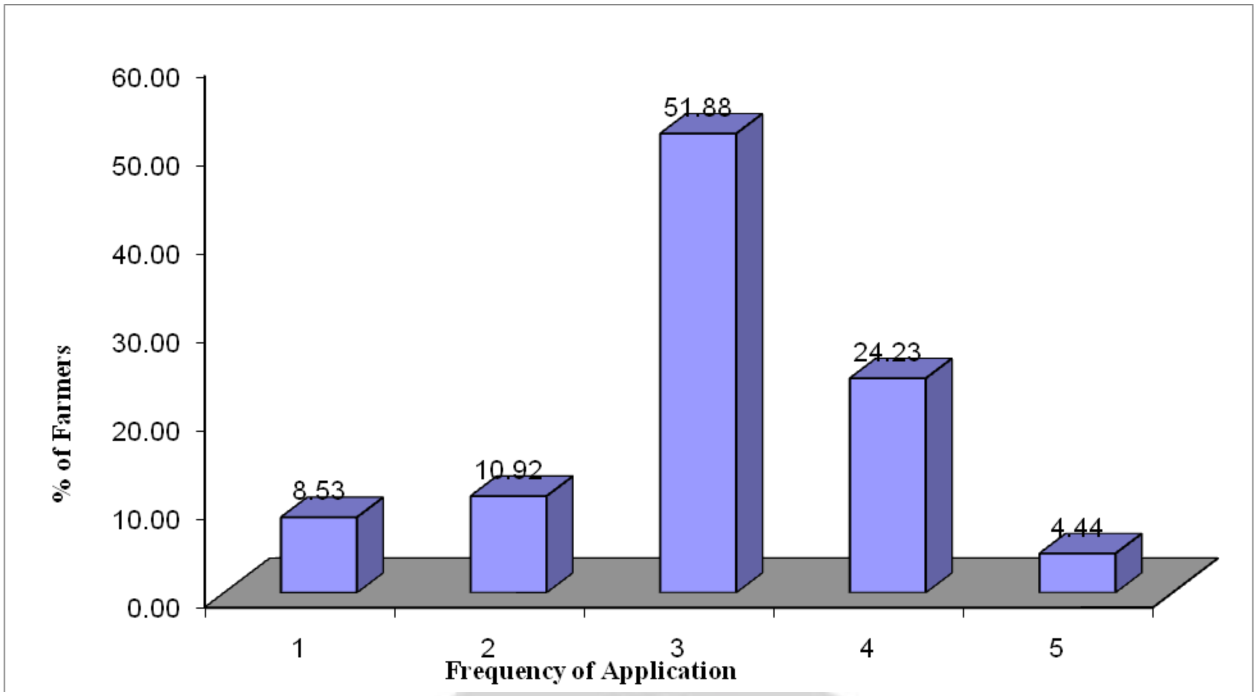
Table 4. 3: Distribution of Respondents by Agrochemicals Application

4.2.2 Insecticides Application

Table 4.3(a) clearly shows that almost all the farmers (97.67%) in the study area apply insecticides on their cocoa farms whilst a very a small proportion (2.33%) allow their farms to be destroyed by capsid. This is a clear indication that Ghanaian cocoa farmers are doing very well with regards to the prevention of swollen shoot diseases which do have very significant impact on yield as well as the quality of the product.

With regards to frequency of insecticides application, 51.88% of the respondents spray their farms three times per production season.

Figure 4.1: Distribution of Cocoa Farmers by Frequency of Insecticides Application per Season, 2008/09



Source: Field Survey, 2010.

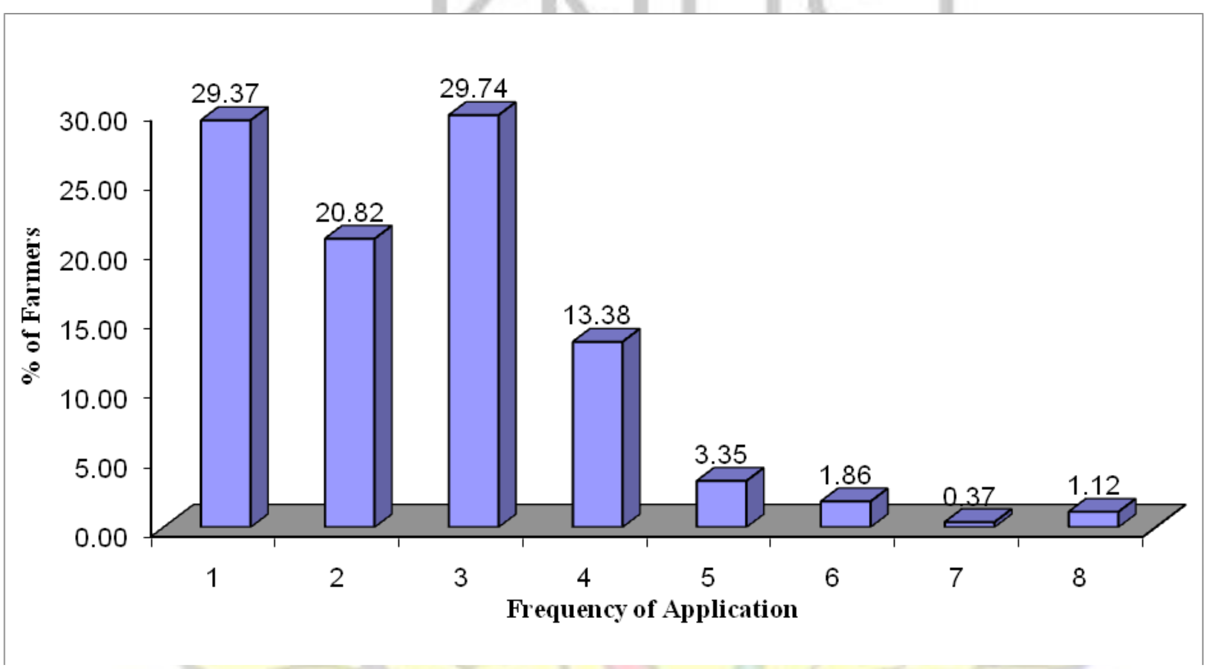
Moreover, 8.53% and 10.92% of farmer's spray their farms once and twice per production season respectively. The proportions of farmers that spray their farm 4 times and 5 times per cocoa season are 24.23% and 4.4% respectively. The results indicate that larger proportion of cocoa farmers (76.1%) in the study area adhere to the recommended frequency of 3 to 4 times per season whilst only a few farmers (4.44%) go an extra mile of 5 times per cocoa season.

4.2.3 Fungicides Application

Table 4.3(b) reveals that a majority of farmers (89.67%) in the study area are serious in preventing the black pod diseases caused by fungicides. Only few cocoa farmers (10.33%)

do not to spray their farms with fungicides. However, the proportion of farmers who did not spray their farms claimed that the chemical was not available to them.

Figure 4.2: Distribution of Cocoa Farmers by Frequency of Fungicides Application per Season, 2008/09



Source: Field Survey, 2010.

However, with regards to the number of times farmers spray their farms with fungicides, 29.37%, 20.82% and 29.79% spray their farms once, twice and three times per cocoa season respectively. Only a small proportion of farmers (1.86%, 0.37% and 1.12%) spray their farms six times, seven times and eight times respectively. 13.38% of cocoa farmers spray fungicides four times where as 3.38% spray their farms five times with fungicides. This indicates that, only a small fraction of farmers (1.5%) adhere to the recommended rate of seven to eight times per season.

4.3 Cocoa Production Function Analysis

Before proceeding to the analyses of efficiency (technical and allocative) and its determinants, it is very important to detect the presence of inefficiency in the production input-output data for the sample cocoa farmers in the study area. The test was carried out by estimating the stochastic frontier production function and conducting a Likelihoodratio test assuming the null hypothesis of no technical inefficiency.

As indicated in Table 4.4, the inefficiency component of the disturbance term (u) is significantly different from zero as indicated by the log likelihood ratio test of chi-square of 36.69 with associate probability of (0.000). The estimated sigma squared (σ^2) shows a "good fit" and the correctness of the specified distributional assumptions of the composite error term. On top of that, the value of gamma (γ) indicates that there is 55.28% variation in output due to technical inefficiency. It also means that technical inefficiency is likely to have an important effect in explaining output differences among cocoa farmers in the study area. However, using Coelli *et al.* (1998) derivation described in equation 12 (chapter 3), the relative contribution of inefficiency to total variance in the analysis equaled 47.79%. This further supported the null hypothesis of the presence of stochastic effect/inefficiency effects among the cocoa farmers from the study area. Therefore, Maximum Likelihood Estimates (MLE) gives appropriate results because OLS estimates failed to do this and hence the use of MLE.

Table 4. 4 Maximum Likelihood Estimates of Stochastic Cocoa Production Frontier

Variable	*Estimates*	*Std error*	*t-statics*	*Probability-level*
Constant	3.4868	0.9246	3.7700	0.0000

Farm Size (ha)	1.4296	0.17608.1200***	0.0000
Farm Management	0.0748	0.0329 2.2700**	0.0230
Frequency of insecticides Application	0.2252	0.1022 2.2000**	0.0280
Frequency of Fungicides Application	0.0077	0.07470.1000	0.9180
Intensity of Insecticides	0.2451	0.05884.1700***	0.0000
Intensity of Fungicides Application	0.0158	0.07070.2200	0.8230
Intensity of Fertilizer Application	0.0266	0.06310.4200	0.6740
Labour (family and Hired)	0.1724	0.0772 2.2300**	0.0260
Mean Age of Cocoa Tree	-0.9343	0.2764-3.380***	0.0010
Return to Scale	**1.2629**		
Variance Parameters			
Sigma U-squared (σ_u^2) 0.2186			
Sigma V-squared (σ_v^2) 0.1768			
Lamda (λ) 1.1119			0.0000

Sigma-squared(σ^2)	0.3954
Gamma(γ)	0.5528
Log likelihood Function	-264.369
Log likelihood Ratio test	36.69***

Source: Field Survey Data, 2010

**** = 1% significance level   ** = 5% significance level   * = 10% significance level*

4.3.1 Farm Size

The coefficient of farm size (1.4296 with t-statistic of 8.12) had a positive sign and is significant at 1% level. The results are in line with Umoh's (2006) and Okike's (2000) findings. The study of farmers in the savanna zone of Nigeria by Okike reported farm size to be significant and positive for the low-population-high-market domain and Umoh gave a similar report about farmers in the urban Nigeria. The result simply indicates that it is possible to expand cocoa farming activities in the study area. It may be possible that competition between infrastructure development and farm land is not yet keen enough to jeopardize the expansion of crop production. Statistically, the magnitude of the coefficient of farm size (1.4296 > 0) shows that output is highly elastic to farm size.

4.3.2 Farm Management

The frequency of weeding and pruning (referred to as farm management in this study) of cocoa farms which is part of cultural practices is significant at 5% level. When cocoa farmers increase frequency of weeding and pruning of their cocoa farms by 10%, their harvested beans are likely to shoot up by 0.7%. Research has shown that when agrochemicals are not available, farmers apply pest control measures based on traditional methods such as pruning and weeding (Krauss and Soberanis, 2001). Weeding and pruning has the potential of minimizing the incidence of diseases and increase aeration which improve yield quality.

4.3.3 Frequency of Agrochemical Application

The production elasticity of output with respect to frequency of insecticides is 0.2252. This means that increasing insecticides application by 1% increases output by a margin of 0.23%. However, frequency of insecticides application is statistically significant at 5% and that of fungicides is statistically non-significant. The positive effect of frequency of insecticides to cocoa production could be attributed to the fact that larger proportion (76.1%) of cocoa farmers in the study area adhere to the recommended rate (3-4 times per cocoa production season) of insecticide application per cocoa season. The non-significant contribution of fungicides to cocoa production in the study area could be partly attributed to the fact that only few (1.5%) cocoa farmers spray their farms seven to eight times per cocoa production season which is the recommended rate of application.

4.3.4 Intensity of Agrochemical Application

The intensity (quantity/ha) of insecticides application is statistically significant at 1%. Increasing intensity of insecticides application by 1% increases output by a margin of 0.25%. However, fertilization intensity shows no contribution to cocoa production in the study area. The findings about fertilization are in agreement with the report by Ogunlade (2009) who claims that the rate of fertilizer has no significant influence on cocoa production in Nigeria. However, this result is in variant with that of Umoh (2006) who showed a magnificent contribution of fertilizer to cocoa production.

Several other studies have shown the importance of insecticides in controlling incidence of cocoa diseases (Tijani, 2005; Opoku *et al.*, 1999; Dakwa, 1984; Nyanteng, 1980 and Babcock *et al.*, 1992). Moreover, Wharton (1962) showed that crop losses due to disease was about 29% in the 1950s and 1960s and therefore controlling them with insecticides could have a significant improvement in the yield of farmers, all things being equal. However, it should be noted that the coefficient of fungicides intensity is not significant even at 10% level.

4.3.5 Labour

The coefficient of labour was significant and had a positive sign. This shows the importance of labour in cocoa farming in the Bibiani-Anhiawso-Bekwai district. Several other studies (Okike, 2000 and Umoh, 2006) have shown the importance of labour in farming, particularly in most parts of West Africa where mechanization is very rare. This involves the use of traditional farming implements such as hoe and machete. Human power plays crucial role in virtually all farming activities. This situation has variously been attributed to small and scattered land holding, poverty of the farmers and lack of affordable equipment (Umoh & Yusuf, 2000).

4.3.6 Mean Age of Cocoa Trees

Age of the cocoa trees had a negative sign and highly significant. This simply means that the age of the cocoa trees was much more critical in determining yield of cocoa. It is in fact commonly accepted that beyond 30 to 40 years, the biological decline of cocoa trees, the exhaustion of soil fertility and the absence of mineral fertilization, imply the regeneration of old plantations (since output declines after 30 years) if they are grown in a monoculture (Jolly 1955; Montgomery 1981). However, the negative relationship of cocoa age to its output could partially be attributed to the fact that most of the farms in the study area are over aged (>30) which is in agreement with the report from Ministry of Finance (1999) that over 25 percent of Ghanaian cocoa farms are over aged and Binam *et.al* (2008) who showed the declining effect of cocoa age on output in the Cameroun Cocoa Industry.

4.4 Elasticity of Production and Return to Scale

Estimates of the dependent variables of the stochastic frontier model presented in Table 4.4 above shows that, all except farm size and mean age of cocoa trees exhibit positive decreasing function to the factors indicating that allocation and utilization of the variables are in the stage ll of the production (i.e the stage of economic relevance of production).

However, farm size exhibited a positive increasing function to the factor, indicating that output could increase more than proportionate increase in farm size. The negative decreasing function of the age of the cocoa to its output indicates that an extra increase in the age of the cocoa trees would decrease its output. The return to scale was 1.26, signifying a positive increasing return to scale and that cocoa farmers are operating in irrational zone of production with the implication that resources are not efficiently allocated and used on their farms. This shows that effort should be made to expand the present scope of cocoa production to actualise the potential in it. That is more of the variable input should be employed to achieve more output.

4.5 Determinants of Technical Efficiency in Cocoa Production

The result of the inefficiency model shows that the signs of the estimated coefficients in the inefficiency model have important implications on the technical efficiency (TE) of cocoa farmers. From Table 4.5, years of experience in cocoa farming, family size and farmers benefit from CODEPEC (mass spraying exercise programme) are major determinants of technical efficiency of cocoa farmers in Bibiani-Anhwiaso-Bekwai district. The size of the farmer's family as a determinant of farmer's efficiency is in agreement with Amos (2007) who indicated that family size contributes significantly to efficiency of cocoa production. While the age of farmer, number of years the farmer spends in school and family size reduce the efficiency level of cocoa farmers, other variables like gender, marital status, years of experience and CODEPEC were observed to increase the efficiency level of cocoa production.

Inefficiency Variable	***Estimates***	***Std Error***	***t-stats***	***Prob.***
Constant	4.2608	0.9696	4.39	0.000

Age of Farmer	0.0017	0.0044	0.4	0.692
Gender	-0.2394	0.1953	-1.23	0.220
Marital Status	-0.1129	0.1413	-0.8	0.424
Years in School	0.0102	0.0157	0.65	0.513
Years of Experience	-0.0122	0.0063	-1.95**	0.051
Family Size	0.1768	0.0911	1.94**	0.052
CODEPEC	-0.8529	0.1114	-7.65***	0.000

Table 4. 5 Determinants of Technical Efficiency

Source: Field Survey, 2010

*** = 1% significant ** = 5% significant

4.6 Technical Efficiency Analysis

Table 4.6 shows that a considerable variation of efficiency index across cocoa farms. The fact that technical efficiencies of all sample cocoa farms are les than one implies that no farm reached the frontier of production. The predicted farm specific technical efficiencies (TE) ranged between 0.03 and 0.93. A mean efficiency of the Cocoa farmers was 0.49 indicating that farmers in the study area produce on the average only 49% of potential output given the technology in the cocoa industry. Thus, in the short run, there is a scope of increasing cocoa production by about 51% by adopting the technologies and techniques practiced by the best cocoa farmer in the area. This is not quite different from that of Binam *et.al* (2008) who indicated that the mean efficiency of cocoa farmers in Ghana was 0.44 and that of Dzene (2010) who used a balanced panel data for a three year period to show that the mean technical efficiency for cocoa farmers in the Western Region of Ghana were 0.486, 0.483 and 0.472 for 2002, 2004 and 2006 respectively.

Table 4. 6 Frequency Distribution of Technical Efficiency Effects

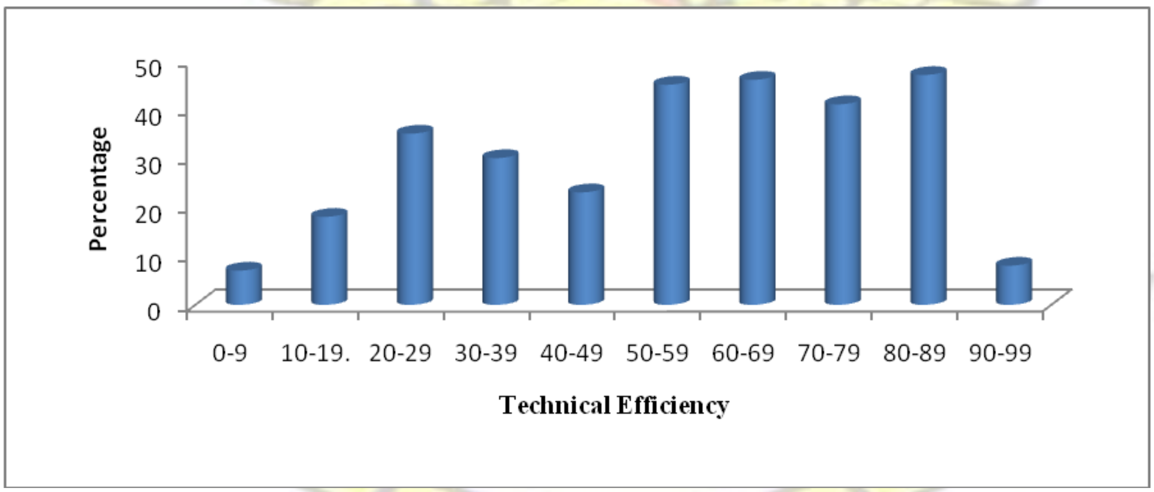
Technical Efficiency (%)	Frequency	Percentage (%)	Cumulative
0-9	7	2.33	2.33
10-19.	18	6.00	8.33

20-29	35	11.67	20.00
30-39	30	10.00	30.00
40-49	23	7.67	37.66
50-59	45	15.00	52.66
60-69	46	15.33	68.00
70-79	41	13.67	81.66
80-89	47	15.67	97.33
90-99	8	2.67	100.00
Efficiency Summary			
Mean	0.49		
Minimum	0.03		
Maximum	0.93		

Source: Field survey, 201

However, this is lower than those observed in other cocoa producing West African countries. For instance, Amos (2007) showed that cocoa farmers in Nigeria are 72% technically efficient whilst Binam *et.al* (2008) observed 0.74, 0.65 and 0.58 among cocoa farmers in Nigeria, Cameroun and Côte d'Ivoire respectively.

Figure 4. 3: Distribution of Technical Efficiency of Cocoa Farmers



However, about 60% of cocoa farmers are more than 50% efficient in their production. Moreover, Figure 4.3 above shows that a very low proportion of farmers have Technical efficiency range of 0-9 and 90-99 whilst the highest proportions of farmers are between the technical efficiency ranges of 80-89.

4.7 Resource Use Efficiency

The result of the resource-use efficiency is given in Table 4.7. The current price of cocoa (2008/2009 cocoa season) is GH¢102/64kg. Given the levels of technology and prices of both inputs and outputs, the marginal productivity value is the yardstick for judging the efficiency of resource use. A given resource is optimally allocated when there is no divergence between its MVP and its unit price. Thus, the marginal productivities of individual resource provides a framework for policy decision on resource adjustment and the difference between the MVP and unit cost indicates the scope of resource adjustment

Table 4.7 Resource use Efficiency Indicator

Resource	*MVP*	*MFC*	*MVP/MFC*	*EFFICIENCY INDICATOR*
Labour	17.5848	Gh¢5.5/day	3.1972	Under-utilization
Intensity of Insecticides Application	25.0002	Gh¢16/ltr	1.5625	Under-utilization
Intensity of Fungicides Application	1.6116	Gh¢0.9/sachet	1.7907	Under-utilization
Intensity of Fertilizer Application	2.7030	Gh¢16/50kg	0.1802	Over-utilization

Source: Field survey, 2010

to attain economic optimum. Table 4.7 shows that comparison of the ratio of MVP to MFC shows resulting ratios to be greater than unity for labour, intensity of insecticides application and intensity of fungicides application indicating that such inputs were underutilised. However, intensity of fertilizer application is less than unity which indicates over-utilisation of the resource. It could be inferred from the study that even though few (41%) farmers in the study apply fertilizer, per acre application is over and above the recommended rate (3 bags per acre) of application. Economic efficiency and productivity could therefore be improved if farmers use more of the insecticides and fungicides per hectare as well as labour resource and use less fertilizer per hectare.

Table 4. 7 Required Adjustments in Marginal Value Product (MVP) (in percentage) for Optimal Resource Allocation of Variable Inputs

Input	*Percentage Adjustment Required*
Labour	68.7230
Intensity of Insecticides Application	36.0002
Intensity of Fungicides Application	44.1549
Intensity of Fertilizer Application	-454.9390

Source: Field Survey, 2010

In both cases all the inputs were not utilised to optimum economic advantage. There is the need for adjustment in the marginal value product of all the inputs to ensure their optimal use. Table 4.8 shows the percentage adjustment in marginal value products for optimum utilisation of inputs. Optimum utilisation of inputs requires that marginal value product be equal to inputs unit price, that is marginal factor cost (MVP = MFC)

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

This chapter presents the main findings of the study and concisely presents the conclusions that were made as a result of the study. The evidence presented by the data as well as the analysis given is also summarised in this section.

5.1 Conclusion

The present study has described some of the socio-economic factors that implicitly or explicitly affect cocoa production. It has modeled the effects of the determinants of cocoa production. Specifically, it has quantified the production elasticities as well as the return to scale using the results from the stochastic frontier. Finally, it has also estimated the technical efficiency level as well as how the resources are allocated.

The descriptive statistics used to analyze the results showed that majority (89.33%) of cocoa farmers in the study area are in their economic active age (< 60) while the majority of cocoa farmers (88.7%) have formal education. Relatively young farmers coupled with high literacy levels implies quality labour and easy adoption of new innovations in farming business, and hence improve productivity. From all indications, it is clear that a majority of cocoa farmers operate on small scale. About 70 percent of the respondents had less than 5 hectares of full bearing cocoa farms producing less than 20 bags of cocoa beans. Moreover, almost all the farmers (98% and 90%) spray their cocoa farms with insecticides and fungicides respectively. However, forty-one percent (41%) of the respondents apply fertilizer on their cocoa farm land.

Based on the maximum likelihood stochastic results, the value of gamma (γ) indicates that there is 55.28% variation in output due to technical inefficiency. Mean age of cocoa trees, labour, farm management (frequency of weeding and pruning), frequency of insecticides and intensity of insecticides application show a significant contribution to cocoa production whilst frequency of fungicides, intensity of fungicides and intensity of fertilizer application showed no significant contribution to cocoa production. The study further showed that, cocoa farmers in Bibiani-Anhwiaso-Bekwai district exhibit a positive increasing return to scale as evidenced by the return to scale estimate, indicating that cocoa production is in stage III of the production process. However, from Table 4.5, years of experience in cocoa farming, family size and farmers benefit from CODEPEC (mass spraying exercise programme) are major determinants of technical efficiency of cocoa farmers in Bibiani-Anhwiaso-Bekwai district. A mean efficiency of the Cocoa farmers was

0.49 indicating that farmers in the study area produce on the average only 49% of potential output given the technology in the cocoa industry. However, the farmers are not economically efficient in the use of their resources as shown by the efficiency indexies.

5.2 Recommendation

Based on the findings of the study, the following recommendations are made;

I. Investing in the cocoa bean industry to raise its productivity especially among small holder farmers should be given the highest priority to increase revenue for both the government and the individual farmers.

II. Government should strive to make cocoa agrochemicals available at the right time during the cocoa season and at subsidized prices. This would make it possible for the farmers to have access to input anytime they want to use it.

III. Cocoa diseases and pest control project (CODAPEC) should be strengthened to meet the recommended fungicides application per cocoa season to boost cocoa productivity. Bottlenecks associated with the programme should be removed to improve its adoption by farmers

IV. There should also be improved extension linkage to sensitize cocoa farmers of the need to apply agrochemicals at the right proportion, recommended frequency per production season and at the right time. This will help to bridge the gap between potential and actual yield and hence, improve the level of efficiency and productivity.

V. There should be critical intervention by relevant stakeholders in the current production technology available to cocoa farmers in order to ensure that cocoa is produced in a more economically efficient manner for the betterment of producers and the country at large.

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APPENDIX A

Survey on Cocoa Farmers in the Bibiani-Anhiawso-Bekwai District in the Western Region (2008/2009 cocoa season) Name of community……………………   ID No. / / / Section A. Socio-Economic Background of the Farmers

1. Name of the farmer: ………………………………...

2. The Age of the Farmer: / / / /

3. Sex: Male [ ]   Female [ ]

4. Marital Status: A.Single[ ] B. Married[ ] C. Divorced[ ] D.Widow[ ] E.Widower[ ]

5. Educational Background: A. Primary [ ] B. Secondary [ ]

C. Technical/Vocational [ ] D. Tertiary [ ]

6. Number of years spend in school, / / / /

7. Tribe; A. Indege Sefwi [ ] B. Other Akan [ ] C. Northerner [ ] D. Others [ ]

8. The number of wives of the farmer / / /

9. The number of children of the farmer (including step-children) . / / /

10. Other household members (living with the respondent). / / /

11. The number of children and household members who help in the cocoa farm activities.

/ / / /

12. Were you involve in cocoa farming before starting your own? Yes [ ] No. [ ]
13. For how long were you involved in cocoa farming before starting your own? / / / /

14. In which year did you start your own cocoa farming? / / / / / / /

15. In which year did you harvest your first cocoa bean? / / / / / / /

Section B. Cocoa Input Information

16. Did you spray your cocoa farms with insecticides? Yes [ ] No [ ]

17. If yes, which of these did you use; A. Confidor [ ] B. Akatemaster [ ]

C. Carbamult [ ]

18. Did you spray your farm with Fungicides? Yes [ ]No. [ ]

19. If yes, which of these did you used; A. Nordox [ ] B. Kocide [ ] C. Ridomil [ ] D. Fungular [ ] E. Others [ ], Name……………………………………………..

20. Did apply fertilizer in your cocoa farms? Yes [ ]No [ ]

21. If yes, which of these did you use; A. Asasewura [ ] B. MOP [ ] C. Urea [ ]

D. Cidakor [ ] E. Others [ ], Name………………………………

22.1 Information on Agrochemical Usage

Inputs	Quantity	Cost per unit	Total Cost
Confidor			
Akatemaster			
Carbamult			
Nordox			
Kocide			
Ridomil			
Fungular			
Asasewura			
Cocofeed			
Cidako			
Urea			

others			

22.2 Information on Agrochemical Usage

Plot No.	**Fertilizer Application**		**Insecticides Application**			**Fungicides Application**		
	Qty		Qty	Frequency	Total/Av.	Qty	Frequency	Total/Average
1								
2								
3								
4								
5								
6								
7								
8								
9								
Total								

23. Do own spraying machine? A. Motorized [ ] B. Hand [ ] C. None [ ]

24. If no, cost of hiring the machine per day (Gh¢) / / / /

25. How many days did you hired the machine last year? / / /

26. Cost of fuelling the machine per day, / / / /

27. Did you receive extension services last year Yes [ ] No. [ ]

28. Did you benefit from mass-spraying exercise? Yes [ ] No [ ]

29. Is labour readily available? A. Yes [ ] B. No [ ]

30. What was the cost of labour per day (Gh¢), / / / / /

31. Labour Information (Hired labour and Family)

Activities	Hired labour			Family Labour			
	No. of persons	Hours spent/ day	No. of days	No. of persons	Hours spent/day	No. of days	Cost/labourer /day
Weeding/pruning							
Fertilizer Application							
Insecticides Application							
Fungicides Application							
Plucking of cocoa beans from the trees							
Husk removal							

Transportation of cocoa beans from the farm							
Drying and Bagging							

Section C. Cocoa Output Information

32. How many bags of cocoa beans did you harvested last cocoa season? / / / /

31. Information on Age of Cocoa tree, Acreage and Output

Plot	Age	Farm size (acre)	Output (bags)	Total/Average
1				
2				
3				
4				
5				
6				
7				
8				

9				
10				