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FARM SIZE, TECHNICAL EFFICIENCY AND WELFARE EFFECT OF FARMING HOUSEHOLDS IN GHANA

NAOMI. A. KANDAWINI

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FARM SIZE, TECHNICAL EFFICIENCY AND WELFARE EFFECT OF FARMING HOUSEHOLDS IN GHANA

BY

NAOMI. A. KANDAWINI

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THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS, FACULTY OF AGRIBUSINESS AND COMMUNICATION SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY IN AGRICULTURAL ECONOMICS

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DECLARATION

STUDENT

I hereby declare that the content of this dissertation/thesis is the result of my original work and that no part of it has been presented in whole or part for any degree in this university or elsewhere:

Candidate's Signature .... Date..................................

Naomi Alareba Kandawini

SUPERVISORS

We hereby declare that the preparation and presentation of this dissertation/thesis was supervised in accordance with the guidelines on supervision of dissertation/thesis laid down by the University for Development Studies.

Principal Supervisor's Signature.......................................

Date…................................

Dr. Samuel A. Donkoh

Co-Supervisor's Signature....................................... Date…................................

Mr. Isaac. G.K .Ansah

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ABSTRACT

High incidence of poverty is one of the major development challenges in developing countries like Ghana. This has mainly been caused by low productivity due to limited use of improved technology and inefficiency among Ghanaian crop farmers. This study investigates the interrelations among farm size, technical efficiency and poverty levels of farming households. Technical efficiency was estimated using the parametric stochastic frontier and the Three Stage Least Squares (3SLS) was also used to analyze the relationship between farm size and welfare, due to the reverse causality between these variables. The results of the stochastic frontier model confirmed the well-known inverse relationship between farm size and technical efficiency, while that of 3SLS revealed a positive relation between welfare and farm size. The majority of Ghanaian crop farmers were found to be operating 50% below the frontier due to improper application of agriculture extension knowledge and inefficient use of land resources. The inefficiency of these farmers was found to be negatively influenced by farm size, household size and age. The positive influencing factors of inefficiency were gender of household head, extension service and marital status. The size of farm a farmer operates was negatively affected by gender, age and off farm work. The positive significant determinants of farm size were household size, land ownership, household labour, hired labour, ownership of farm equipment and locality. Age, household size, land ownership, marital status and distance were found to be the negative significant factors of Ghanaian farmers' welfare. The positive influencing factors were gender, education, credit access, off farm work, cooperative participation, ownership of vehicle and durable asset. The study concluded that smallholders are more efficient than those with the relatively large farms. These efficient farmers were also poor, confirming previous empirical findings. The welfare of Ghanaian farmers can be improved with appropriate adjustment in land policies, investment in human capital and financial supports. Poverty gaps among rural and urban dwellers should be resolved through extension of economic activities to rural areas. Government should also strength market systems to favour farmers in terms of pricing, so as to improve their returns to production

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DEDICATION

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LIST OF ACRONYMS

3SLS	Three Stage Least Square
AHM	Agricultural Household Model
CAADP	Comprehensive Africa Agriculture Development Programme
CES	Constant Elasticity of Substitution
COLS	Corrected Ordinary Least Squares
EE	Economic Efficiency
ERP/SAP	Economic Recovery and Structural Adjustment Programs
FASDEP	Food and Agriculture Sector Development Policy
FBO	Farmer Based Organisation
GDP	Gross Domestic Product
GLSS	Ghana living standard survey
GR	Green Revolution
LHS	Left Hand Side
MDG	Millennium Development Goal
METASIP	Medium Term Agriculture Sector Investment Plan
MLE	Maximum Likelihood Estimation

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MoFA	Ministry of Food and Agriculture
OLS	Ordinary Least Squares
RHS	Right Hand Side
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa
SURE	Seemly Unrelated Regression Equations
TE	Technical Efficiency
Translog	Transcendental Logarithmic Production Function

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CHAPTER ONE

INTRODUCTION

1.1: Background to the Study

Agriculture plays a central role in the Ghanaian economy through promotion of economic growth, poverty reduction, employment and income generation. Agriculture contributes 22% to the economy in the form of export earnings and absorbs 44.7% of the working population (Mamudu et al, 2012 and GLSS, 2014). Agriculture also serves as the growth engine for the non-agricultural sector through the provision of raw materials. In the rural areas, agriculture remains the main source of income for about 90% of the rural population, making agriculture development the major driver of poverty reduction strategies in Ghana (Owusu et al, 2010 and Breisinger, 2008).

Smallholder farming plays a unique and pivotal role in agriculture's contribution to the economy, as it contributes about 80% of output to the total agricultural production of Ghana (Zaney, 2015) and also serves as an important source of livelihood for a large proportion of the rural population (Ajibefun, 2002 and Chirwa et al, 2012). However the contributions of smallholders to the nation's economy is not only unrecognized but also faced with serious constraints including limited access to productive resources such as land, improved seeds, planting materials, agro chemicals, credit, labour, information, technology, market access , strong farmer–based organizations and sustainable farming practices. These challenges result in low productivity and poor returns to production, rendering farmers perpetually poor. Reports of Ghana's remarkable achievement on meeting the target for the millennium

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development goal (MDG1) before 2015, by halving poverty and hunger with a per capita GDP of US$ 1858, revealed that the improvement was not experienced throughout the country. Over a quarter of the Ghanaian population still live below the poverty line of US$1.25/day and farmers who are mostly rural dwellers form a greater proportion of this population.

Since agriculture is the basis for the general process of social and economic development of the country, it is vital that government and development agents find a way to develop and build up the sector to reduce poverty among farmers. For this target to be accomplished, governments, foundations and other partners in Sub-Saharan Africa have formulated policies directed towards the enhancement of agricultural production. One of such policies is the 2002 Maputo Declaration on Agriculture and Food Security, which recommends that 10% of annual budgetary allocation goes to the agricultural sector and the METASIP (2011/2015) investment plan which seeks to implement the second Food and Agriculture Sector Development Policy

(FASDEP II).

Notwithstanding the impressive interest and investments geared towards the sector, agricultural production in developing countries are still experiencing substantial inefficiencies and smallholders still remain poor. According to ActionAid (2013), the nonprofit, indicates that most governments are failing to live up to their CAADP (Maputo Declaration) commitment. Kherallah et al. (2002) also reported that the aim of Economic Recovery and Structural Adjustment Programs (ERP/SAP) to promote a perfect competition in the agricultural market through the elimination of price

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controls on agricultural produce and controlling resource allocation has failed. This failure is manifested through the reduction in access to agricultural inputs and wide income distribution gaps. Dessy et al. (2006) and World Bank (2008) also confirm that development of the agricultural sector has not adequately addressed poverty, food security and sustained GDP development issues in developing countries.

To fully address the problems of agriculture in Ghana towards improved wellbeing of farmers, it is important to identify issues that are critical to the potential of marginal/smallholder farmers, such as; access to land; improvement in staple crop productivity; investment in public goods (research and infrastructure); and increased service provision to smallholder farmers.

1.2: Problem Statement

Agricultural development is crucial to the economic development of developing countries and Ghana for that matter, for poverty reduction and food security. Poverty and hunger are more pronounced among rural smallholder farmers and this is attributed to the fact that policies seeking to address challenges in these areas, have been mostly directed towards increasing output rather than promoting production efficiency and building marketing structures.

According to FAO (2003), encouraging efficiency among farmers empowers them in the market systems, leading to higher returns to production (higher income) and reduction in poverty among this group. Statistics on agricultural yields in 2012 indicates there is a significant gap in production efficiency. According to MoFA (2013), IFPRI (2013) and MoFA (2010), the actual yield of rice and maize were

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2.5Mt/ha and 1.9Mt/ha, respectively as against the achievable yield of 6-8Mt/ha and 2.5Mt/ha respectively.

Backed by adequate education and information, the advocacy for promoting efficiency in agricultural production has taken roots among farmers and agricultural development agents for some time now. While there has been a paradigm shift from increasing productivity to increasing efficiency there is still high incidence of poverty among farmers (especially smallholders).

A report by IFPRI (2005) revealed that smallholder farmers are the most vulnerable and majority lives below the poverty line. But these smallholders, according to Gul et al. (2009), Owens (2003) and Schultz's (1964) are more efficient than large farm holders. Given these empirical evidence that exists in the literature, one would question why the efficient smallholders are still poor. Addressing this question would require one to examine the linkages among farm size, efficiency and welfare.

In the empirics, studies have proven that smallholders are more efficient than their large scale counterparts, yet there are also evidences that large scale farmers are better off in terms of welfare. This could mean that efficiency is not an end in itself, but a means to an end. The ultimate goal of every farmer, like any other producer, is to increase their welfare. While answers to these puzzles are important for policy decisions and effective interventions, these links are not yet explored in the literature, to the best of researchers' knowledge. More important is the mechanism by which technical efficiency influence the welfare of agricultural farm households.

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This study therefore aims at first establishing the true relationship between farm size and technical efficiency in Ghanaian agriculture and then investigating the effect of farm size and efficiency on welfare. In doing so, the study extends the frontiers of knowledge in the farm size-efficiency-welfare nexus by providing a possible answer to two key questions: (1) why do some farms achieve higher efficiency than other farms? and (2) why are smallholder farmers still poor despite being efficient? Understanding the mechanisms that link farm size, efficiency growth and welfare of farm households has important implications for policy orientation.

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1.3: Research Questions

The study seeks to address the following research questions;

1. What is the relationship between farm size and households' welfare?
2. What are the technical efficiency levels of farming households in Ghana?
3. What is the effect of farm size on technical efficiency?
4. What other socioeconomic factors influence household farm size, technical efficiency and welfare levels?

1.3.1: Main Objective

The main objective of the study is to determine the interrelationships among farm size, technical efficiency and welfare of agricultural households in Ghana.

1.3.2: Specific Objectives

The specific objectives of the study are to;

1. Investigate the relationship between farm size and households' welfare.
2. Estimate the technical efficiency levels of farms.

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3. Measure the effect of farm size on technical efficiency.
4. Identify the other socioeconomic factors that influence farm size, technical efficiency and welfare.

1.3.3: Study Hypothesis

1. Households with small farm holdings are more efficient than the relatively large farm holdings.
2. Small farm holders are poorer than larger farm holders.

1.4: Scope of the study

This study mainly focuses on productivity of Ghanaian farmers. It investigates the determinants of farm size, technical efficiency and welfare levels. The study assesses the interrelationships among farm size, technical efficiency and welfare of these farmers. It uses the GLSS6 data obtained from Ghanaian households to achieve the objectives.

1.5: Justification

Globally, developmental efforts have been directed towards improving the living standards of people and one way to achieve this is through improvement in the agricultural sector. Studies have shown that more efficient use of resources must be encouraged, as this leads to increased productivity and income. This study therefore seeks to expand knowledge on farm efficiencies by including the welfare aspect of farmers.

Studying the relationships among farm size, efficiency and household welfare would reveal the impact of these variables on one another and the factors responsible for the interrelationships. This would provide information which will help in the formulation

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of policies such as land redistribution to help farmers gain access to productive and optimal farm sizes. It will also promote growth in farmers' income and even reduce the rising income inequalities among farming households. The growth in income and reduction in income inequalities will accelerate progress in the achievement of the first sustainable development goal (SDG1), which seeks to end poverty in all its forms everywhere. Government, donors and development agents can also effectively plan appropriate programmes and projects which will directly deal with the right targets (the marginalized smallholders who actual need some deliberated/targeted policy interventions). This would help avoid wastage of government and donor agencies' resources geared towards development.

The outcomes from the technical efficiency analysis would inform policy makers on the best way to approach agricultural and economic development. It also help policy makers to judge whether they are delivering the best interventions to address productivity and efficiency related challenges in the agricultural sector.

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Finding out the relationship between farm size and welfare and the effect of farm size on technical efficiency will aid farmers to cultivate the actual farm size that would improve both efficiency levels and their wellbeing. Investigating the socioeconomic factors that influence farm size, technical efficiency and welfare, would also help farmers, development agents and government to implement the right policy interventions for the improvement of both agriculture and the living standards of farmers.

Finally, it is expected that the knowledge generated from this study on efficiency, farm size and welfare will bridge important gaps in the literature by providing

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relevant answers to poverty, farm size and technical efficiency issues surrounding agricultural households in Ghana and give explanation to why there is a need for researchers and research institution to focus more attention on the welfare of farming households.

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1.6: Study Organization

The study comprises five chapters. Chapter one has laid the background to the study, problem statement, research questions, research objectives and the justification of the study. Chapter two entails the literature review of the study, which delves into the general state of agriculture in Ghana, agriculture and the economy, farm size in Ghanaian agriculture, methodological appraisal of welfare, farm size and technical efficiency and finally the empirical literature on welfare, farm size and efficiency.

Chapter three covers the research methodology, which consists of the description of the study area, variables definitions and measurement and analytical methods. Chapter four covers descriptive and empirical results of the study. Chapter five covers the summary of major findings, conclusions based on findings and recommendations.

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CHAPTER TWO

LITERATURE REVIEW

2.1: Chapter outline

This chapter provides both theoretical and empirical reviewed literature relevant to the study. The chapter consists of ten sections; section 2.1 outlines the content of this chapter, section 2.2 describes the agricultural sector in Ghana, section 2.3 outlines the role of agriculture in economic growth and development, section 2.4 contains discussion on small and large farms, section 2.5 gives the theoretical background of the study, section 2.6 contains a discussion and review of poverty studies, section 2.7 and 2.8 provides the concept and review of production and efficiency, section 2.9 outlines the concept of endogeneity and the three stage least square. The final section (2.10) provides review on the determinants of efficiency.

2.2: The Agricultural Sector in Ghana

Agriculture has been the mainstay of Ghana's economy since post-independence (McKay and Aryeetey, 2004). Even though the performance of the agricultural sector has been declining of late, it still remains the sector which employs about half of the labour force and it is the largest foreign exchange earner (MoFA, 2010a). Agriculture in Ghana is predominantly small holder, family-operated farms with about 90% of farms less than 2 hectares (Asuming- Brempong et al., 2004). The use of rudimentary technology is common among Ghanaian farmers and production is primarily rain-fed. Ghanaian farmers practice the traditional system of farming. Two major traditional farming systems are practiced by most farmers in Ghana: bush fallow and continuous cropping (Gyasi, 1995; Barry et al., 2005). Inside these systems, there are two types of cropping systems: polyculture and monoculture.

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Polyculture is a cropping system where two or more crops are cultivated on the same land. Mixed cropping is when two or more crops are grown simultaneously without a particular row arrangement (intermingled).Intercropping is when crops are cultivated simultaneously in alternate rows. Monoculture is a cropping system where a single product is developed on a specific area of land. Bush fallow is a system land rotation between natural vegetation (bush) and crops. Farmers practicing bush fallowing, cultivate a zone of land for quite a long while, briefly surrender the developed land, and move to another plot of land that is destined to be cleared and developed. This framework happens in all agro-biological zones where soil nutrients are not being renewed by alluvial stores, commercial fertilizer or manure (Oppong-Anane, 2006; Barry et al., 2005), and where households can allow land stay uncultivated sufficiently long to renew soil fertility following quite a while of farming (Oppong-Anane, 2006).The agricultural sector consist of five major sub sectors (food crops, livestock, fisheries, cocoa and forestry). The main food crops grown in the country include cassava, yams, plantains, maize, rice, peanuts, millet and sorghum. Ghana's main export commodities are cocoa and cocoa products, timber and wood products, fish and fish products, shea nuts and coffee. Other industrial crops include cotton, oil palm, rubber, coconut and sugarcane.

According to Kwarteng et al. (1994), agricultural sector in Ghana is categorized into six (6) main sub sectors namely; food crops, industrial crops, export crops, livestock and poultry, fisheries and forestry. The country is however divided into six distinct agro ecological or vegetational zones namely; high rainforest, semi deciduous forest, forest savannah, guinea, sudan and coastal savannah.

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The sector's production meets only 50% of domestic cereal and meat needs, 60% of domestic fish consumption and less than 30%of the raw materials needed for agro-based industries. The level of self-sufficiency in food items varies, with 30% self-sufficiency for rice, 92% for maize, 115% for plantain, 117% for cocoyam, 214% for cassava to 350 % for yam.

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2.2.1: Challenges in Ghanaian Agriculture

There are a number of challenges to the development of agricultural production in Ghana. These include Land ownership (which is mainly communally owned by families), inadequate credit facility, poor storage facilities, post-harvest losses, poor agriculture practices, factor market constraints, poor returns on productivity-related costs and irrigation facilities. This section will give a brief description of some of these challenges.

1. Over reliance on rainfall: Farmers (especially smallholders) in Ghana depend more on rains for their farming activities and are therefore hard-hit by rainfall variability. The over reliance on rain-fed agriculture exposes farmers to a high risk of production failure, especially in the dry seasons. Alternate means of irrigation which is mechanized irrigation, tends out to be highly expensive to the smallholder farmer. A study by Hatibu et al. (2000) reveled that more than 33% of disasters were related to drought, which is a major pre-cursor in agricultural problems. Gowing et al., 2003; Barron et al., 2003; Mupangwa et al., 2006 have argued that rainfed agriculture in Sub-Saharan Africa has negative implications on soil moisture and fertility, which is a serious challenge to agriculture development this region.

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2. Low access to inputs and technologies: The agriculture sector is dominated by smallholder farmers who are marginalized in many ways hence they gain low access to inputs such as tractors, fertilizers and credit. They also have difficulty transporting their produce to the market market centers. Also lands are sometimes taken away from smallholder farmers for the development of large industrial projects like mining, supermarkets and plantations (Asafo, 2013), this threatens farm productivity and the livelihood of the affected farmers (Twomlow et al., 2002).

3. Low level of technology and value addition: usage of technology is low among Ghanaian farmers. This could be attributed to lots of factors including failure of extension agencies to disseminate technological knowledge and skills to farmers due to lack/inadequate logistics. Secondly, farmers' inability to understand and implement acquired technological knowledge due to high illiteracy, contributes to low technological application and value addition.

4. High post-harvest losses: Postharvest losses come about as a result of technological and value addition constraints. According to World Bank (2011), 40% - 60% of fresh foods produced are lost after harvest globally. In Ghana and in many developing countries, it is estimated that more than 50% of the working population earn their livelihoods from the agricultural sector, and most of these are smallholder farmers who cultivate cereals, roots and tubers, legumes as well as other crops of economic and social importance. These above mentioned crops are highly perishable and are mostly susceptible to post harvest losses.

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2.3: Agriculture, Economic Growth and Poverty Reduction

Despite the above challenges, agriculture still plays a role in economic development through its contribution to GDP and poverty reduction. Singer (1979); Schultz (1964); Lewis (1954), pointed out the importance of agriculture to economic growth. Recent empirical literature like Mellor (2011) and Christiaensen et al. (2010) have argued that agricultural progress on poverty alleviation is highly positive.

The standard economic theory, defines development as the economic growth process which occurs due to an appropriate reallocation of production factors from the low productivity rural (agricultural) sector to the urban (industrialized) sector. In this setting the agricultural sector supplies the urban areas with food thus releasing savings and labour which enhances industrialization.

2.3.1: Agriculture as Lever of Economic Growth and Development

Economic thoughts and theories in the 1950s and 1960s viewed economic growth as synonymous with economic development (Thodaro and Smith, 2006). Economic growth generally means growth in output of a country. Economic growth occurs if the output of the nation expands at a "reasonable" rate on a continuous bases resulting in improvements in real income of the average citizen (Firestone, 1982). The evidence of growth in output is seen in the performance of all the sectors of the economy. But recent economics has drawn a clear distinction between the two economic terms. Schumpeter (1934), however, defined the term "economic development" as a spontaneous and discontinuous change in the stationary state which disturbs the equilibrium state previously existing. He defined "economic

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growth also as a steady and gradual change in the long run which comes through a general increase in the rate of saving and population in a dynamic economy.

The early development economics in the 1950's often ignored the role agriculture plays in economic development (Lewis, 1954) and mostly lacked a micro level understanding of agriculture in the tropics. The evolution of new theories such as the theory of rational farmer (Schultz, 1964) have changed the notion of traditional agriculture as something that draws development backwards and needs a back-out quickly as possible.

Empirical studies (e.g. Gollin et al., 2002; Tiffin et al., 2006) have shown that agriculture is important but its achievement must be judged against how much of real impact it can make on the lives of farmers and the Ghanaian economy as a whole. Figure 2.1 which presents the increasing trend of agriculture's GDP contribution from 2006 to 2016 in Ghana attests to the fact that recent contributions of Ghanaian agriculture have been relatively impressive, particularly in the food crop sub-sector, which is important for rural poverty reduction. It can be observed from Figure 2.1 below that GDP from agriculture in Ghana increased to 7790.18 GHC million in 2016 from 7567 GHC million in 2015 with a mean level of 6541.21 GHC million.

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Figure 2.1: Ghana's GDP from Agriculture
Source: Ghana statistical service (2017)

2.3.2: Agriculture and Poverty

Agriculture can aid in poverty reduction through increased income earnings by the poor engaged in farming (Minten et al., 2008). Second, non-farm jobs can be created through its overflow impacts (Eswaran et al., 2009; Ravallion, 2009).

Agriculture is to a great extent essential for the unskilled rural poor, whose option of higher paying employments is solely farming (de Janvry and Sadoulet, 2010). Ravallion (2009) contends that, as an initial step, productivity growth in smallholder agriculture is imperative if SSA countries are to replicate China's achievement in poverty reduction. Even where increased productivity includes just non-tradable in the global sense, poverty reduction could be encouraged if such output is consumed by a large segment of the populace (Dorward et al., 2004).While increasing farm profit, raising food crop yields help bring down urban food prices in this manner, increasing real incomes and adding to urban poverty reduction (Al-Hassan and Jatoe,

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2007; de Janvry and Sadoulet, 2010). Yield increments and labour productivity growth are critical determinants of rural poverty reduction (de Janvry and Sadoulet, 2010). Increments in land and labour productivity tend to profit rural poor households by discharging labour for other supplementary income generating activities that could help enhance household welfare (Valdés and Foster, 2007).

There are purposes behind the recently revived agriculture-led poverty reduction optimism. In the first place, agriculture is the largest sector of SSA economies as far as it offers the rural populace employment and it contributes to GDP. For instance, in Ghana, the average share of agrarian GDP over the past ten years is around 31 percent. As at 2010 the national average share of the economically dynamic populace employed in agriculture was 42 percent but greater than 70 percent in most rural rural areas (Ghana Statistical Service, 2012). Second, development in agriculture is accounted for to be more pro-poor than development in other sectors. Christiaensen et al. (2011) have shown using cross country data including 80 countries (of which 20 are SSA countries) that agriculture is up to 3.2 times more powerful for poverty reduction than non-agriculture. Diao et al. (2010) have also demonstrated that the poverty elasticity of agriculture-led development is about a percentage point larger than development stimulated by other sectors, using data from Ghana.

Thirdly, due to the imperfect tradable nature of staple crops, increasing productivity, aside from working around price and wage transmissions to create competitiveness in the staple food sector, also promotes household food security (World Bank, 2007). Finally, the World Bank (2007) reported that agrarian countries are not competitive

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in manufacturing, their comparative advantage lies in agriculture and other primary sectors.

However, another school of thought argues that Africa's agriculture-led poverty reduction has not to date been effective. Factors accounting for this could be the accuracy of the 'small-farm-first revivalist' description, which has been challenged as efforts targeted at increasing agricultural productivity have not had marked effects on poverty reduction (Ellis, 2010). The low productivity of African agriculture may be due to policy neglect and low public investment (Timmer, 2005). Mogues et al. (2008) have proven that agricultural productivity is responsive to public investment in Ghana.

Other argument against the agriculture-led growth optimism is that there are some factors hindering the likelihood of African 'green insurgency' and the most crucial ones among these factors is the distinction in historical, institutional, policy and market antecedents between Asia and Africa. Indeed, the World Development Report recognizes this yet insists 'conditions have changed and that there are numerous local successes and new opportunities on which to build' (World Bank, 2007). Third, it has been argued that domestic markets in SSA are excessively restricted, making it impossible to give the driving force to an African 'green revolution' (Dercon, 2009; Ellis, 2005; 2010).

However, Rosegrant et al.(2001) and Diao and Hazell (2004) have shown that domestic staple crop markets offer great potential for African farmers. The argument that expanding staple crop output could dampen food prices and therefore make productivity increases less pro-poor in Africa, have little or no practical relevance.

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(Aksoy and IsikDikmelik, 2008) because the majority of African rural households are net buyers of staples (Barrett, 2008). Other arguments against agriculture-led growth in SSA, says focusing on smallholders is questionable given their extreme heterogeneity (Collier and Dercon, 2009; Maxwell, 2004). They are also of the view that promoting commercial agriculture is more likely to achieve vertical integration and economies of scale than small scale; rural urban transition holds the key for poverty reduction in rural SSA and not productivity increases by themselves.

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2.4: Small and Large Scale Farms: Relative Efficiency

Small scale farm: the question of what is small and large scale farms keeps receiving different answers depending on the context in which the question is posed. According to Eastwood et al (2008), households with heterogeneous endowment in capital, land and labour will have different farm size. Based on the role and heterogeneous historic context, we will define the term small scale farm as the production that takes place on a small piece of land without the use of advanced and sophisticated technologies. It plays a dual role of being the source of income as well as food security for households. In line with the above definition, Dixon et al. (2004) also defined small farms as farms with limited resource endowment compared to other farms.

Large scale farm: According to Vulcan (2017), large farm production does not depend solely on the size of the farms but the method of production. Hence large farm is defined as the modern trend enlarged farms that reach the optimal size as a commercial enterprise. Large farms are normally operated with advanced and modern technologies.

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In this study, for reasons of directness and simplicity, we use the scale of land area under cultivation to describe small and large scale farms. According FAO (2010), farm holdings that are 2 hectares below are categorized as small farms while those above 2 hectares are large farms of land.

Surveys of farms of different sizes in developing countries frequently show small farms producing more per hectare than large farms, with an inverse relationship between farm size and production per unit of land (Cornia 1985, Eastwood and Lipton 2004). Muburu et al. (2014) states that there are explanations usually put forward for the inverse relationship between farm size and productivity. Among these explanations are imperfect factor market (failures in land and credit market), methodological issues and economies of scale in farming. There may be diseconomies of scale once the farm grows larger than can be managed and operated by household labour. These diseconomies may arise from labour use; household labour can be readily available, flexible in time and effort to suit the demands of the farm that finds it difficult to predict exactly for example, planting times, control of pests and diseases, harvesting. Besides, household labour is usually self-supervising and motivated to carry out operations diligently. In contrast, larger farms depending largely on hired labour incur (transactions) costs in recruiting and supervising labour. Hence small farms usually use more labour per hectare than larger farms and consequently produce more but with lower marginal returns to labour. A study by Mburu et al. (2014) confirmed that large farms have high diseconomies of scale, since these farms depend highly on hired labour.

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Diseconomies of scale in farm production are therefore likely to be stronger when labour is a major input to production, as applies when labour is relatively cheap and capital relatively costly. Other advantages of small-scale in farming that are mentioned are farmers operating small plots may have considerable detailed knowledge of their soils, topography, drainage, etc. allowing them to work the land appropriately. Small farms may be better able to resist temporary slumps in prices, since household labour may be prepared to accept lower returns to their labour at times when a commercial farmer would simply go bankrupt.

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2.4.1: Economic concept of Scale and Farm Size

According to Ellis (1993), the mix conception about the appropriate size of farm and the existence of economies of farm size is often debatable. The most common problem that arises in this mixed conception is area size of farm with economic size as units of production. However the distinguishing factor between the two concepts is, area size of farm refers to the physical quantity of land under cultivation while economies of farm size treats farm size as the total economy of the farm as an enterprise.

In this study, we adopt farm will refer to the term “farm size” as the total area of land under cultivation and the term “scale of farm enterprise” is referred to as the difference in the overall economic size of farms. The two concepts; economies of scale and economies of size describes what takes place in production or cost when the size of a farm changes (increases). Economies of scales deals with how a production increases when a farm increases its scale of production (both fixed and variable). Economics of size explains what happens to cost per unit of output when

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cost increases in a minimizing way. Both economies of scale and economies of size takes place in a production process which requires factor inputs like capital, labour and land. This factor inputs are applied in varying proportions to a technological process to produce outputs. A production function is used to measure the relationship between input and output to define the production process. The return scale is the approach in assessing the production generic characteristics.

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The concept return to scale in this sense refers how output responds to changes (decreases or increases) in all inputs. Hence, if this simultaneous increase in all resources results in a percentage change in output, there is a constant returns to scale, if the change results in a smaller percentage increase in output, it is referred to as diminishing returns to scale and if it results in a larger percentage increase in output, it is called increasing returns to scale (Ellis, 1993). As the scale of physical production increases, most production processes will exhibit increasing, constant and decreasing returns to scale. The empirical application of the concept of scale is to ascertain the effect of increasing scale and varying the level of some resources holding others fixed.

2.4.2: Returns to scale and Economies of scale

The concept of returns to scale and size is used to investigate the relationship among levels of input, output and costs. According to de Janvry (1972), econometric studies which utilize production or profit functions are usually concerned with return to scale. In general the term return scale refers to the physical relationship between inputs and outputs while economies of scale translates this information into monetarized cost values. Hence expressing in monetary terms, increasing returns to scale is reflected in increasing economies of scale (with a decreasing average cost per unit output), constant returns to scale into constant economies of scale (with a constant average cost per unit output) and decreasing returns to scale into diseconomies of scale (with a rising average cost per unit output).

Economies and diseconomies of scale have a wide application and in the context of this study, if two farms (large and small) enter into production and there are substantial aggregation of economies of scale, then it follows that small scale farms would be experiencing diseconomies of scale while large scale farms experiencing economies of scale. This can be argued that small scale farms record higher expenditure on inputs (especially on labour) than large farms.

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2.4.3: Farm size and Productivity

The World Census of Agriculture defines an agricultural holding as an economic unit of agricultural production under single management regardless of title, legal form, or size and may consist of one or more parcels.

In previous studies agricultural productivity and farm size have been compared and a positive relationship between farm size and productivity has been observed over the past three decades in Australian Nossal et al. (2008). Larger farms also demonstrate higher rates of return and overall profits than smaller farms (Knopke et al. 2000; Hooper et al. 2002; Gleeson et al. 2003). A similar relationship has been found between size and performance in other developed economies, including the United States and European Union (see, for example, Hallam, 1991; OECD, 1995; Chavas 2001). These findings suggest that large operating scale is productive and profitable. Two typical economic explanations have been spelt out to explain the positive correlation between farm size and productivity. One is the presence of increasing returns to scale or 'economies of scale' (Knopke et al. 1995; 2000) and the other is that technologies advancement which favours farms with a relatively large operating size, resulting in greater scope for input substitution and improved access to capital for financing developments in management and farming practices (Knopke et al. 1995; Hooper et al. 2002).

Wiggins (2009) noted that the scale of agricultural land plays an important role in productivity, considering the case of countries where the bulk of output comes from small farms (Burkina Faso, Ghana, Mali, Niger) but has made tremendous improvement in productivity compared with countries that have or had notable large-farm sectors such as Namibia, South Africa and Zimbabwe but are well down the growth ranking.

A great deal of variability in farm sizes over time exists across countries. Several middle-income countries in Asia are now in a period of rapid decline in the number of farmers, much like the United States in the 1960s. The poorest countries, however, have growing rural populations and fixed land bases. Many regions in South Asia and Africa have experienced decades of decline in the available acreage per farmer, sharply reducing their ability to feed themselves or initiate the economic transformation out of agriculture.

Ghana's agricultural sector experienced an average growth of 4.2% in 1990-2006 and 65% of this growth was explained by increases in land, labour, capital, while 35% of the growth is explained by productivity growth. This has not changed in recent times as increases in output are due to expansion in cultivated land areas. Data on yield

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gaps among all crops is evident that actual yields are less than achievable yields (MoFA, 2013 and 2012). However, the over dependence of Ghana's agricultural growth on land extension is a threat to its sustainability since landholding size has a solid association with land tenure. However an effective land tenure system which presents entitlement and rights to the utilization of land, including other natural resources, in developing nations like Ghana, is not working effectively to guarantee land usage security.

Bugri (2008); Ubink and Quan (2008) noted that in nations and societies where land tenure system did not advance appropriately to oblige changes in farming, industry and administrations, the development and improvement of such economies have stagnated. Empirically it is also established that the determination of farm size and its change over time is complex. This includes factors such as history, institutions, economic development, the development of non-farm sector (both in rural and urban areas), land and labor markets, and policies related to land tenure and property rights. Among these factors, land policy, institutions and legislation have been the most influential.

Seidu (2008) and Donkoh et al. (2013) reported negative returns to resources committed to rice production, indicating a poor performance of the agricultural sector. Kasanga and Kotey (2001); Kandine et al. (2008); Abdulai et al. (2011); Nyasulu and Ampadu (2011); Oladele et al. (2011) attributed the poor performance of the agricultural sector in Ghana to the insecure nature of the communal land tenure systems, in the sense that, land rights insecurity impedes investment in both the rural and urban areas of Ghana, and this amounts to slow economic growth and

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development in these areas (Bugri, 2008 and Ubink et al, 2008). Figure 2.4 below throws more light on the linkage between land policies, farm size and productivity. The linkage is such that good land policies (tenure systems) guarantee some level of security, which increases the demand for economic usage. It also provides grounds for owners to use land as collateral to access credit facilities, which leads to improved utilization of production resources (inputs). These improvements goes a long to increase yield.

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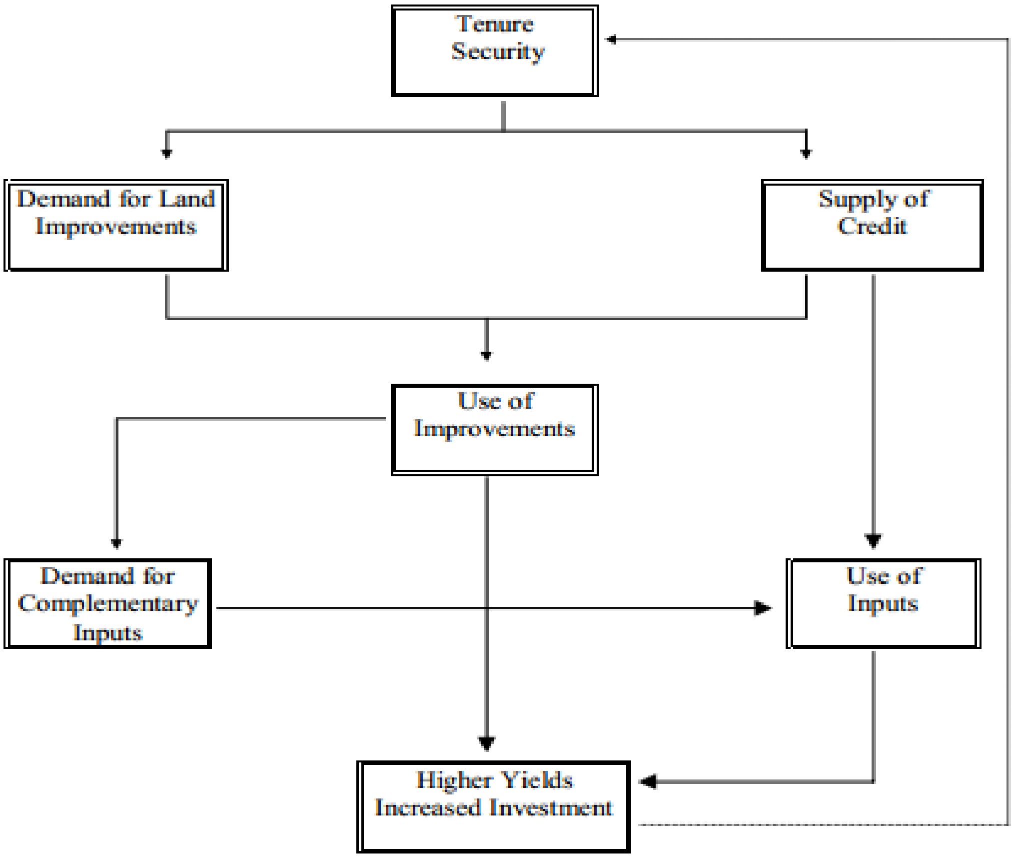

Figure 2.2: Conceptual Model Linking Tenure Security with Agricultural sustainability and productivity

Source: Roth and Dwight (1998)

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2.5: Theoretical Background: Agricultural Household Model

This section presents a review of agricultural household model which forms the theoretical underpinning of the study.

2.5.1: Agricultural Household Models (AHM)

Family farming dominates Ghanaian agriculture, making agricultural households very important to economic development in the countries. For this reason, a study of their behaviour requires a thorough theoretical and empirical investigation.

According to Ligon (2011), basic economic models involve firms and consumers and for levels of aggregation at the microeconomic level, consumers are often aggregated up to level of households. Households are used as the socio-economic unit bases in the sense that (1) most data on things like expenditures and income are collected on outcomes for households, not individuals. (2) In most economic environments, there is a great deal of sharing of both income and consumption within many households, so that it may be very difficult to draw sharp distinctions among individuals.

In a society where people live close to the economic artificial division between households and firms, individuals make consumption decisions based on the preferences of those in their household, prices the household faces and the household's resources. Some individuals work for firms, which is where the locus of production is located. However, the economic division between firms and households is often less clear-cut for agricultural households especially in developing countries. The agricultural household here is the locus for both production and consumption, hence the household model for this study is sketched along the lines pursued by Donkoh (2011), Singh et al. (1986) and Becker (1965).

Agricultural household models (AHMs) provide a framework for analyzing household behavior that integrates households' decisions (consumption, Production and Work (labour) allocation). According to Singh et al.(1986), AHMs provide insight into three extensive areas of interest to policy makers: (1) the welfare or real incomes of agricultural households; (2) the spillover effects of agricultural policies onto the rural, nonagricultural economy; and (3) at an aggregate level which considers the interaction between agricultural policy and international trade or fiscal policy. Thus the introduction of AHMs was mainly to capture interaction in a theoretical manner that allows empirical application in order to make policy informed conclusions. Agricultural household models (AHMs) began with the search for an explanation to the counterintuitive empirical finding that an increase in the price of a staple did not significantly raise the marketed surplus in the rural sector of Japan (Kuroda et al, 1978). The search led to a model in which production and consumption decisions are linked due to the fact that a decision unit is both a producer (choosing the allocation of labor and other inputs to crop production), and a consumer (choosing the allocation of income from farm profits and labor sales to the consumption of commodities and services).

Taylor and Adelman (2003) noted that (1) as long as perfect markets for all goods, including labour, exist, the household is indifferent between consuming own-produced and market-purchased goods. (2) By consuming all or part of its own output, which could alternatively be sold at a given market price, the household implicitly purchases goods from itself. (3) By demanding leisure or allocating it's time to household production activities, it implicitly buys time, valued at the market

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wage, from itself. In a rural farming system, there are; (1) net-surplus producing family farm, typical of small owner-operated farms of medium productivity; (2) subsistence and sub-subsistence household farm, typical of small-scale, low productivity agriculture, frequently operating under marginal conditions and incomplete markets; (3) small scale renter and sharecropper farms; and (4) owner-operated commercial farms producing food for both domestic consumption and agro-industry and export markets.

The household playing a dual role as producer and consumer, it makes production decisions (such as labour allocation) and consumption decisions interdependent upon one another. However the main objective of the household is to maximize expected utility (discounted future stream) from a list of consumption goods including home-produced goods, purchased goods, and leisure, subject to a large set of constraints. The form of this solution, especially the interactions between production and consumption that are a trademark of household-farm models, are extremely sensitive to assumptions about the extent to which households are integrated into product and factor markets.

Analytically, AHM provides answers to the apparent paradox of a positive own-price elasticity of demand for food in agricultural households, as well as the irony of sluggish marketed-surplus responses to food-price changes. The distinguishing characteristics between the AHM and the pure consumer model is that, in the latter, the household budget is generally assumed to be fixed, whereas in household-farm models it is endogenous and depends on production decisions that contribute to income through farm profits. Thus the AHM adds an additional farm profit effects,

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which may be positive (example, if the price of the home-produced staple increases) or negative (as when the market wage increases, squeezing profits), to the standard slutsky effect of consumer model (Taylor and Adelman, 2003).

Singh et al. (1986) mentioned that an increase in food prices has two opposite effects on farm households. The farm household as a consumer is adversely affected by a higher food price, but as producer, its profit from food production increases.

According to Taylor and Adelman (2003) household-farm models were viewed as either trade models or very small general equilibrium models. For the purpose of this study, we will borrow from the small general equilibrium models.

Algebra of AHMs

For any production system, the household assumed a utility function of

$$U = U(X_a, X_m, X_l) \qquad 2.1$$

Where, X_a is agricultural staple, X_m is market purchased goods and X_l is leisure. LaFave (2011)

added U_t, which represents a vector of characteristics that parameterize the utility function including household size and composition with time t, hence equation 2.1 is rewritten as:

$$MaxE\left[\sum_{t=0}^{\infty} \beta^t U(X_{at}, X_{mt}, X_{lt})\right] \qquad 2.2$$

These functions are maximized subject to three different constraints; time, cash and production.

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1. Cash Constraint

$$p_m X_m = p_a(Q - X_m) - w(L - F) \quad 2.3$$

Where, p_m and p_a are the prices of the market purchased commodities and staples respectively. Q is the household's production of the staples, w is the market wage, L is total labour input and F is family labour input. From these definitions,

$Q - X_m$ = Market Surplus

$L - F$ = positive; surplus labour, and negative; off-farm labour surplus

2. Time Constraints

Farm households allocate their total time to leisure, on-farm and off-farm production activities. Hence the constraint equation takes the form:

$$T = X_l + F \quad 2.4$$

Where T is the total time stock available to the household (Singh et al., 1986) and $F = l_f + l_0$; l_f is on-farm labour and l_0 is off-farm labour (LaFave, 2011).

3. Production constraint

Household is faced with production constraint or production technology that reflects the relation between inputs and outputs. Therefore:

$$Q = Q(L, A) \quad 2.5$$

Where A is the household's fixed quantity of land.

Taylor and Adelman (2003) made the following assumptions as a way of summary;

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1. There are no variable inputs like fertilizer.
2. Only one crop is producible.
3. Family labour and hired labour are perfect substitutes.
4. The three prices p_m , p_a and w are unaffected by the household's action.
5. Land and capital are given (explicit assumption added by LaFave, 2011).

Disintegrating the constraint functions gives us;

$$p_m X_m + p_a X_a + w X_l = wT + \pi \qquad 2.6$$

Where $\pi = p_a Q(L, A) - wL$ and is a measure of farm profit. The left hand side (LHS) of the equation shows total household expenditure and the right hand side (RHS) is Becker's (1965) concept of full income. From this equation, the value of the stock of time can be known. Exploring the maximization of labour.

$$p_a \, {\partial Q}/{\partial L} = w \qquad 2.7$$

This means that the household will equate the marginal revenue product of labour to the market wage. Over here, only a single endogenous variable appears in the equation, hence p_a and w, technological parameters and land area can be solved.

Letting the solution of L be:

$$L^* = L^*(w, p_a, A) \qquad 2.8$$

And substituting into equation 2.6 yields,

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$$p_m X_m + p_a X_a + w X_l = Y^* \qquad 2.9$$

where Y^* is the value of full income associated with profit maximizing behaviour.

Forming the utility function subject to the constraint function

$$U = U(X_a, X_m, X) + \lambda(Y^* - p_m X_m - p_a X_a - w X_l) \qquad 2.10$$

Maximizing

$$\frac{dU}{dX_m} = \frac{\partial U}{\partial X_m} - \lambda p_m = \frac{\partial U}{\partial X_m} = \lambda p_m \qquad 2.11$$

Doing same for the other parameters, we have:

$$\frac{\partial U}{\partial X_a} = \lambda p_a \qquad 2.12$$

$$\frac{\partial U}{\partial X_l} = \lambda w \qquad 2.13$$

and

$$p_m X_m + p_a X_a + w X_l = Y^* \qquad 2.14$$

The solution to these maximization equations gives;

$$X_l = X_l(p_m, p_a, w, Y^*) \qquad 2.15$$

This means that demand is a function of price indicators and income. But income in itself depends on production activities of agricultural households. Therefore any change in production factors will change output and hence consumption behaviour.

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This is the reason why consumption and production behaviour are interdependent. From the above equation, the profit effect of an increase in staple price on consumption can be derived as

$$\frac{dX_a}{dp_a} = \frac{\partial X_a}{\partial p_a} + \frac{\partial X_a}{\partial Y^*}\frac{\partial Y^*}{\partial p_a} \qquad 2.16$$

The first term in the RHS is the result of a consumer demand theory which is negative for normal commodities. The second term captures the profit effect. This shows that a change in the price of the staple increases farm profits hence full income.

Rearranging;

$$\frac{\partial Y^*}{\partial p_a}dp_a = \frac{d\pi}{dp_a}dp_a = Qdp_a \qquad 2.17$$

This result implies profit effect equals output times the change in prices.

2.5.2: Limitations of the Neoclassical AHMs

The earlier assumptions show a presence of separation in consumption and production. In any case, LaFave (2011) noticed that if this is not the case and the simple framework is a substantial model, it would incredibly streamline the investigation of producer-consumer household behaviour. The study further contended that because of various potential market imperfections that may lead to violations of assumptions made within the model, the standard neoclassical model might be an inadequate characterization of agricultural household behaviour. Additional constraints on the number of hours individuals can work off-farm, the amount of labour available to hire onto one's own farms, or absence of access to credit

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markets may likewise be pertinent for agrarian households. Transaction costs, monitoring costs, or preference for own farm versus market work may remain as opposed to the ideal substitutability and homogeneity of employed and family labour accepted in the model.

Despite these limitations, a few portions of AHMs are important to this present study and are discussed in this section.

2.5.3: Relevance of AHMs in this Study

From the review, key issues of AHMs that are relevant to the study are summarized as follows:

1. Household generally includes only those living in one "abode".
2. Most households take unified decision-making (unanimity, consensus or dictatorship).
3. Most farming households in developing countries are into both the production and consumption of agricultural commodities (i.e. they consume part of their produce and sell part).
4. Part of the production inputs, especially labour, comes from a households' own input stock while some are hired. In other words, these households work on their own farms providing their own labour and sell part of it to others in a form of hired labour.
5. By increasing labour for work, they reduce their leisure hours (Family maintenance (cooking, cleaning), Reproduction (kid tending), Social obligations (religious, cultural stuff) and Sleep).

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6. The objective of this production-consumption decision is to maximize output and consumption utility (welfare) subject to cash, time and production constraints.

In this study, crop farmers are small-scale farmers who produce and consume their crops. They feed their farms with family labour and sell off part of their labour to others who may need employment. Therefore, these households are said to be integrated into both the product and factor markets. The household also aims at maximizing total crop output and consumption utility or welfare subject to time and other resource constraints. This study however does not directly estimate an AHM because the data set has no information on prices and it is cross sectional in nature, meaning prices would not vary much across the households. Instead, the study seeks to find out whether crop farmers who produce on small scale are able to maximize their welfare relative to their counterparts who produce on large scale. A similar studies that conceptualize these dynamics in a simplified and concise manner is Dzanku (2015) on household welfare effects of agricultural productivity, who found productivity to be an increasing factor of welfare, and Donkoh (2011) on the adoption of Green Revolution (GR) inputs and its effect on household's efficiency and welfare in Ghana, also found that the adoption of GR inputs leads to increased technical efficiency as well as welfare.

2.6: Review of Poverty studies

The World Bank (2016) defines poverty as the inability to live up to a particular set standard of a society. The standard set by the World Bank demands that a household

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that is unable to live up to poverty line threshold of $1.90 per day, should be classified as poor.

Poverty depends not only on income but also on access to services, hence poverty is also defined as the deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education and information. As a multidimensional phenomenon, poverty is defined and measured in a multitude of ways. This is broadly categorized into absolute or relative poverty measures.

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2.6.1: Relative and Absolute

Absolute poverty occurs when people cannot obtain adequate resources. Relative poverty occurs when people do not enjoy a certain minimum level of living standards as determined by a government. Relative poverty can be associated with people who are lowly paid or working poor representing the longest groups in poverty line. Large families also experience poverty; the addition of subsequent mouth to feed merely compounds the problem. Amartya Sen (2004) established that poverty in an absolute term occurs in the space of capabilities and relative in commodities or characteristics. For example, households incapable of obtaining sufficient food for survival are considered absolutely poor. However, the costs and composition of that food basket may vary considerably between households across different groups, regions and countries.

2.6.2: Poverty Estimation

The common measure of Poverty has been the monetary approach where the income consumption expenditure are used as indicator for poverty calculation. This approach to poverty measurement operates on the assumption that individuals and households are poor if their income or consumption falls below a certain threshold (poverty line), usually defined as a minimum, socially acceptable level of well-being.

The poverty lines defers across time and societies, therefore, each country uses lines which are appropriate to its level of development, societal norm and values (World Bank, 2007). In most cases, two poverty lines are applied to the distribution of standard of living. These are upper and lower poverty lines. In Ghana the current upper poverty line is GHC 1,314 Cedis per adult year while the lower poverty line is GHC 792.05 Cedis per adult year (GSS, 2014). Households above this line are rich while those below but above the lower poverty line are poor and those below the lower poverty line are extremely or very poor.

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2.6.3: Poverty Indices

In calculating poverty indices, more emphasis is placed on material well-being (i.e. monetary measure). The traditional income poverty indicators are the headcount index and per capita GNP.

2.6.3.1: Headcount Index

The headcount index is based on a poverty line that is established by costing a minimum basket of essential goods for basic human survival, using income or consumption expenditure data of households. The incidence of poverty is then calculated as the percentage of the population whose incomes fall below that threshold. The headcount is however expressed as

$$H = (q/n) \qquad 2.18$$

Where q = number below the poverty line

n= size of population

2.6.3.2: Foster, Greer and Thorbecke (1984) index

Income indicators can also be used to measure the depth and severity of poverty. The poverty gap index measures the degree to which the mean income of the poor differs from the established poverty line (depth of poverty). The Foster, Greer and Thorbecke (1984) Index is expressed as

$$P_a = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z - y_i}{z}\right)^a \qquad 2.19$$

Where z is poverty line, y is welfare measure (total income/expenditure of household). $z - y_i$ is the proportionate shortfall below the poverty line. a is a parameter which captures the degree of poverty and it ranges between 0 and 2, depending on the purpose of the measure. Thus if a =0, P_a decrease to the headcount; if a =1, P_a captures the depth of poverty and if a =2, P_a measures the severity of poverty.

There is also distributional sensitive measures, such as the squared poverty gap index, which measures differences in income levels among the poor (severity of poverty). In the absence of household survey data, income poverty is sometimes measured in per capita GNP terms. However, this indicator is a very crude measure and can often be misleading since it is possible for per capita GNP to grow while personal incomes can remain static or even decline among particular population groups. For this reason, per capital personal income is a preferable aggregate income indicator.

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2.6.4: Approaches to Poverty Estimation

As discussed earlier, household expenditure is the basis for ranking households and defining poverty lines. There are two main approaches to estimating poverty, namely the direct and indirect effects.

2.6.4.1: Direct Approach

The direct approach is the OLS approach and the dependent variable in this approach is welfare (household per capita consumption). Mathematically, the direct approach is expressed as;

$$\ln C_i = w_i \gamma + e_{3i} \tag{2.20}$$

Where

$\ln C_i$ is the natural logarithm of real per capita consumption expenditure of household i

w_i is a set of household and community characteristics that that effects consumption expenditure

e_{3i} is a normally distributed random term with mean zero and constant variance capturing unobserved variables.

2.6.4.2: Indirect Approach

In the indirect approach (logit or probit), the dependent variable is discrete; 1 if household is rich (per capita consumption is above the upper poverty line) and 0 if household is poor (below the upper poverty line), thus the dependent variable denoted by Y takes the form

$$prob(Y=1)=F(\beta' x)$$
$$prob(Y=0)=1-F(\beta' x) \qquad 2.21$$

The logistic distribution gives;

$$prob\ (Y=1)=\frac{\ell^{\beta' x}}{1+\ell^{\beta' x}} \qquad 2.22$$

$$=\Phi(\beta' x)$$

Where Φ is the logistic cumulative distribution function (F), thus probability model is of the regression;

$$E[y/x]=0[1-F(\beta' x)]+1[F(\beta' x)]$$
$$=F(\beta' x) \qquad 2.23$$

This approach has been used by Chirwa et al. (2002); Anyanwu (2005) and Donkoh (2006).

2.6.5: Determinants of Poverty

The determinants of poverty could be macro, sector-specific, community, household and individual characteristics. These characteristics can be used to determine the factors causing poverty, or at least the factors correlated to poverty.

Region: At the regional level, there are various attributes that may be related with poverty. The relationship of these characteristic with poverty is nation specific. In

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general, however, poverty is high in regions characterized by geographical isolation, a low resource base, low precipitation and other unwelcoming climatic conditions.

Other essential regional and national factors that influence poverty include great administration, a sound natural approach, economic, political and market stability, mass cooperation (global and regional), practical, and effective judiciary.

Household Size and Structure: This indicator is a vital one as it demonstrates a conceivable correlation between the level of poverty and household composition (size and characteristics).This varies across locality and even varies more for the poor and non-poor families.

Age & Gender of the Household Head: It is generally believed that the sexual orientation of the household head altogether impacts household poverty, and all the more particularly, the households headed by women are poorer than those headed by men. Women assume an essential part in the labour force, both in the financial management of the household and in the labour market and yet they seem to confront more prominent level of discrimination. They are seriously influenced by both fiscal and nonmonetary poverty; for instance, they have low level of education; they are paid lower compensation; and have less access to land or equivalent employment.

Household Employment: A household's state of employment covers the employed, unemployed and underemployment. Most literature have established that households with unemployed heads and/or members are likely to be living in poverty, while Paid employment impacts on poverty when it provides households with sufficient income. Unemployment is noted as the most important cause of poverty. The relationship

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between poverty and employment or unemployment is strong especially in the case of long-term employment/unemployment.

Household Income and Structure of Consumption Expenditure: Income represents a vital area to consider while portraying poor people, since its dispersion among household individuals and among the different socioeconomic group varies. The structure of household consumption expenditure (the make-up of food and non-food spending) is significant representation if households' income and can be used to characterize households' welfare status (poor or rich).

Household assets: The assets of household are indicators of households' inventory of wealth and, along these lines, they influence households' income stream. Moreover, certain households, particularly those in the rural regions, can be poor in terms of income but well off when their property is converted into monetary value.

Education: the sort of education and tutoring a household have access to or can access is an essential indicator of the quality of life the household is privileged to enjoy. Being a key determinants of poverty, it reflects individuals' capacity to exploit pay gaining opportunities.

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2.7: The Concept of Production

Production refers to the combination of inputs (raw materials) with a given state of technology to produce a stipulated output. The technical relationship between output and input is known as the production function. Production function describes the laws of proportion in the process of transforming factors of production (inputs) into products (outputs) at a given period (Koutsoyannis, 2003). The primary objective of a production function is to address efficiency in the use of factor inputs in production

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and the resulting distribution of income to those factors. The production function is expressed as;

$$Q = f(X_i; \beta) \quad 2.24$$

where Q is the stipulated output and $X_{i=1....n}$ is the factors of production. β is vector of unknown parameters estimated. Q depends on how much of X_i is used. If the levels of X_i are increased/reduced, then it is expected that Q will also increase/decrease respectively. However the increase or decrease in Q is not only attributed to X_i but other factors such as technology and such relation is expressed as;

$$Q = A(t)\, f\left(X_i; \beta\right) \quad 2.25$$

Where $A(t)$ is the technological factor suspected to be responsible for the change in the given output aside X_i inputs.

Agriculture production economics relates to issues concerning producers of agricultural produce. Some of these issues are goals and objectives of the farm manager, choice of outputs to be produced, allocation of resources among outputs, the competitive economic environment in which the farm firm operates and assumption of risk and uncertainty.

Goals and objectives of the farm manager is the focus of this study since it can be related to welfare. The goal of every farmer is to maximize profit, that is; to maximize the difference between returns from the sale of their commodities and the costs of

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producing these commodities. This objective can be realized when farmers improve on their production efficiency.

The more common empirical production functions are the Cobb-Douglas (C-D) and the translog production functions. While the former is simple, the latter is flexible.

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2.8: The Concept of Efficiency

In this section we introduce a measure of the distance from the frontier, which is known as a measure of efficiency. Farrell argued that the firm's efficiency can be calculated empirically and he proposed, for the first time, an innovation method of efficiency frontier estimation from real situations of production observations. Farrell (1957) work was enormously influenced by Koopmans (1951's) formal definition and Debreu (1951's) technique. Farrell (1957) however decompose the general efficiency of a production unit into its technical and allocative parts. A combination of the two gives economic efficiency. Debreu (1951) and Farrell (1957) proposed two approaches to measure technical efficiency. The first being the input oriented and the second, output oriented; this is mutually known as Debreu-Farrell measure of technical efficiency. One desiring property of technical efficiency estimation is the invariant property which states that under conditions where the units of input or yield estimations are changed, efficiency scores stays unaffected. Figure 2.3 below is an illustration of the concept of efficiency by Farrell.

Farrell (1957) assumed a constant returns to scale (CRS) in his paper, the detailed explanation of the technological principle is given by the unit isoquant YY', which entails the minimum inputs combination per unit of output needed to produce a unit

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of output. Thus, under this system, a firm operating at R is technically efficient in that it is using a bundle of input along the unit isoquant (YY'). On the other hand any firm that operates at P is characterized as technically inefficient since it is operating at a point far away from R (meaning the firm is utilizing all input bundle that could possibly be needed to create a unit of yield). Thus the technical efficiency of this firm is measured in by which is equal to. However TE takes the value between zero and one. TE value of one indicates that the firm is fully efficient, while zero value implies that the firm is inefficient. The line also demonstrates the input price combination of the two inputs to produce the given output level; the least cost combination of inputs. It defines an allocatively efficient point of production, hence point $R^{'}$. according to Farrell's definition, point is said to be a point where economic efficiency is attained since at this point, both technical and allocative efficiencies are attained (Kumbhakar and Lovell, 2000).

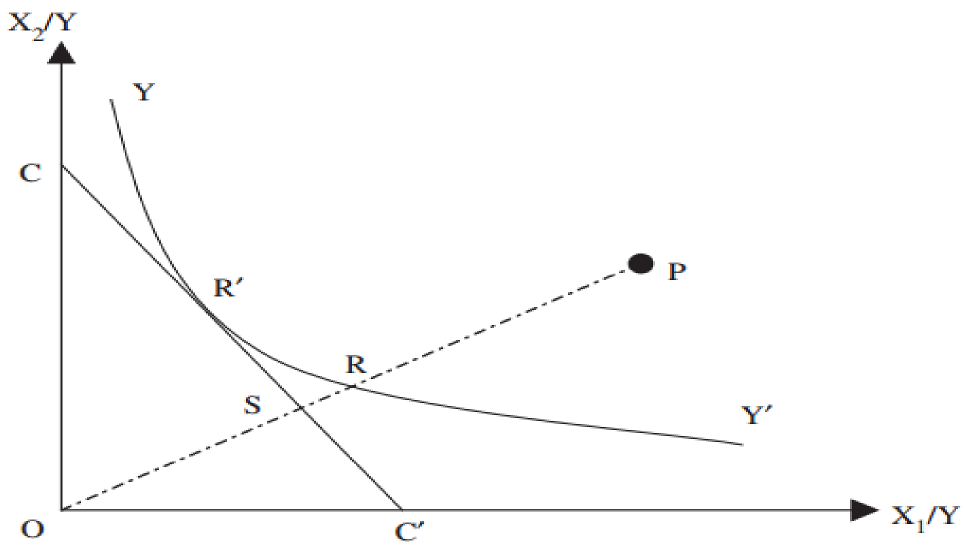

Figure 2.3: Technical and All7ocative Efficiency Measures.
Source: Murillo Zamorano (2004)

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2.8.1: Methods of Estimating Efficient Frontier

Efficiency measurement can be addressed using several approaches, these approaches can be classified broadly into two; parametric and non-parametric methods. The difference between these two approaches are functional form specification, the merits and demerits including model specification problems, are discussed in details by Kumbhakar and Lovell (2000) and Coelli et al. (2005).

Non Parametric approach: This is established y Farrell (1957) for measurement of efficiency based on data without functional form specification. The aim of this non-parametric approach is to define a frontier envelopment surface for all sample observations. The non-parametric approach has a limitation of mathematical programme.

Parametric approach: Parametric approach entails functional model specification which needs to be predefined by the efficient frontier. This approach is further divided into deterministic and stochastic frontier production functions. Deterministic frontiers assume that all the deviations from the frontier are a result of firms‟ inefficiency, while stochastic frontiers assume that part of the deviation from the frontier is due to random events (reflecting measurement errors and statistical noise) and part is due to firm specific inefficiency (Forsund et al.1980; Battese, 1992; Coelli et al., 1998).The parametric approach is stochastic, and includes the random error term. The common functional forms under the parametric approach include the Cobb Douglas production function, stochastic frontier function, Constant elasticity of substitution function, Tobit model, translog and bootstrapped frontier functions.

These models can be applied to production, cost, profit and possibly, revenue functions for the estimation of efficiency. This approach is the main focus of this study.

The limitations of the non-parametric approach can be resolved using the parametric approach in estimating technical efficiency. However, the parametric approach also has a limitation which is; it imposes parametric restrictions on the production function and assumptions about the data, for example, there is the assumption of unitary elasticity of substitution in Cobb-Douglas production function (Chavas and Aliber, 1993). Moreover, estimation of the econometric model poses challenges of including all relevant inputs in the production function due to the problem of multicollinearity.

The stochastic model's parameters can be estimated with the maximum likelihood estimation (MLE) when the distribution of the deviation from the frontier (u) is specified. The error term can be corrected to permit the usage of OLS by correcting for the known bias in the intercept terms. This approach is known as the Corrected Ordinary Least S quares (COLS) (Ali, 1991).

2.8.2: The stochastic frontier

Most of the literature related to the measurement of economic efficiency have based their analysis either on parametric or non-parametric methods. The choice of estimation method has been an issue of debate, with some researchers preferring the parametric (e.g. Berger, 1993) and others the nonparametric (e.g. Seiford and Thrall, 1990) approach. The main disadvantage of non-parametric approaches is their deterministic nature. Data Envelopment Analysis, for instance, does not distinguish

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between technical inefficiency and statistical noise effects. On the other hand, parametric frontier functions require the definition of a specific functional form for the technology and for the inefficiency error term. The functional form requirement causes both specification and estimation problems.

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The stochastic frontier is a parametric method that imposes assumptions (as discussed in previous section) on the dataset. Therefore in the stochastic frontier model, variation from the frontier is not only as a result of inefficiency that the farmer has no control over but also other factors such as uncertainties, poor weather and market irregularities, which are beyond the control of a firm. However, factors beyond the control of firms are required to be separated from those that are within in order to make a proper estimation of inefficiency. The stochastic frontier model proposed by Aigner (1977) and Meeusen and Van den Broek (1977), assume a composed error term(ε_i) consisting of u_i and v_i (i.e. $\varepsilon_i = -u_i + v_i$). v_i measures factors outside the control of firm, while u_i measures the factors within the control of the firm. The stochastic frontier production function in this study is modelled in terms of the size the farming operation for crop farmers. The equation is therefore expressed as;

$$y = f(x) \bullet \exp(v - u) \qquad 2.26$$

The term v_i is assumed to be independently and identically distributed $N(0, \sigma^2 v)$, independent of the term u_i. Also u_i is assumed to be independently and identically distributed but as half-normal; $u_i \sim iid\ N^+(0, \sigma_u^2)$ (Aigner *et al.*, 1977; Kumbhakah and Lovell, 2000).

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The distributional function for the composed error term is given as (Weinstein, 1964)

$$f_{\varepsilon}\left({u_i}/{\varepsilon_i}\right) = \frac{2}{\sqrt{2\pi\left(\sigma_u^2 + \sigma_v^2\right)}}\left[\Phi\left(\frac{\varepsilon_i(\sigma_u/\sigma_v)}{\sqrt{\sigma_u^2+\sigma_v^2}}\right)\exp\left(\frac{-\varepsilon_i^2}{2\left(\sigma_u^2+\sigma_v^2\right)}\right)\right] \qquad 2.27$$

The log-likelihood function for the half normal stochastic frontier can also be estimated by

$$LnL\ (\beta,\sigma,\lambda) = -N/n\sigma - cons\tan t + \sum_{i=1}^{N}\left\{\ln\Phi\left[\frac{\varepsilon_i\lambda}{\sigma}\right] - \frac{1}{2}\left[\frac{\varepsilon_i}{\sigma}\right]^2\right\} \qquad 2.28$$

Using Maximum Likelihood (ML), consistent values of $\beta, \lambda\ and\ \sigma$ are obtained. Where $\lambda = {\sigma_u}/{\sigma_v}$, $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and Φ is the standard normal cumulative distribution function

Since u_i and v_i are assumed independent, the conditional mean of u_i can be estimated using

$$f\left({u_i}/{\varepsilon_i}\right) = \sigma^*\left[\frac{f(\varepsilon_i\lambda/\sigma)}{1-F^*(\varepsilon_i\lambda/\sigma)} - \frac{\varepsilon_i\lambda}{\sigma}\right] \qquad 2.29$$

Where f is the standard normal density and F^* is the distribution function. Using a Z-test formulation as $Z = \frac{\hat{\lambda}}{Se(\hat{\lambda})} \sim N'(01)$, we can simply determine the presence of inefficiency or otherwise among the farmers (Coelli *et al.*, 2005).

After obtaining the conditional estimates of u_i, the technical efficiency can be estimated and according to Jondrow et al. (1982) technical efficiency is expressed as

$$TE = 1 - E\left[u_i/e_i\right] \qquad 2.30$$

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This study would be using the Battese and Coelli (1988) estimator which is much preferred to other estimators due to the fact that u_i is not closer to zero. It is expressed as

$$E\left[\exp(-u_i)|e_i\right] = \frac{1-\Phi\left(\delta + \left(\gamma e_i / \delta\right)\right)}{1-\Phi\left(\gamma e_i / \delta\right)} . \exp\left(\gamma e_i + \left(\delta^2 / 2\right)\right) \qquad 2.31$$

Where $\delta = \frac{\sigma_u . \sigma_v}{\sigma}$ and $\gamma = \frac{\sigma_u^2}{\sigma^2}$

The technical inefficiency effect is expressed as;

$$U_i = \delta z_i + w_i \qquad 2.32$$

z_i is a vector of observable explanatory variables, δ is a vector of unknown parameters and w_i are unobserved random variables which are assumed to be independently distributed and obtained by truncation of normal distribution with zero mean and constant variance.

The SFA model requires specification of the appropriate production function. The most commonly used functional forms are the Cobb-Douglas and Transcendental Logarithmic (translog) production functions.

2.8.2.1: Functional Form

Cobb-Douglas production function

One of the widely used functions to represent the relationship between inputs and outputs in economics is the Cobb-Douglas (C-D) production function. Historically, the development of the theory takes antecedent from the Euler"s theorem. In their study, they modelled the growth of the American economy during the period

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1899–1922 in which production output is determined by the amount of labour involved and the amount of capital invested. The production function modeled was;

$$P(L,K) = bL^{a}K^{\beta} \qquad 2.33$$

Where;

P = total production (the monetary value of all goods produced in a year)

L = labour input (the total number of person-hours worked in a year)

K = capital input (the monetary worth of all machinery, equipment, and buildings)

b = total factor productivity and are the output elasticities of labour and capital respectively which are determined by the existing technology. Based on specification, there are three basic assumptions underlying the C-D formulation and usage:

1. If either labour or capital vanishes, production will also vanish.
2. The marginal productivity of labour is proportional to the amount of production per unit of labour.
3. The marginal productivity of capital is proportional to the amount of production per unit of capital.

2.8.2.1.1: Limitations of C-D

The C-D production function is based on marginal productivity theory of value which was desirous due to its mathematical convenience and necessity. However, as

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econometric methods advances, the theoretical issues of measuring input substitutability becomes necessary. The inability of the C-D to estimate input substitutability was due to the inflexibility of the model itself. Although the function accommodates elasticity of substitution different from zero or unity, they remained constant at all levels of input. The general applicability has then been restricted to only nonlinear problems.

2.8.3: Translog production functions

The development of the transcendental logarithm (Translog) production functions was in response to the limitations of C-D production function (Christensen et al., 1972). Translog is a special form of the C-D that has gained wide usage due to its several possible interpretations and its mathematical similarity to the applications of Shepard's duality theory. As with other exponential functions, the translog functional form is often written in its logarithmic form as:

$$Y = f(x_1, ...x_n) = a_0 \prod_{i=1}^{n} x_i a_i \prod_{i=1}^{n} x_i \, ^1\!/_2 \left[\sum_{j=1}^{n} \beta_{ij} \ln x_{ij} \right] \qquad 2.34$$

where Y is output, a_0 is an efficient parameter, x_i is a set of input and a_i and β_{ij} are unknown parameters. Taking the natural logarithm of both sides:

$$\ln Y = \ln a + \sum_{i=1}^{n} a_i \ln x_i + ^1\!/_2 \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} \ln x_i \ln x_j \qquad 2.35$$

β_{ij} maintains Young's theorem of integral functions that the second order partial derivatives of the function with respect to i, then j is equal to the differential of j, then i (Berndt and Christensen, 1973). This equation can reduce to the C-D

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production function if $\beta_{ij} = 0$. This offered a straight forward test of the appropriateness of the C-D function hypotheses. Maddala (1977) noted that this test can be done using F-test by restricting (eliminating) the quadratic terms.

2.7.3.1: Limitations of translog production function

The problem with estimating a translog production function is that, as the number of production inputs increases, the number of parameters to be estimated also increases due to the squared and cross products. An econometric violation that is likely to occur when more factors are included is multicollinearity. However, this can be resolved by simply eliminating the squared or cross product terms whose t-ratios are below a certain critical value. This was effectively proven worthy by Shih et al. (1977). Vinod (1972) also proposed removing all the squared terms to mitigate multicollinearity while maintaining the function's property. Though the flexibility assumption of the translog production function is necessary to represent the production technology accurately, it may not be justifiable enough to estimate the translog function if estimates of elasticities of substitutions are less important than estimates of scale elasticities. Mathematically, it is difficult to manipulate and also, it suffers from degrees of freedom.

Notwithstanding the limitations of the translog production function, it possesses certain properties that makes it appropriate for this studies. The advantages includes;

1. Flexible functional form which allows for a second order approximation.
2. It imposes restrictions on parameters (homogeneity conditions).

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3. It does not assume rigid premises such as: perfect or "smooth" substitution between production factors or perfect competition on the production factors market.

2.9: The Three Stage Least Square

2.9.1: The Concept of Endogeneity

From basic regression model

$$Y = b_0 + b_1 x_{1i} + b_2 x_{2i} + b_3 x_{3i} + \ldots\ldots + b_k x_{ki} + e_i \qquad 2.36$$

and Gauss-Markov assumptions, a number of assumptions are necessary for the OLS estimator to be consistent, unbiased and efficient. However a failure in one of the assumptions which states that the $X_{ki's}$ are non-stochastic (fixed), implying that there is no relationship between X_{ki} and e_i

$$\text{cov}(X_{ki}, e_i) = 0 \;\; or \;\; E(X_{ki} e) = 0 \qquad 2.37$$

gives rise to a problem of endogeneity

$$\text{cov}(X_{ki}, e_i) \neq 0 \;\; or \;\; E(X_{ki} e) \neq 0 \qquad 2.38$$

Endogeneity means that changes in Y are not only associated with changes in X but also changes in e. Endogeneity occurs for several reasons, including measurement error in variables, omitted / missing variables, inclusion of irrelevant variables, influential observations, missing observations, simultaneous equations (simultaneity), wrong direction of causality, autocorrelation with lagged and dependent variable.

In this study the cause of endogeneity is simultaneous equations (simultaneity), in a sense that the objective of investigating the relationship between farm size and

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household welfare, requires two systems of equations (welfare and farm size). Since the study will revolve around simultaneity, we will briefly discuss issues of simultaneity in this section.

2.9.2: Simultaneity and Reverse Causality

According to Greene (2004) and Henningsen et al. (2007), most economic theories are built on a set or systems of relationships and many theoretical models that are econometrically estimated consist of more than one equation. Some common examples include market equilibrium, models of the macro-economy and set of factors or commodity demand equations.

Illustrative system of equations: the following are components of market equilibrium model;

Demand equation:

$$q_{d,t} = \alpha_1 p_t + \alpha_2 y_t + \varepsilon_{d,t} \qquad 2.39$$

Supply equation:

$$q_{s,t} = \beta_1 p_t \qquad + \varepsilon_{s,t} \qquad 2.40$$

Equilibrium condition:

$$q_{d,t} = q_{s,t} = q_t \qquad 2.41$$

Since these structural equations are joint determination of price and quantity, they are referred to as jointly dependent or endogenous variables and income y is assumed to be determined outside the model, hence is referred as exogenous. All three equations are required to determine the equilibrium price and quantity, hence the system is interdependent. However, if these interdependencies exist between the explanatory

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variables, thus creating a two-way or reverse causality, and are substantial, then this gives bias problems in estimation due to simultaneity.

The basic problem in simultaneous equations models is the correlation between the explanatory variables and the residual terms.

Figure 2.4 below illustrates the problem of endogeniety.

We observe that a change in Y_t from Y_1 to Y_2 makes the demand function to shift from q_1 to q_2. This leads to a change in price p_t from p_1 to p_2 because equilibrium has to be restored again. Hence, price is not independent and it is said to be endogenous due to simultaneity. Equilibrium is established if

$$q_{d,t} = q_{s,t} = q_t$$

$$\alpha_1 p_t + \alpha_2 y_t + \varepsilon_{d,t} = \beta_1 p_t + \varepsilon_{s,t} \qquad 2.42$$

Solving this above equation yields

$$p_t = \frac{b_2 y_t}{a_1 - b_1} + \frac{\varepsilon_{s,t} - \varepsilon_{d,t}}{a_1 - b_1} \qquad 2.43$$

This implies that p_t is related to e_t, therefore $\operatorname{cov}(p_t, e_t) \neq 0$

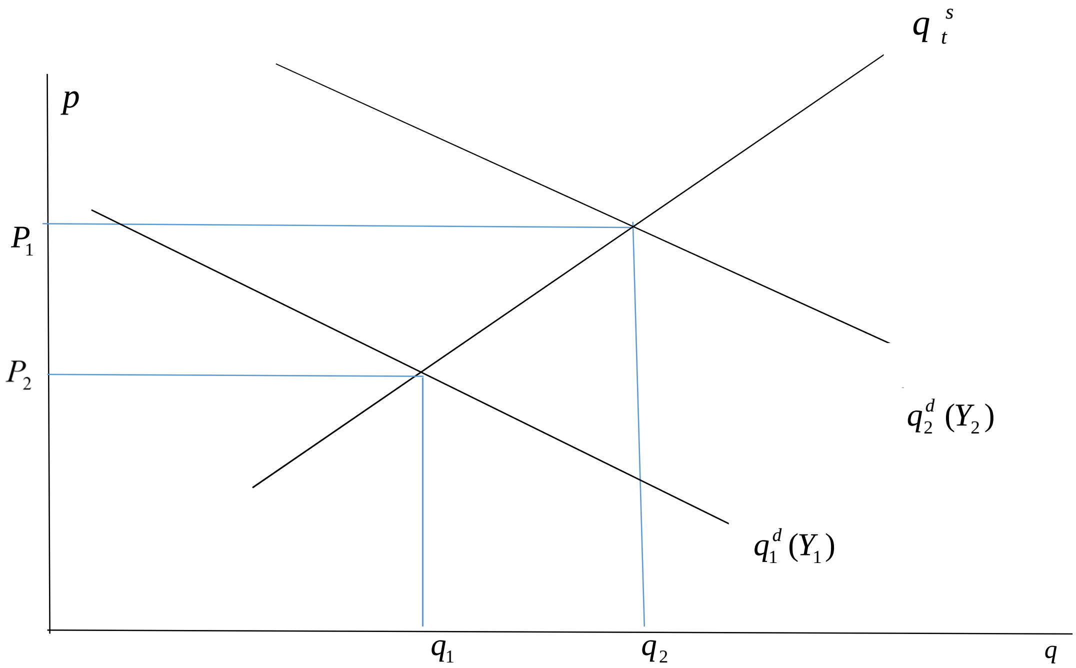

Fig 2.4: Simultaneity in a market model
Source: Adopted from Maddala (2001)

Thus if the supply equation is estimated with OLS, it yields;

$$\hat{a}_1 = \frac{\sum p_t q_t}{\sum p_t^2} = \frac{\sum p_t (a_1 p_t + \varepsilon_{s,t})}{\sum p_t^2} = a_1 + \frac{\sum p_t \varepsilon_{s,t}}{\sum p_t^2} \qquad 2.44$$

This shows that $\hat{a}_1 = a_1 + \frac{\text{cov}(p_t, \varepsilon_t)}{\text{var}(p_t)}$ if n approaches infinity. So $p\lim \hat{a}_1 \neq a$. This implies that $\hat{a}_1$ is not a consistent estimator of a The expected value of $\hat{a}_1$ given by makes $\hat{a}_1$ is a biased estimator of a Therefore, under simultaneity, OLS estimator is both biased and inconsistent.

$$E(\hat{a}_1) = E\left[(a_1 + E\left(\frac{\sum p_t \varepsilon_{s,t}}{\sum p_t^2}\right)\right] = E(a_1) + E\left(\frac{\sum p_t \varepsilon_{s,t}}{\sum p_t^2}\right) = a_1 + E\left(\frac{\sum p_t \varepsilon_{s,t}}{\sum p_t^2}\right) \neq a_1 \qquad 2.45$$

To estimate the parameters in the context of simultaneity the following model could be use: Instrumental variable estimation; Indirect least squares (ILS); Two-Stage Least Squares (2SLS); and Three-Stage Least Squares (3SLS). Since the focus of the

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study requires application of the two- stage and three-stage least squares (3SLS) model, we will briefly discuss the 2SLS and 3SLS model.

The 3SLS model is a special case of multi-equation which combines two systems of equation (seemly unrelated regression (SURE) and two stage least square (2SLS)), where a set of instrumental variable is common to both equations. Combining the 2SLS estimation method with the SUR method results in a simultaneous estimation of the system of equations by the three-stage least squares (3SLS) method (Zellner and Theil 1962).

The 3SLS was introduced by Zellner et al. (1962) to bring improvement in efficiency for simultaneous equation systems with endogenous regressors than 2SLS, since the 2SLS focuses on individual equations within the system while there are simultaneous correlations between the error terms of the various (individual) equations. The 3SLS equation is therefore expressed as;

$$\begin{Bmatrix} Y_1 = \tilde{Z}_1 * \tilde{F}_1 + \varepsilon_1 \\ Y_2 = \tilde{Z}_2 * \tilde{F}_2 + \varepsilon_2 \\ \vdots \quad \vdots \quad \vdots \quad \vdots \\ Y_m = \tilde{Z}_m * \tilde{F}_m + \varepsilon_m \end{Bmatrix} \tag{2.46}$$

Where $\tilde{Z}_j = [\tilde{Y}_j \ \tilde{X}_j]$ – is a vector of explanatory variables (endogenous and exogenous variables respectively) in the $j-th$ equation.

Let $\hat{F}_j^{2SLS}$ – vector $j-th$ equation's parameter estimates via 2SLS.

Casting the model into matrix form;

$$\begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_m \end{bmatrix} = \begin{bmatrix} \tilde{Z}_1 & 0 & 0 \\ 0 & \tilde{Z}_2 & 0 \\ \vdots & \vdots & \vdots \\ 0 & 0 & \tilde{Z}_m \end{bmatrix} \begin{bmatrix} \tilde{F}_1 \\ \tilde{F}_2 \\ \vdots \\ \tilde{F}_m \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_m \end{bmatrix} \qquad 2.47$$

Where $\varepsilon_1, \varepsilon_2 \ldots\ldots \varepsilon_m$ are vertical vector sized T*1

With the 2SLS estimated parameters and residuals, the variance-covariance matrix of the random disturbances can be estimated $(Var(\varepsilon_t) = E(\varepsilon_t \varepsilon_t^T)$ element by element in a standard way:

$$\hat{\Sigma} = [\sigma_{ij}]$$
$$\sigma_{ij} = (y_i - Z_i \hat{F}_i^{2MNK})^T / T \qquad 2.48$$

Where T= number of observations. Alternatively, instead of T, one can divide the product sum in the nominator by the geometrically average degree of freedom for equations i and j:

$$\sqrt{(T - \overline{M}_i - \overline{K}_i)(T - \overline{M}_i - \overline{K}_i)} \qquad 2.49$$

$\overline{M}_i (\overline{M}_j)$= number of endogenous regressors in j-th equation

$\overline{K}_i (\overline{K}_j)$=number of exogenous regressors in i-th equation

The 3SLS can be applied by a three step procedure;

1. Estimating the reduced form and finding the theoretical values for j-th equation:

$$\hat{\overline{Z}}_j = Xn_j = x(X^T X)^{-1} X^T \overline{Z}_j \qquad 2.50$$

2. Individual equations parameters estimation in the structural form (2SlS):

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Empirical endogenous explanatory variables replaced with theoretical values from step 1:

$$\hat{F}^{2SLS} = (\hat{Z}T\hat{Z})^{-1}\hat{Z}^{T}y \tag{2.51}$$

3. Recognizing the simultaneous correlation of the error term in the model such that if j-th equation's error term is spherical, its variance-covariance matrix is:

$$\begin{bmatrix} \sigma_{jj}^{2} & 0 & 0 \\ 0 & \sigma_{jj}^{2} & 0 \\ 0 & 0 & \sigma_{jj}^{2} \end{bmatrix} \tag{2.52}$$

With the knowledge of the entire variance-covariance matrix $\hat{\Sigma}$, the GLS can be applied to the model; $y = ZF + \varepsilon_1 \varepsilon \sim (0, \Omega)$

$$\hat{F}^{GLS} = (Z^{T}\Omega^{-1}Z)^{-1}Z^{T}\Omega^{-1}y \tag{2.53}$$

All this is done jointly, using the 2SLS theoretical values for endogenous regression obtained in step 1;

$$\hat{F}^{3SLS} = (\hat{Z}^{T}\Omega^{-1}\hat{Z})^{-1}\hat{Z}^{T}\Omega^{-1}y \tag{2.54}$$

For a continuous endogenous regressors, a control function approach has been proposed by Blundell and Powell (2003, 2004), where a linear model specifies the relationship between the continuous endogenous regressors the full set of enxogenous covariates (including the instruments).

2.9.3: The two stage estimator

With a valid instrument, the parameters of the regression equation can be estimated with 2SLS estimator. The estimation is done in two stages:

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Stage 1: The endogenous variable (X_k) is separated into two components: (i) a problem free component that is uncorrelated with the error term and (ii) a problematic component that may be correlated with the error term. This is achieved by regressing the instrument(s) on the endogenous regressor, and calculating predicted values for the regressor (problem free component). A residual is yielded from this estimation, which is plugged into the second stage estimation procedure.

Stage 2: In this stage, the problem free component (predicted values/ residual) is used to estimate the endogenous regression coefficients. This is done by replacing the endogenous regressor by its predicted values from the first stage.

2.10: Determinants of Efficiency

In the sections that follow, we provide a review of some empirical studies on the determinants of technical efficiency. In literature, there are several important determinants of technical efficiency in production and this study would be considering some of these factors. The following give an insight into the determinants of technical efficiency;

Age: Age of farmer is required to impact efficiency in any direction. This implies that age can affect efficiency positively or negatively. Some schools of thought argue that efficiency increases with a farmer's age, reaches a maximum and finally drops. Tiamiyu (2010) holds a view that is quite contrary to these schools of thought. In Tiamiyu's study, it was discovered that there is a significant negative relationship between age and efficiency indices.

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Gender: The FAO appraises that, in SSA Africa in general, 31 percent of rural households are headed by women. This is mainly due to the fact that men relocate to urban areas in search of wage labour to better their lives. In spite of this significant role, women have less access to land than men. At the point when women do claim land, the land holding has a tendency to be smaller and situated at peripheral regions. Rural women additionally have less access to credit than men, which restricts their capacity to buy seeds, compost and different information sources expected to receive new farming strategies (FAO, 2002). But Adesina and Djato (1996) contended that both men and women farmers are productive in terms of asset utilization. Contrary to the findings of Adesina and Djato (1996), Dolisca and Jolly (2008) found that male farmers are more technically efficient than their female counterparts.

Education: Education enhances a farmer's ability to seek and make good use of information about production inputs, and therefore it is expected to influence efficiency positively. Education plays a great role in the adoption of most new technologies that normally call for better management including consistent record keeping and proper use of the various inputs in maize production (Cheryl et al, 2003). Some empirical studies such as Owour and Shem (2009) have shown a negative relationship between education and technical efficiency of farmers. One possible explanation is that technical skills in agricultural activities, especially in developing countries are more influenced by "hands on" training in modern agricultural methods than just formal schooling.

Household size: In a village setting household members are a source of farm and off-farm income generating activities (Sentumbwe, 2007). The size of farmers' household is another factor that influences the efficiency of farmers. Abdulai et al.(2001) pointed out that although large household size puts extra pressure on farm income for food and clothing, they at times ensure availability of enough family labour for farming activities to be performed on time.

Cooperative membership: A positive relationship between TE and EE was reported by Galawat and Yabe (2011). According to their findings, farmers who are members of cooperatives or associations are more efficient than those farmers who are nonmembers. They argued that membership of cooperatives/FBOs presents farmers with opportunities like easy access to information on modern agronomic practices. This also helps in dissemination of information to farmers since farmers would share information amongst themselves.

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Credit: Access to credit improves liquidity and enhances use of agricultural inputs in production as it is often claimed in development theory. It also provides farmers with additional source of investment in new ideas and therefore it is expected to be positively related to efficiency. However, there could be some exceptions. For example, Okwir(2016) points out that access to credit has negative and significant influence on the technical inefficiency, therefore improving farmers' access to credit reduces technical inefficiency.

2.11: Literature Review on Farm Size Productivity and Welfare Impact on Farm Households

Not all farm households prevail with regards to using the minimum inputs required to produce a given output, considering the innovations available to them. Even if the farmers are technically efficient, not all of them prevail with regards to reallocating

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their inputs in a cost effective way, given the input costs they are confronted with. Variation in allocative efficiency is ascribed to variation in factors which are not under the control of producers e.g. the biophysical environment and the disparity amongst expected and genuine prices, satisficing conduct among others. Stiglitz (1989) also attributes these variations to market failures, a typical phenomenon in developing economies.

The debate of inverse relationship between inputs and efficiency has been on since 1960s after a study was carried out in India on farm management. The economists viewed farmers in developing nations as inefficient. This instigated many studies such as Schultz (1964), which also brought an upsurge in the number of research geared towards agriculture efficiency, many of these studies (Chennareddy, 1967 and Welsch, 1965) had results that conformed to Schultz's poor but efficient hypothesis. The position taken by Schultz (1964) and rehashed in his Nobel Lecture (1980) "poor but efficient" revolutionarised the perceptions of the early economists. A study in Paraguayan on Agriculture Productivity, Technical Efficiency, and Farm Size revealed that smaller farms yield higher per hectare income and are more technically efficient than large scale farms (Masterson, 2007). However, Helfand et al (2004) also carried out a study which sought to find the determinants of technical efficiency, and the relationship between farm size and efficiency in the Center-West of Brazil, a non- linear relationship was found between farm size and efficiency, with efficiency falling initial and then rising with farm size. The rise in efficiency was attributed to preferential treatment large farms have over smaller farms in access institutional assistance and also the practice of modernized agriculture.

Wadud et al. (2000) in their study which employed stochastic translog production frontier in both one-stage and two-stage technical inefficiency model found that inefficiency decrease with farm size.

Donkoh et al. (2013) to assess the technical efficiencies of rice farmers at Tono irrigation site in the Upper East Region and found an average efficiency level of 85%. Also, male farmers are more efficient than their female counterparts and likewise, education tended to minimize farmers' inefficiency. Thus educated farmers appeared more efficient than uneducated farmers.

The above empirical studies discussed did not place much emphasis on the welfare effect on the inverse relation between farm size and efficiency. Very few studies have attempted to address this gap in literature. The following are among such studies;

Goto et al. (2009) examined the efficiency and welfare impact of landholdings. The outcome affirm that nonfarm work plays an important role in determining farmers' welfare.

Amare et al. (2016) conducted a similar study to investigate the impact of agricultural productivity on welfare growth of farm households in Nigeria. The result showed that both low and high income households were not productive.

A study by Asogwa et al. (2012) also showed a direct relationship between poverty gap and economic efficiency estimates among the respondents. They concluded that as the cost of maximizing output increases, poverty increases. The result also revealed that the overall economic efficiency and poverty reduction among the respondents resulted more from technical efficiency.

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While the study therefore seeks to mimic the works of Shultz (1964), Goto et al.(2009) and Amare et al. (2016) , it goes beyond proving that there is an inverse relationship between farm size and technical efficiency, by investigating the relationship between farm size and welfare of farmers using the 3SLS estimation procedure.

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CHAPTER THREE

METHODOLOGY

3.1: Chapter Outline

This chapter presents the methodology of the study; consisting of the description of study area (section 3.2), description of data (section 3.3), method of data analysis (section 3.4), conceptual framework of the study (section 3.5), theoretical framework of the study (section 3.6), the three stage model (section 3.7) and technical efficiency estimation (section 3.8).

3.2: Study Area

The study was carried out in the Republic of Ghana which consist of ten administrative regions. Ghana is geographically located at Latitude 4^0 44'N and 11^0 11'N and Longitude 3^0 11' W and 1^0 11'E. Its coastline is 550km long. The 2010 Population and Housing Census puts the country's population at24.22 million with a population growth of 2.4% per annum. Demographically Ghana is dominated by the young with a median age of 20 and 18.7% of the population falls within the age bracket of 15 and 24. A percentage of 38.6 of the population falls at or below 14 years. The country is rapidly urbanizing with 51.9% of the total population living in urban areas. The study was carried out in all the ten administrative regions (Upper East, Upper West, Northern, Brong Ahafo, Volta, Western, Eastern, Ashanti, Central and Greater Accra, which is the national capital.

3.2.1: Land Use in the Study Area

Ghana has a total land size of 23,853,900 hectares. Land usage in the country is classified into six categories (Agriculture land area, Area under cultivation, Area under irrigation, Area not under cultivation, Area under inland water and others

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(forest reserves, savannah woodland, etc)). The proportion allocated to each category is shown in the table3.1 below.

Table 3.1: Land Use (specific to agriculture)

Type of land use	Area in hectares	(%)
Agriculture land area	13,628,179	57.1
Area under cultivation	7,846,551	57.6
Area under irrigation	30,269	0.2
Area not under cultivation	5,781,628	42.4
Area under inland water	1,100.000	8.0
Others(forest reserves, savannah woodland, etc)	9,125,721	38.3
Total land area	23,853,900	100

Source:MoFA (2010)

3.2.2: Ecology of The Study Area

There are five main agro-ecological zones in Ghana based on climate, vegetation and soil. These are Rain Forest, Deciduous Forest, Transitional Zone, Coastal Savannah and Northern Savannah (Guinea and Sudan Savanna). However for the purpose of this study we focus on the three main zones which are the forest, savannah and coastal zones. The study considered the three main zones because the data covered only these three zones.

Forest zone: The forest agro-ecological zone is made up of rain forests and decidious forests. Regions in Ghana that occupy the forest zone are Brong Ahafo,Western, Eastern and Ashanti regions The zone has a bimodal rainfall dctribution (April-July and September-November). The average annual precipitation for the forest zone is about 2000mm of rain.

Coastal zone: This zone is practically warm and dry with a much shorter rainfall seasonwith a range of 100-110 days.This zone also has a bimodal rainfall with an average rainfall of 750mm. The zone however has a thick vegetation and grassland. The coastal zone encompasses the Volta, Greater Accra and Central regions.

Savanna zone: The Savanna zone has a unimodal rainfall pattern which falls between April and september. However, the average rainfall is 1,100mm which is comparatively high. The vegetation of the zone consists of low bush, grassy plain and park-like savannah. The zone consists of the three Northern regions (Uper East, Upper West and Northern).

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3.2.3: Climate and Topography of Ghana

Ghana's tropical eastern coastal belt is warm and comparatively dry, its south west corner is hot and humid while the north is hot and dry. Annual average temperatures range from $26.1^0 C$ in places near the coast to $28.9^0 C$ in the extreme north.Temperatures can sometimes move into the $40^0 C$ in the north where the highest temperatures in the country are recorded in the Upper East region, specifically at Navrongo.

The area's topography is mostly undulating. The country has 70% of its lands under severe sheet and gully erosion although the slopes are gentle.

Crop production remains the main source of livelihood for the majority of rural dwellers across the country. It is also the single source of food for the entire nation. Unfortunately, across the country, farmers are often poor.

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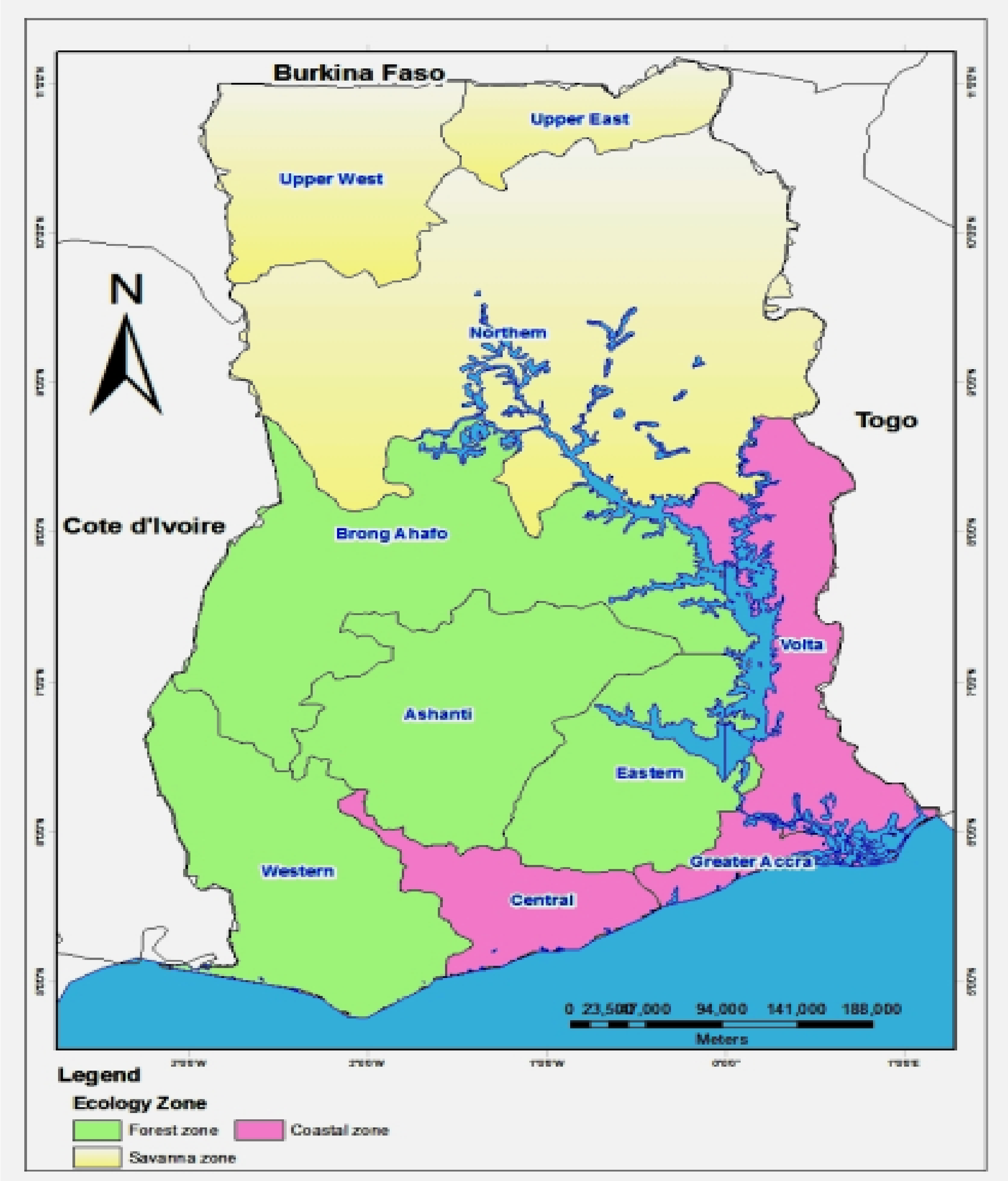

Figure 3.1: Ghana Administrative Map (Showing the Various Ecological Zones)

Source: Author's Construction

3.3: Description of Data

The study employed the round six of the Ghana Living Standard Survey (GLSS 6) data, which is a one year pooled data. In this survey, 18,000 households in 1,200

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enumeration areas were sampled and out of this data, 16,772 households were extracted. The data focuses on the household as the main socio-economic unit. It also provides information on the estimates of living standards and welfare of households in Ghana. In addition, there are detailed information on demographic characteristics of households, education, health, employment, housing conditions, household agriculture, household expenditure, income and their components and access to financial services, credit and assets which are relevant to the study. This study covers the 2,507 farming households in the dataset.

3.4: Method of Data Analysis

The Stata software was employed in analyzing the data. Descriptive analysis and econometric models were also used in analyzing the data. The translog production function specification of the stochastic frontier was estimated with the maximum likelihood method to analyze objective one. The levels of efficiency were also predicted together with the determinants of technical efficiency. For objectives two and three, the three stage least square was employed, where welfare and farm size were regressed on farmers' socioeconomic variables.

3.5: Conceptual Framework

The proposed conceptual framework for the relationship among farm size, technical efficiency and welfare is illustrated in figure 3.3. The figure indicates that these three variables are interdependent and are influenced by several other factors. The influential variables are grouped into socioeconomic, farm characteristics, institutional setting, demographic characteristic, policy factors related to marketing characteristics and input factors. These are briefly discussed below;

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The factors related to demographic characteristics include age, sex, family size and household size, while the socioeconomic characteristics include livestock holding, off-farm or non-farm income, level of education and family education. In relation to farm characteristics, variables considered include farm size, number of plots, and experience of farming. While institutional factors include use of credit, extension services, membership of cooperatives and accessibility to development centers. Factors relating to the marketing characteristics include accessibility of markets and availability to market information. Finally, input factors includes the use of fertilizer, improved seeds and agro chemicals.

Efficiency of production could be obtained through the utilization of better farm management practices, minimizing or removing some existing production constraints and improvement of farm technology. Improved farm technologies include High Yielding Varieties (HYV), fertilizers, and agro-chemicals such as herbicides and pesticides. Improving efficiency goes a long way to positively affect productivity (crop output per unit input).

Increasing agricultural productivity also has a number of advantages. It facilitates the flow of resources from one sector to another and contributes to economic growth. Secondly, a higher level of agricultural productivity results in lower food prices for consumers and a rise in income of producers that increases the welfare of the society, thereby enhancing the economic growth of the country. Agricultural productivity growth also improves the competitive position of the sector (Jema, 2006).

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There are many factors that influence farm households' farm size. These are age, sex, household size, location, land ownership, credit access, etc. Farm size plays a crucial role in raising crop output and farmers' efficiency of crop production and, the literature support the argument that small farms are efficient than large farms. Increase in output also means that farm incomes would increase leading to increased welfare of the farmers, other things being equal

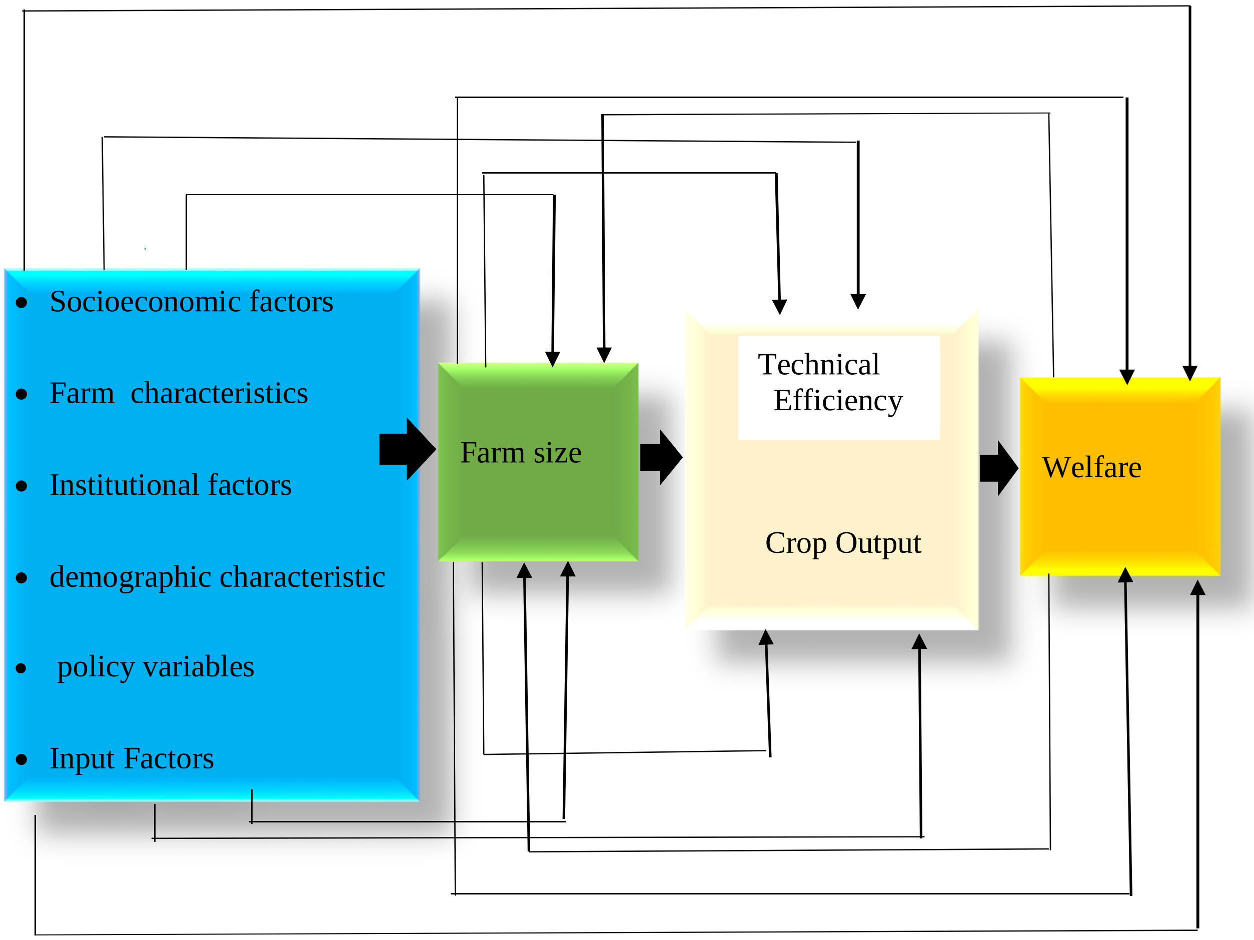

Fig 3.3: Conceptual Framework of the Study

Source: Author's Construction

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3.6: Theoretical Framework

3.6.1: Household Production and Production Constraints

In chapter two, we discussed the basic concept of agricultural household model. In this section, we would narrow it down to this study by considering the production constraints of a typical farm household.

The focus of this research is on the effect of farm size on household welfare and technical efficiency. To capture these relationships, it is necessary to examine the characteristics of farming households that undertake production activities. Since farming households are producers it is seemingly appropriate to model their behaviour by assuming profit maximization. However, most of these households in this study are smallholders whose primary intention of production may not necessarily be to maximize profit but to satisfice. Hoque et al (2015) argued that profit maximization is subject to constraints in many instances. Hence in the context of smallholder farmers in developing countries, many of these farmers have multiple objectives than simply maximizing profit (Gedikoglu and McCann, 2012). Based on this literature, the study adopted the broader concept of utility maximization.

In this framework, households' production system assumes a utility function which is maximized subject to time and input constraints. Following Becker (1965) and Heckman (2014) who introduced the general investigative structure for examining households' distribution of time into the production of their consumable commodities, the theoretical assumption for the study is that a household produces and consumes commodities $G = (G_i),\ i = 1,...,I$. These commodities identify with various activities

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undertaken in the household, including leisure, agricultural production, reproduction and many more.

The utility function of a household is accordingly expressed as:

$$U = U(G_i, ..., G_1.) \qquad 3.1$$

$$G_i = G(X_i, T_i), \; i = 1, ..., I. \qquad 3.2$$

where X_i is a vector of goods inputs (which includes land) for the production of G_i and T_i is time input available to a household. Therefore, the price of G_i is determined by the prices of T_i and X_i. The household's production and consumption activities are subject to both time and cash income budget constraints. However, Becker under certain assumptions showed that the household effectively faces only time budget constraint. If the price of time is w across all uses, then the maximum income a person can earn is $Full\,Income, B = wT + V$, where $T = \sum T_i$ and V is income transfers to the household. Therefore, time as a factor of production is used to produce commodities G_i, which encompasses household activities such as leisure and child bearing, among others and specified as follows:

$$\sum_{i=1}^{T} \pi_i G_i = wT + V = B. \qquad 3.3$$

where π_i is a scale-invariant price index for each commodity produced in the household.

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This implies that the household maximizes its utility in equation (3.1) subject to both production and time constraints in equations (3.2) and (3.3) respectively. Therefore, household demand for inputs X_i and T_i are derived from the demand for G_i. The degree of responsiveness of demand for commodities (G_i) as a result of variations in the prices of goods input (X_i) and time input (T_i) depends, in part, on the intensities of X_i and T_i used in the production of G_i.

Farming households will choose to invest the amount of X_i and T_i, that provides the maximum utility. This will yield higher returns, which is translated in monetary terms as a proxy for household welfare. In this study, our focus is on the input constraint of household production and we expect that farming households with the ability to expand their lands under cultivation (farm size) have greater chances of increasing the productivity (technical efficiency) which would translate into higher income returns (welfare). This concept was simplified in Donkoh (2011), in a study on adoption of Green Revolution (GR) inputs and its effect on household's efficiency and welfare in Ghana. He found that increasing technology adoption increases technical efficiency as well as per capita consumption of households. He illustrated this as follows:

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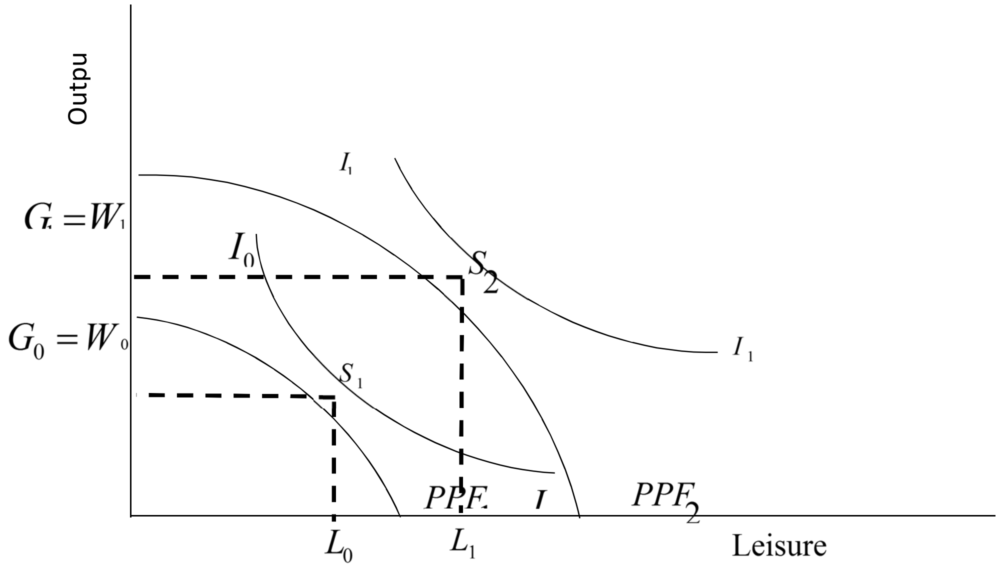

Figure 3.4: Effect of Technology adoption on household's production and consumption
Source: Extract from Donkoh (2011)

where PPF_1 and PPF_2 are production possibility curves that indicate output levels; I_1 and I_2 are indifference curves indicating welfare levels; L_1 and L_2 are the levels of leisure while S_1 and S_2 indicate efficiency and welfare maximization levels. From the figure, Donkoh concluded that adoption of technology leads to increased output resulting in a shift of the output frontier from PPF_1 to PPF_2 . PPF_2 intersects with I_2 , indicating an increase in the welfare of the adopting households.

In this study the *a priori* expectation base on literature (Shultz, 1964) is small farm size leads to increase efficiency, which implies a higher frontier being tangent to an indifference curve (welfare). This study seeks to find out the effect of farm size on technical efficiency and farming households' welfare.

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3.7: Modeling Farm size

In this study farm size is measured as the area of land used for previous season's cultivation. According to Ahearn et al. (2004) farm size is a function of technological factors, public policies (such as extension and commodity payments), farm organizational characteristics, operator demographic characteristics (including engagement in off-farm work), and urban influence, Hence the farm size model is mathematically is expressed as;

$$\ln fs_i = \beta \chi_i + u_i \qquad 3.4$$

where

$\ln fs_i$ is the natural logarithm of the acreage of land under cultivation.

x_i is a set of household and community characteristics that affects the size of farm a household decides to operate.

u_i is a normally distributed random term with mean zero and constant variance capturing unobserved variables.

3.8: Modeling welfare

Welfare is the level of prosperity and quality living standard of either an individual or a group of persons. In the field of economics, it is referred to as utility gained through the achievement of material goods and services.

Welfare is noted as a multidimensional variable and mostly measured in terms of real income, real GDP, (how income and expenditure is distributed through society), intangibles (such as the degree of individual's liberty) and literacy. This study however, will measure welfare as household per capita expenditure which is limited compared to the broad dimension of welfare as described above. Following the works of Donkoh (2006), the dimension of welfare in this study goes beyond the levels of income, thus factors influencing people's standards of living should be an issue of concern in measuring welfare. Grootaert (1997) also established that poverty is a function of household endowment (consisting of human and physical capital), where human capital entails members of household and their ability to manage scarce resources (example; age, sex and education). Physical capital on the other hand, includes value of durable assets and land.

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In this study the household consumption (household expenditure) approach of estimating welfare was used.

In this approach, the relationship between the total per capita consumption and the explanatory variables is likely to be nonlinear, therefore a log transformation of consumption is often used, hence the welfare function takes the form;

$$\ln C_i = w_i \gamma + e_{3i} \qquad 3.5$$

where $\ln C_i$ is the natural logarithm of .real per capita consumption expenditure of household i, w_i is a set of household and community characteristics affects consumption expenditure, e_{3i} is a normally distributed random term with mean zero and constant variance.

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As indicated in chapter two, welfare is a measure of living standards that define the poverty level of an individual within a specific society, hence using consumption expenditure is more appropriate than income. Aigbokhan (2000) established that the use of income is more problematic as compared to the use of expenditure, since people turn to under report their incomes. Also the use of cash income as sole indicator of a household's income, underestimates the welfare of a household (Oladeebo, 2012). This study will therefore measure household's welfare using total per capita expenditure of the household as consumption expenditure, which includes consumption value of goods and services goods and loans.

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The unit of analysis is the household. The GSS poverty lines are used to categorize households into poor, extremely poor and non-poor based on their per capita consumption expenditure on food and non-food items in this study. Welfare is computed as household per capita consumption divided by the Greater Accra (1999) price index augmented by Ghana's equivalence scale. Households with welfare above the upper poverty line (GHC 1,314), are considered rich and those below the upper poverty line but above the lower poverty line (GHC 792.05) are poor while those below the lower poverty line are extremely poor.

3.9: Modeling the Relationship between Farm Size and Welfare

Some farm size studies express farm size as a function of several other factors which can be estimated in a single equation. But the problem with the single equation estimation is that farm size is assumed to be exogenous, yet farm size is not truly exogenous; while farm size determines households' welfare, it is determined itself by other variables including welfare. This means that estimating a single equation and making farm size exogenous would lead to simultaneous bias (Koutsioyannis, 1977; Gujarati, 2004). Hence the appropriate model should be a simultaneous equation involving two equations; farm size and welfare. The most appropriate estimator for a simultaneous equation model involving these two equations is the three stage least squares (3SLS).

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3.7: The Three Stage Least Square

The 3SLS is a special case of the least square regression which consists of three stage estimation of a set of equations. The study introduced the concept of reverse causality among farm size and welfare and in this, the dependent variables (farm size, technical efficiency and welfare) are endogenous; that is they influence one other in a simultaneous equation system. The estimation of the parameters using OLS will result in bias, inconsistent and inefficient estimators. This is because the dependent variables in the model are non-stochastic.

Gujarati (2004) established that estimating single equations with one or more explanatory variables that are endogenous will lead to a case of simultaneous equation bias. Thus to estimate the effects of the endogenous variables, which is the objective of the study (to estimate the effect of welfare, farm size and technical efficiency on one other), this study used the three stage least square to address the endogeneity problem described above. However due to the composed error term of the stochastic frontier model, the study estimated the stochastic frontier model separately and the farm size and welfare model were estimated in the three stage equation. Mathematically, the structural equation of the 3SLS is given as:

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$$y_1 = b_{12}y_2 + \gamma_{11}\chi_1 + \gamma_{12}\chi_2 + ...+ \gamma_{1i}\chi_i + u_1 \qquad 3.6$$

$$y_2 = b_{22}y_1 + \gamma_{21}\chi_1 + \gamma_{22}\chi_2 + ...+ \gamma_{2i}\chi_i + u_2 \qquad 3.7$$

where y_1, and y_2 are endogenous variables; $\chi's$ are predetermined variables; $b's$ are coefficients of the endogenous variables and $\gamma's$ are coefficients of predetermined variables; $u's$ are the random terms with zero mean, constant variance and zero covariance, but non-zero covariance between the $y's$ and the $u's$. The reduced form of the structural model is obtained by solving the structural equations simultaneously as follows:

Substituting Equation 3.7 into 3.6, we obtain:

$$y_1 = b_{12}(b_{22}y_1 + \gamma_{21}x_1 + \gamma_{22}x_2 + ...+ \gamma_{2i}x_i + u_2) + \gamma_{11}x_1 + \gamma_{12}x_2 + ...+ \gamma_{1i}x_i + u_1 \qquad 3.8$$

$$y_1 = \frac{1}{(1 - b_{12}b_{22})}\left[b_{12}(\gamma_{21}x_1 + \gamma_{22}x_2 + ...+ \gamma_{2i}x_i + u_2) + \gamma_{11}x_1 + \gamma_{12}x_2 + ...+ \gamma_{1i}x_i + u_1\right] \qquad 3.9$$

Thus,

$$y_1 = \pi_{11}x_1 + \pi_{12}x_2 + \pi_{13}x_3 + ...+ \pi_{1i}x_i + v_2 \qquad 3.10$$

where

$$\pi_{11} = \frac{b_{12}\gamma_{21} + \gamma_{11}}{(1 - b_{12}b_{22})};\ \pi_{12} = \frac{b_{12}\gamma_{22} + \gamma_{12}}{(1 - b_{12}b_{22})};\ \pi_{1i} = \frac{b_{12}\gamma_{2i} + \gamma_{1i}}{(1 - b_{12}b_{22})} \text{ and } v_1 = \frac{b_{12}u_1}{(1 - b_{12}b_{22})} \qquad 3.11$$

Similarly, substituting equation 3.6 into 3.7, we obtain

$$y_2 = b_{22}(b_{12}y_2 + \gamma_{11}x_1 + \gamma_{12}x_2 + ...+ \gamma_{1i}x_i + u_1) + \gamma_{21}x_1 + \gamma_{22}x_2 + ...+ \gamma_{2i}x_i + u_2$$

$$y_2 = \frac{1}{(1 - b_{12}b_{22})}\left[b_{22}(\gamma_{11}x_1 + \gamma_{12}x_2 + ...+ \gamma_{1i}x_i + u_1) + \gamma_{21}x_1 + \gamma_{22}x_2 + ...+ \gamma_{2i}x_i + u_2\right] \qquad 3.12$$

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The reduce form is expressed as

$$y_2 = \pi_{21}x_1 + \pi_{22}x_2 + \pi_{23}x_3 + \ldots + \pi_{2i}x_i + v_2 \qquad 3.13$$

Where

$$\pi_{21} = \frac{b_{22}\gamma_{11} + \gamma_{21}}{(1 - b_{12}b_{22})};\ \pi_{12} = \frac{b_{22}\gamma_{12} + \gamma_{22}}{(1 - b_{12}b_{22})};\ \pi_{1i} = \frac{b_{22}\gamma_{1i} + \gamma_{2i}}{(1 - b_{12}b_{22})} \text{ and } v_2 = \frac{b_{22}u_2}{(1 - b_{12}b_{22})} \qquad 3.14$$

Thus, the reduced forms of the structural model for the two endogenous variables are:

$$y_1 = \pi_{11}\chi_1 + \pi_{12}\chi_2 + \pi_{13}\chi_3 + \ldots + \pi_{1i}\chi_i + v_1 \qquad 3.15$$

$$y_2 = \pi_{21}\chi_1 + \pi_{22}\chi_2 + \pi_{23}\chi_3 + \ldots + \pi_{2i}\chi_i + v_2 \qquad 3.16$$

From the equation above it can be observed that $y's$ and $u's$ are correlated. This implies that estimating the equation with the OLS will produce inconsistent coefficients thus the need to use the three stage least square.

To apply the 3SLS, the reduced form equations were estimated using the 2SLS to obtain estimates of π 's. The results obtained from estimating these equations (3.8 and 3.9) were a set of estimated values of the endogenous variables $\hat{y}_1$ and $\hat{y}_2$. In the next stage (stage 2), the estimated endogenous variables ($\hat{y}_1$ and $\hat{y}_2$) were substituted into the structural equations 3.15 and 3.16 to produce the transformed equations as;

$$y_1 = b_{12}\hat{y}_2 + \gamma_{11}\chi_1 + \gamma_{12}\chi_2 \ldots \gamma_{1i}\chi_i + u_1^* \qquad 3.17$$

$$y_2 = b_{22}\hat{y}_1 + \gamma_{21}\chi_1 + \gamma_{22}\chi_2 \ldots \gamma_{2i}\chi_i + u_2^* \qquad 3.18$$

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where $u_1^* = u_1 + b_{22} v_2$; $u_2^* = u_2 + b_{12} v_1$

Solving the transformed equations (3.17 and 3.18) using the 2SLS will yield the 3SLS estimates of the structural parameters.

3.7.1: Empirical Model of the 3SLS

From the theoretical discussion in the previous section, the empirical model for this study consists of two main equations; welfare and farm size equations as specified below. It must be noted that to obtain unbiased estimates from the structural equations, both equations must satisfy the order and rank conditions. Identification in a system of structural equations also ensures that there is sufficient information to consistently estimate the structural parameters of interest in the models. The identification process requires that the number of exogenous variables omitted from a particular equation must equal or greater than the number of endogenous variables less one (Kumar, 2009; Gujarati, 2004). Since we have two structural equations with two endogenous variables, we necessarily require at least one exogenous variable (with a non-zero coefficient) not appearing in either equation respectively; this is termed as the exclusion restriction principle or rank condition for identification (Wooldridge, 2012).

If a structural equation satisfies the rank condition, then it is both necessary and sufficient for the parameters to be consistently estimated. We consider a number of farmer and farm-specific variables to identify the two equations. We also include three control variables and with the identifying and control variables established, the empirical structural models are expressed as follows:

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Farm size

$$\begin{aligned} farmsize = {} & \delta_0 + \delta_1 welfare + \delta_2 Age\_hd + \delta_3 sex + \delta_4 hhsize + \delta_5 loc + \delta_6 off\ farm + \delta_7 extsn + \\ & \delta_8 credit + \delta_9 farm\_eqmt + \delta_{10} dist + \delta_{11} crop\exp + \delta_{12} output + \delta_{13} land\_own + \\ & \delta_{14} hiredlab + \delta_{15} hhlab + u_1 \end{aligned} \qquad 3.19$$

Welfare

$$\begin{aligned} welfare = {} & \alpha_0 + \alpha_1 farmsize + \alpha_2 Age\_hd + \alpha_3 hhsize + \alpha_4 sex + a_5 loc + a_6 dist + \alpha_7 marital\_st + \\ & \alpha_8 edu + asset + \alpha_9 off\ farm + \alpha_{10} land\_own + \alpha_{11} credit + \alpha_{12} partcop + \\ & a_{13} extsion + a_{14} output + a_{15} farm\_eqmt + a_{16} vehicle\_own + u_2 \end{aligned} \qquad 3.20$$

The description and *a priori* expectation of the variables are given in table 3.4

Table 3.2: Measurement of Variable

Variables	**Description**	***a prior* Expectation for Farm size**	***a prior* Expectation for Welfare**
Sex of household head	Dummy variable; 1 if head is male and 0 if otherwise	+/-	+/-
Age of household head	The total number of years from birth of a farmer	+	+
Age squared	age multiplied by itself	-	-
Education of household head	The total number of years a farmer had spent in formal education.	+	
Marital status of household head	Dummy; 1 if head is married, 0 otherwise	+/-	+/-
Household size	The total number of members in a farmer's house that cook from the same pot.	+	-

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Ownership of land	Dummy; 1 if household own land; 0 if otherwise	+/-	+/-
Vehicle	Dummy; 1 if a household owns a commercial vehicle, 0 if otherwise	+/-	+/-
Ownership of durable assets	Total value in millions of Ghana Cedis of household durable assets	+/-	+/-
Locality	Dummy; 1 if household lives in urban center and 0 if otherwise	+/-	+/-
Regional distance	Distance in kilometers from Accra (the national capital) to the capital of the region in which a household lives		-
Welfare	Household total per capita expenditure divided by the product of Accra price index and the national equivalence scale	+	
Ownership of farm equipment	Dummy; 1 if household own farm equipment; 0 if otherwise	+/-	
Household labour	Total number of labour (women and men) from household	+	
Hired labor	Total amount of money (Ghana Cedis) spent on hired labour	-	
Off farm work	It takes a value of 1 for households who are engaged in off-farm activities and 0 for those who did not.	+/-	+/-
Access to credit	1 if household has access to credit and 0 if other wise	+/-	+/-

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Participation of cooperation	1 if household head belongs to a cooperative and 0 if other wise	+/-	+/-
Access to extension service	1 if household has access to extension service and 0 if other wise	+/-	
Farm size	The total number of acres cultivated by a farmer		+

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3.8: Estimating Technical Efficiency

This study involves the estimation of a stochastic frontier which aids in the analysis of technical efficiency levels and determinants. The estimation of efficiency is paramount to production theory in that, its helps in the judicious and sustainable use of the existing scarce resources. As indicated earlier, efficiency is decomposed into two, technical and allocative efficiency; the product gives economic efficiency. Technical inefficiency arises when actual or observed output from a given input mix is less than the maximum possible and allocative inefficiency occurs when farmers do not equalize marginal returns with true factor market prices. The focus of this study is technical efficiency, which measures how farmers can maximize output from a given set of inputs (Kumbhakar and Lovell, 2000). The stochastic frontier model is widely preferred due to its ability to isolate the sources of inefficiency into two, the random and nonrandom sources. (Reinhard et al, 2000). It is expressed as

$$Y_t = \beta_0 + X_i\beta + v_i - u_i \qquad 3.21$$

where Y_i is the log of output and X_i is a $(1 \times m)$ vector of input quantities, β is a $(m \times 1)$ vector of parameters that are to be estimated. The error term is decomposed into a two-sided random error that captures the random effects outside the control of the firm (the decision making unit) and the one-sided efficiency component, u_i, which is a non-negative random variable associated with technical inefficiency. It implies;

$$\varepsilon_j = u_j + v_j \qquad 3.22$$

where U_j is technical inefficiency, given by;

$$U_j = Z\delta \qquad 3.23$$

Z = Observable characteristics and δ = parameters to be estimated

Battese and Coelli (1993) defined technical efficiency as the ratio of output obtained by a farm in comparison to the output of best producing (frontier) farm that is using the same technology (from equation 4) and it is mathematically expressed as;

$$TE = \frac{Y_i}{Y_{i*}} = \frac{f(X_i;\beta)\exp(v_i - u_i)}{f(X_i;\beta)\exp v_i} = \exp(-u_i) \qquad 3.24$$

where the numerator is the frontier output and the denominator is the observed output of the farm.

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The value of technical efficiency falls within the range of zero and one. Thus a firm that operates on the frontier has a TE value of one. But if the firm's TE falls below one, there is a difference between the actual and desired output. This gap is therefore referred to as technical inefficiency (Battese et al, 1996). Equation 3.21 can be expressed in various forms, but the most common ones are the translog and the Cobb-Douglass function.

This study is limited to technical efficiency estimation due to in adequate input and output prices information which are important components of allocative efficiency estimation. The Battese and Coelli's (1993 and 1995) simultaneous estimation procedure, using the translog function was used. The translog functional form places very little restrictions before estimation compared to the Cobb-Douglas, or Constant Elasticity of Substitution (CES) technologies. Its ability to deduce future effects from present factors and also explaining the possibility of factor substitutability. Nonetheless, the choice of the functional form would be based on a likelihood ratio test.

According to Kumbhakar (1989), the translog function for k number of inputs is specified as

$$\ln Y = a + \sum_{k=1}^{k} \beta_k \ln + \tfrac{1}{2} \sum_{k=1}^{k} \sum_{m=1}^{k} \gamma_{km} \ln X_k \ln X_m \qquad 3.25$$

Where k=5 in this study and it includes land, household labour, hired labour, crop expenditure and capital.

To assume the specifications of the stochastic frontier appropriate to fit the data, this study performed the following test:

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(1) a. $H_0 : \beta_{ij} = 0$; the Cobb-Douglas is the appropriate functional form.

b. $H_i : \beta_{ij} \neq 0$;the Cobb-Douglas is not the appropriate functional form.

(2) a. $H_0 : \gamma = 0$; there is no inefficiency effect in the model.

b. $H_1 : \gamma \neq 0$; there is inefficiency effect in the model

(3) a. $H_0 : \gamma = \delta_0 = \delta_1 .. \delta_n = 0$; the inefficiency effects are not stochastic.

b. $H_1 : \gamma = \delta_0 = \delta_1 .. \delta_n \neq 0$; the inefficiency effects are stochastic.

The generalized likelihood ratio test to be used for testing the above hypothesis and is expressed as;

$$\lambda = -2\{\ln[L(H_0)] - \ln[L(H_1)]\} \qquad 3.26$$

where $L(H_0)$ and $L(H_1)$ are the likelihood functions under null and alternate hypotheses respectively. If the given null hypothesis is true, then the test statistic λ has a chi-square distribution of degree of freedom, which is equal to the difference between the estimated parameters under $L(H_0)$ and $L(H_1)$. However, if the null hypothesis involves 0, then the asymptotic distribution includes a mixed chi-square distribution

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Using the maximum likelihood estimation, the study performed following test to justify the inclusion of farm size in the inefficiency model.

1. Model1; farm size is included in both parts of the model
2. Model2; farm size is included in the first part of the model
3. Model3; farm size is included in the second part of the model

The model the lowest AIC value would be the preferred model for the study.

3.8.1: Empirical model for technical efficiency

Following Coelli et al. (1998) and Battesse (1992), the stochastic frontier model of the study is given as:

$$\ln Y = \beta_0 + \sum_{j=1}^{5} \beta_j \ln X_{ji} + \frac{1}{2}\sum_{j\geq}^{5}\sum_{k=1}^{5} \beta_{jk} \ln X_{ji} + \ln X_{ki} + V_i - U_i \qquad 3.27$$

where

$\ln Y$ is a scalar of the natural of the value all the crop output produced by farmer,

$\ln X_1$ is the natural log of farm size (total number of land under cultivation),

$\ln X_2$ is the natural log of total number of family labor,

$\ln X_3$ is the natural log of total number of hired labor,

$\ln X_4$ is the natural log of total expenditure on crops (expenditure on weedicides, insecticides, seeds and fertilizer),

$\ln X_5$ is the natural log of depreciated value of farm equipment (capital).

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Table 3.3: Summary of Output Model Variable

Variables	Description	Measurement	*aprior* **Expectation**
Land (χ_1)	Natural log of farm size	Acre	+
Family labour (χ_2)	Natural log of family labor	Number of household members	–
Hired labour (χ_3)	Natural log hired labor wages	Total amount in Ghana cedis spent on hired labour	+
Crop expenditure (χ_4)	Natural log of crop expenditure	Total amount in Ghana cedis spent on crop inputs	+/-
Capital (χ_5)	Natural log of depreciated value of farm equipment	Ghana cedis (million)	+

3.8.2: Empirical Model of Inefficiency

The model for determining the factors that influence the efficiency of Ghanaian crop farmers is defined as;

$$u_j = \delta_0 + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \dots\dots\dots \dots\dots + \delta_n z_n + \varepsilon \qquad 3.28$$

where the variables are as defined u_j is the inefficiency term as described earlier on.

Table 3.4 is a summary of the inefficiency effect variables

Table 3.4: Summary of Inefficiency Variables

Variables	**Measurement**	***A priori* expectation**
Sex of household head (z_1)	Dummy variable; 1 if head is male and 0 if female	+/-
Age of household head (z_2)	Number of years	+
Age squared (Z_3)	Number of years squared	+
Education of household head (z_4)	Number of years of formal education	+/-
Marital status of household head (z_5)	Dummy; 1 if head is married, 0 otherwise	+
Household size (z_6)	Number of members in the household cooking from the same pot.	+/-
Off farm work (z_7)	1 if head of household has off activity and 0 if otherwise	+
land ownership (z_8)	Dummy; 1 if household owns land and 0 if otherwise	+
Credit access (z_9)	1 if household had access to credit 0 if otherwise	+
Extension service (z_{10})	1 if household received extension service and 0 if otherwise	+
Farm size (z_{11})	Number of land (acre) under cultivation.	-

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CHAPTER FOUR

RESULTS AND DISCUSSION

4.1: Chapter Outline

This chapter is a presentation of analysis and discussion of the findings on the data. The chapter is organized into five section; the first section 4.1 presents an outline of the chapter, section 4.2 presents the descriptive statistics of the variables of interest, section 4.3 provides results of the technical efficiency analysis and the hypotheses and section (4.4 and 4.5) presents the three stage analysis results.

4.2 Demographic and Socioeconomic Description of Farmers

4.2.1: Descriptive Statistics

The Tables in this section present the descriptive statistics of the socioeconomic characteristics of farming households in Ghana.

Table 4.1 shows the statistical summary for the sampled crop farming households in Ghana. On average, a typical crop farmer in Ghana is 49 years old and spends about 7 years in education. The average household size for these farmers is approximately 5 members while the average crop farming household cultivates 10.55acres of land.

4.2.2: Statistical Summary of Dummy Variables

Table 4.2 shows that farming households in Ghana are mostly rural dwellers and crop production in this region is dominated by male headed households (80.49%). This is not surprising because the nature of farming is strenuous for female farmers. Most of these farmers (70.8) are married. The majority (56.9%) of these farmers work full-time on their farms, while only few of them (18.34%) have membership of farmer cooperation. The table also reveal that only 16.71% and 38.96% of the farmers have access to credit and extension services, respectively. Most of the farming households (65.15%) and (62.64%) own lands and farm equipment respectively. However very few farming households (5.82%) own vehicles.

Table 4.1: Distribution of Respondents According to Socio-Economic Characteristics

Variables	Frequency	Percent
Years of education(mean=7.35)		
0 – 5	1,048	41.79
6-10	199	7.93
11-15	1,002	39.95
16 – 20	243	9.69
Above 20	16	0.64
Household size(mean=5.28)		
0 -3	727	28.99
4-6	1,074	42.82
7-9	516	20.57
10-12	121	4.82
Above 12	70	2.79
Age (48.70)		
15 – 30	243	9.69
31 – 45	953	38
46 – 60	787	31.38
61 – 75	355	14.15
Above 75	170	6.78
Farm size (mean= 10.55)		
0 – 8	1,609	64.15
9-16	525	20.93
17 – 24	174	6.94
25 – 32	91	3.63
Above 32	109	4.35

Source: Author's computation from GLSS6

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Table 4.2: Distribution of Respondents According to some Dummied Socio-Economic Characteristics

Variable	Frequency	Percentage
Sex		
Male	2,018	80.49
Female	489	19.51
marital status		
Married	1,775	70.8
Single	732	29.2
Locality		
Urban	463	18.47
Rural	2,044	81.53
credit access		
No	2,088	83.29
Yes	419	16.71
Extension Service		
No	1,531	61.04
Yes	977	38.96
cooperation participation		
No	2,048	81.66
Yes	460	18.34
ownership of Land		
Yes	1,634	65.15
No	874	34.85
ownership of farm equipment		
No	937	37.36
Yes	1,571	62.64
Ownership of vehicle		
No	2,362	94.18
Yes	146	5.82
off farm work		
No	1,427	56.9
Yes	1,081	43.1

Source: Author's computation from GLSS6

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4.2.3: Summary Statistics of Continuous Variables

Table 4.3 presents the summaries of some of the continuous variables used in the analysis. These summaries include the general measures of central tendency such as mean, standard deviations, minimum and maximum values.

The average asset value of farming households in Ghana is GHC 6,688.98 and the average welfare level is also GHC 2,771.23. The average farming household uses about 15.74 of household labour and spends GHC 276.70 and GHC 798.26 on hired labour and crop inputs, respectively. The table also shows that these households generate an average output value of about GHC 199.56 per season. The value of farm equipment owned by the households was very low considering a mean of GHC 80.57.

Table 4.3: Summary Statistics of Continuous Variables

Variable	Mean	Standard Deviation	Minimum value	Maximum value
Output value	199.56	785.46	0.20	25113.00
Hired labor	276.70	494.65	0.50	9000
Household Labor	15.74	25.19	0.00	577.00
Crop expenditure	798.26	1841.32	5.00	62860.00
Depreciated Value of Agric. Equipment.	80.57	778.49	0.00	27114.67
Value of household asset	6688.98	21042.71	0.50	562755
Welfare per capita consumption	2771.23	2898.45	182.11	73834.30

Source: Author's computation from GLSS6

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4.3: Technical efficiency analysis of crop production in Ghana

This section provides empirical results of crop production in Ghana. Specifically, it involves the estimated results of the stochastic frontier discussed in chapter three. It is important to note that the dependent variable in the output model is value of output. From Coelli et al. (1998), if the value of crop output, rather than the physical quantities, are used as the dependent variable, then the efficiency scores are allocative rather than technical efficiency. However, since the independent variables are input quantities, whose prices may not vary much among the farming households, we proceeded with explaining the result as technical efficiency. It must also be noted that farm size was included in the inefficiency function as an independent variable, based on the result in table (4.5), which tested for the significance of including farm size in the inefficiency function.

4.3.1: Tests of Hypotheses

To ascertain the appropriate function, existence or nonexistence of inefficiency and to determine the significance of the socioeconomic variables of Ghanaian farmers on efficiency, three hypotheses were tested in the technical efficiency model. These were as follows: (1) the Cobb-Douglas is the appropriate functional form; (2) there is no inefficiency effect in the model; (3) the inefficiency effects are not stochastic. The test suggested a rejection of all the three hypotheses at 1% significance level since the chi-squared (χ^2) value was 0.000. The testing of model specification for technical inefficiency in Table 4.4, shows that the null hypotheses that the Cobb Douglas function specification is rejected in favor of the translog function. Inefficiency effects were present and stochastic in nature, meaning the variation in production of Ghanaian farmers is due to differences in their practices and personal characteristics rather than random variation. The sigma-square (δ^2) estimate of 1.926 attests to the good fit of the model.

Table 4.4: Testing the Specification of Technical Inefficiency Model

Null Hypothesis	Log-likelihood function (H0)	Test statistic (λ)	Critical value	Decision
$H_0 : \beta_{ij} = 0$	4372.657	39.72	29.93	Reject H_0
$H_0 : \gamma = 0$	4384.063	22.81	21.74	Reject H_0
$H_0 : \gamma = \delta_0 = \delta_1 ... \delta_n$	4384.071	24.80	23.91	Reject H_0

Source author's computation

To test whether farm size variable should be included in the inefficiency function, the maximum likelihood estimation was carried out and the AIC value for the three model computed in table 4.5 suggest a rejection of model 2 and 3 and acceptance of model 1.

Table 4.5: Testing the significance of farm size in the inefficiency function

Model	AIC	Log-Likelihood Function	Number of Parameters	Decision
Model1 (farm size in both parts)	8817.32	-4372.66	12	Accept
Model2 (farm size in first part)	8818.04	-4374.02	11	Reject
Model3 (farm size in second part)	8818.04	-4375.78	12	Reject

Number of observation in each model =2507

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4.3.2 Determinants of Output of Ghanaian Farmers

This section gives a detailed discussion on the estimated results of the stochastic frontier function which consists of the output and inefficiency effects models. The output model includes 20 variables (five conventional inputs: land, capital, crop expenditure, hired and household labour; squared and interactive terms). It should be noted that preceding the estimation, the five inputs values were mean corrected, thus deflated against their means such that the first order coefficients can be interpreted as partial elasticities.

From Table 4.6, ten of the variables were statistically significant and of these, three were first-order terms (land, household labour and crop expenditure), only household labour squared was significant among the squared terms, while the interaction terms were six (crop expenditure *capital, household labour *capital, land * hired labour, land * crop expenditure, household *hired labor and household labor *crop expenditure).

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Table 4.6: The Maximum Likelihood Estimates of the Stochastic Translog Production Frontier for Output

Variables	Coefficients	Standard Error
Constant	2.046	22.99
Land	0.147**	0.160
Household labour	-0.387*	0.199
Hired labour	-0.078	0.093
Crop expenditure	0.833**	0.242
Capital	-0.016	0.062
Land *capital	-0.017	0.011
Crop expenditure *capital	0.029*	0.015
Household labour *capital	-0.029**	0.014
Hired labor *capital	0.004	0.007
Land * household labour	0.044	0.039
Land * hired labour	-0.037**	0.019
Land *crop expenditure	-0.079*	0.043
Household *hired labour	0.054**	0.022
Household labour *crop expenditure	0.092*	0.052
Hired labour *crop expenditure	-0.033	0.026
Capital squared	0.005	0.005
Land squared	0.063	0.045
Household labour squared	0.059***	0.017
Hired labour squared	-0.047	0.051
Crop expenditure squared	-0.108	0.068

***, ** and * represent 1%, 5% and 10% level of significance, respectively.

Log likelihood = -4372.6579; Prob > chi2 = 0.0000; Wald chi2 (20) = 333.5

The squared terms in the translog production function represent the impact of continuous usage of those variables on output. The interaction terms also indicate the substitutability or complementarity of the input variables, thus a significant positive

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coefficient of the interaction terms shows complementarity of the inputs while a negative significant coefficient indicates substitutability. Therefore, positive significant squared coefficients imply monotonicity of input usage, meaning additional units of such inputs will not decrease output. Hence, the positive coefficient of household labour squared implies additional units of household labour will not decrease output.

For the interaction terms, household labour *hired labour, household labour *capital and household labour *crop expenditure interactions had positive coefficients. This means household labour and hired labour; household labour and capital, as well as household labour and crop expenditure are complementary inputs. Thus, employing additional household labour would increase the marginal physical product of hired labour, capital and crop expenditure holding all other inputs constant.

Crop expenditure and capital; land and hired labour as well as land and crop expenditure and household labour and capital also had negative coefficients. This implies that these inputs are substitutes; thus holding all other inputs constant, a Cedi increase in expenditure on crop would lead to a reduction in the marginal physical product of capital. Moreover, an acre increase in land results in reduction of marginal physical product of hired labor and expenditure on crop. A Cedi increase in household labour leads to decrease in the marginal physical product of crop expenditure.

4.3.3: Output Elasticity and Returns to Scale

From table 4.7, the empirical results indicate that the estimated output elasticities of Ghanaian crop farmers with respect to land, household labour, hired labour, crop expenditure and capital are 0.147, -0.387, -0.078, 0.833 and -0.004 respectively at mean input value. The parameter estimates of the production function showed that land, household labour and crop expenditure had a significant influence on the output of farmers. Thus a percentage increase in land and crop expenditure increases the mean output of crop farmers by 0.147% and 0.833% respectively. On the other hand, a percentage increase in household labour would result in 0.387% decrease in mean output.

Return to scale represents a long run phenomenon that deals with the output's responsiveness to proportional changes in all inputs. The summation of the first order coefficients (land, household labour, hired labour crop expenditure and capital) in Table 4.7 gives the returns to scale of crop farmers in Ghana. Therefore, the estimated returns to scale for the study is 0.593, which is less than 1, implying decreasing returns to scale. Thus, a percentage increase in all inputs would result in a less than proportionate (0.593%) increase in mean output. This means that on a whole, farmers are operating below the optimal scale, which could be attributed to the fact that farmers may not be using production inputs judiciously. This could be as a result of farmers' inability to apply good agronomic practice and management on the farms.

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Table 4.7: Output Elasticity and Returns to Scale

Variables	**Coefficients**	**Standard Error**	**Mean**
Land	0.147**	0.714	1.733
Household labor	-0.387*	1.891	4.858
Hired labor	-0.078	0.155	1.874
Crop expenditure	0.833**	4.058	5.983
Capital	-0.004	0.023	1.073
Returns to Scale	0.593		

Source: Authors Computation

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4.3.4 Determinants of Technical inefficiency among Ghanaian Crop Farmers

The conventional inputs discussed in Table 4.6 above shifts the production frontier away or contrasts it. The inefficiency effects variables on the other hand draw farmers to the frontier or move them away from it. Thus, both sets of variables are crucial in the discussion on the determinants of technical efficiency in Ghanaian agriculture. The estimated determinants of technical inefficiency among Ghanaian farmers are presented in Table 4.8 below and the empirical results indicate that technical inefficiency is influenced by the following farmer characteristics; farm size, household size, sex of household head, age, extension service and marital status. A negative sign on a parameter means that the variable decreases technical inefficiency, while a positive sign means that the variable increases technical inefficiency.

Table 4.8: Determinants of Efficiency among Ghanaian Farmers

Variables	Coefficients	Standard Error
Constant	0.816	22.986
Farm size	0.003*	0.002
Household Size	-0.027*	0.010
Sex of Household Head	0.197**	0.086
Age	-0.019*	0.011
Age of Squared	0.000	0.000
Education	-0.022	0.060
Off farm Work	0.010	0.058
Extension Service	0.105*	0.058
Credit Access	0.028	0.076
Land Ownership	0.016	0.061
Marital Status	0.122*	0.074

***, ** and * represent 1%, 5% and 10% level of significance, respectively.

Source: Author's Computation

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Household Size: The estimated coefficient of household size had a negative sign at 10% significance level, indicating that households with larger size are more technically efficient than those with smaller sizes. This could be due to the fact that Ghanaian farmers depend so much on household labour for farm production. This result contradicts that of Danso-Abbeam et al. (2012), who reported a positive relation between household size and technical inefficiency but confirms that of Amos (2007), who found a negative relation between household size and technical inefficiency.

Gender of household head: Gender of household head showed a positive effect on technical inefficiency at 5% significance, indicating households headed by males are less efficient than those headed by females. This is unexpected, since males are associated with much more physical strength and are able to put in more physical efforts in their farms than their female counterparts. However the unexpected result could be attributed to the fact that some women now obtain aids from development agencies all in an attempt to bridge the inequality gap between males and females. This finding support the need for addressing gender bottlenecks in crop production to bridge the gender gap in agricultural production.

Age: At a significance level of 5%, age of a farmer affects technical inefficiency negatively. Thus, households headed by older farmers are more efficient than those headed by younger farmers. Perhaps, the older farmers have more years in farming and experuencde, hence are more efficient. The aged have experience and have connections that enable them to lobby for scarce inputs.

Extension service: Similar to the findings of Adzawla et al. (2015) and contrary to our *apriori* expectation, extension service showed a positive effect at 10% significance on technical inefficiency. This means that farmers who had no access to extension service were more efficient than those who had access. Two possible reasons may explain this finding. Firstly, the farmers might have misapplied lessons from the extension officers and secondly, the advices provided by the extension officers were practically not suitable on the farms. Moreover, farmer might have wasted time (which they could invest on farms) attending such meeting with the extension officers.

Marital status: Marital status was found to have a positive effect on technical inefficiency and was significant at 10% level. It means that households headed by the married are less efficient than their unmarried counterparts. This result however is contrary to the findings of Adzawla et al. (2015). Unlike the unmarried farmers, the married farmers could share responsibilities, hence should be more efficient. But it may be argued that married household heads are unable to do much investments on their farms, since marital status comes with its own household responsibilities.

4.3.4.1: The effect of Farm Size on technical efficiency

This section explores the nature of relationship (direct or inverse) between technical efficiency and farm size.

Considering the tedious nature of Ghanaian agriculture, it did not come as a surprise to find that farmers with small farm size were more technically efficient than those with larger farms. This can also be explained that smaller farm holders use land diligently, which reduces the chances of losing soil fertility level, thus making them

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more productive than their counterparts with larger farms. This finding is consistent with that of Taphee et al. (2014) and Adzawla et al. (2015).

Other literature attribute the increasing land productivity as farm size decreases to the fact that, small farms mostly engage in multiple cropping than large farm. Multiple cropping however has an increasing effect on the total output value of given land area (Ellis, 1993).

Other contributing factor to the inverse relation between technical efficiency and farm size is, smaller farms tend to utilize labour intensively than larger farms. However, high labour intensity promotes factors like the amount of multiple cropping that can be done on small farms.

In the analysis, land size remains a key variable explaining differentiation in output, especially to keep farmers near to or on the frontier. It must be noted that the superiority of efficiency of smaller farm solely depends on the intensity of land utilization and not the difference in yield per farm size.

Increasing farm size is however likely to have contributed to technical inefficiencies. This result seem to favour Ghanaian agriculture, considering the fact that agriculture in this region is challenged by numerous factors including population pressure, land fragmentation due to conflicts and inheritance and dominance of smallholders farmers.

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4.3.5: Technical Efficiency Distribution of Ghanaian Crop Farmers

The technical efficiency scores shown in Table 4.10 below revealed a maximum of 83%, minimum of 7% and a mean of 50%. The results in figure 4.1 and 4.2 presents efficiency scores by frequencies and efficiency scores by percentages respectively. Figure 4.2 reveals that the most efficient farmers operate 17% below the frontier and the least efficient farmer operates at 93% below the frontier. About 91% of the farmers have efficiency scores between 40% and 61%.

Table 4.9 presents the central tendencies of efficiency score by percentages. The mean efficiency score is an indication that, on the average Ghanaian crop farmers were only halfway into full efficiency. In other words, crop output could be increased by 50% (half of current output) without an additional input usage. Although most studies estimated mean efficiency above 70%. Adzawla et al. (2015) for instance estimated mean efficiency of 83% among selected farmers in the three northern region), other studies also estimated mean scores around 50%. For instance, Danso-Abeam et al. (2012) in the Western region estimated mean efficiency score of 49.04% while Essilfie et al. (2011) estimated a mean efficiency of 58% for selected farmers in the Central region.

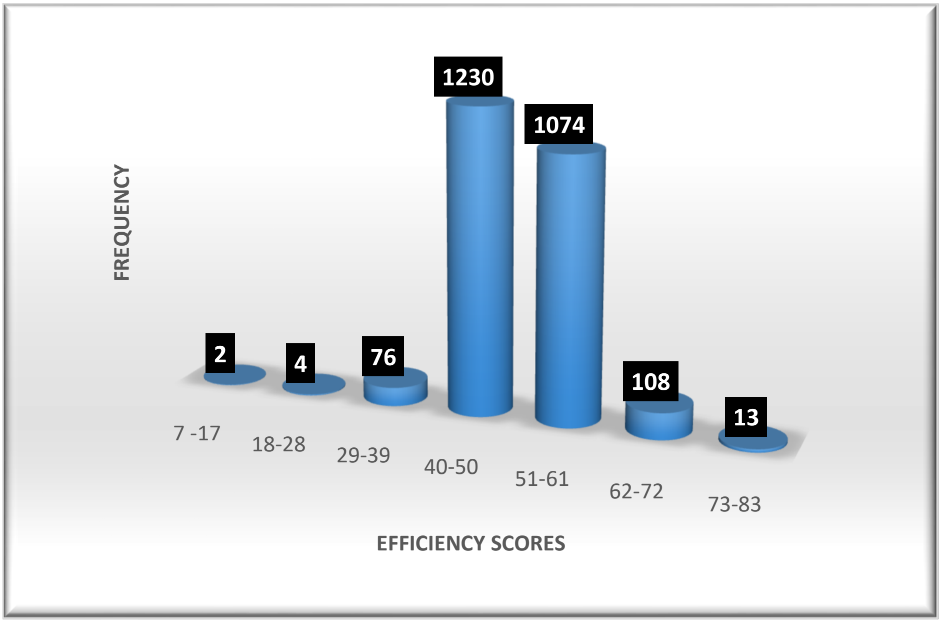

Figure 4.1: Technical Efficiency Scores by Frequency

Source: Author's Computation

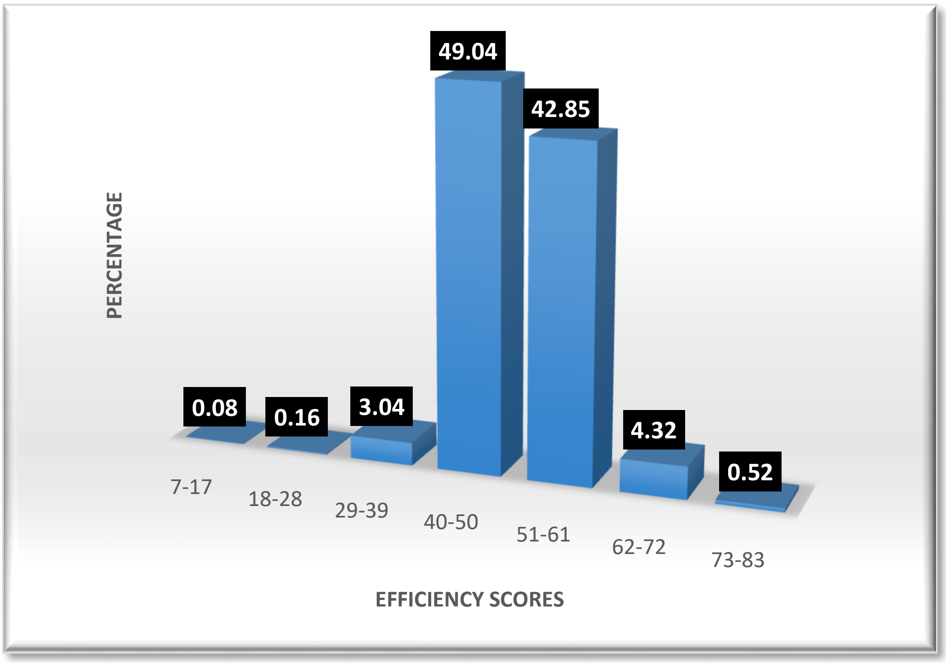

Figure 4.2: Technical Efficiency Scores by Percentage

Source: Author's Computation

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Table 4.9: Statistical Summary of Efficiency Scores

Central Tendency	Percentage
Mean	50%
Minimum	7%
Maximum	83%

Source: Author's Computation

4.4: Welfare Analysis of Agricultural Households in Ghana

This section provide the empirical results on the distribution of welfare or poverty among the households and the factors (including farm size) influencing household welfare. These provides policy relevant options on how to improve welfare among farming households in Ghana.

4.4.1: Poverty Distribution of Household Head

Results from figure 4.3 reveal that poverty was more pronounced among farming households in Ghana, as more than half (53%) of households were found to be poor and 24% had per capital consumption expenditure below the upper poverty line. A very small percentage (23) fell within the non-poor category. The estimated poverty levels in the study outweighs the national poverty level of 24.2%, reported by GSS (2014).Poverty is more predominant among farming households. This confirms farmers' vulnerability status and the need to deliberately include farmers in developmental issues.

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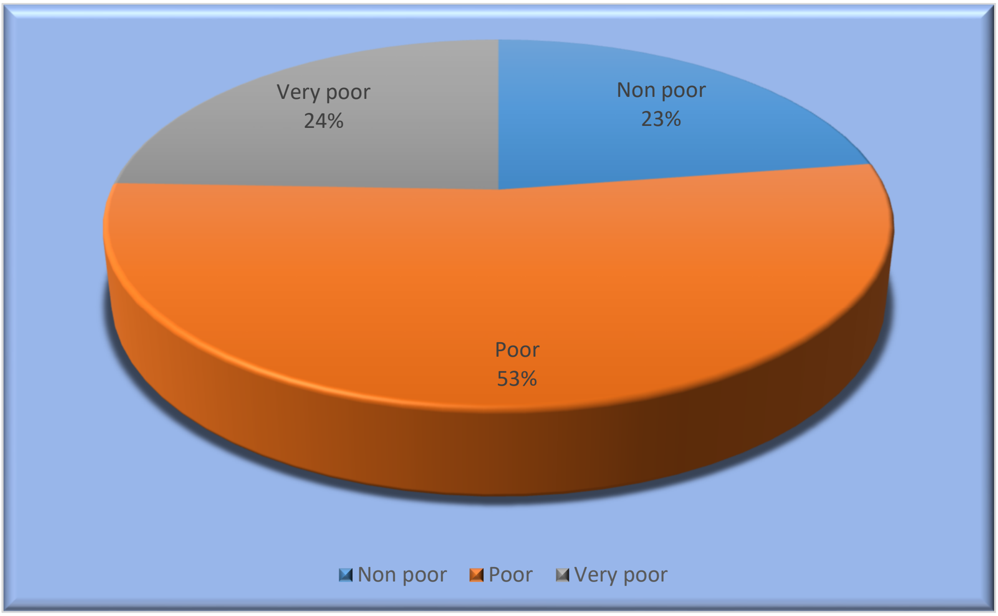

Figure 4.3: Distribution of Poverty Status among Households

Source: Extract from GLSS6

4.4.2: Poverty Distribution by Ecological Zone

Agricultural households are distributed based on three agro-ecological zones as coastal, forest and savannah zones. Expectedly, there are more farmers in the forest zone followed by the savannah and the coastal zones. However, poverty was high among (37.6%) household in the savannah zone followed by the forest zone (17.2%) and the coastal zone (7.2%) as shown in Table 4.11 below. Generally, the savannah zone covers the three northern regions of Ghana where poverty levels are historically high (Cooke et al, 2016 and CARE International et al, 2012).

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Table 4.11: Poverty Status by Ecological Zone of Farmers

	Non poor		Poor		Very poor		Total	
Ecological zone	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Coastal	120	90.2	10	7.5	3	2.3	133	100.0
Forest	1,191	82.8	200	13.9	48	3.3	1,439	100.0
Savannah	584	62.4	210	22.4	142	15.2	936	100.0
Pooled	1895	75.6	420	16.7	193	7.7	2508	100.0

Source: Extract from GLSS6

4.4.3: The Effect of Farm Size on Household's Welfare

Results from the maximum likelihood estimation of the stochastic translog production frontier shows that small farms are technically efficient than large farms. But efficiency is not an end in itself but a means to an end of increasing households' welfare. It is against this background that research and policy are geared towards poverty reduction. In this section as shown in Table 4.12 below, the analysis of the effect of farm size on households' welfare is provided. It is important to recall from chapter three that the endogeneity of farm size in the welfare model, and vice versa, has been resolved using the 3SLS. The goodness of fit for the estimated models as indicated by the Wald Chi-square tests were significantly different from zero. Thus, the explanatory variables jointly explained the variations in the dependent variables (welfare and farm size). However, the welfare equation generated a relatively high adjusted R-squared (34.4%) compared to the farm size model (28.5%).

Under the 3SLS model, positive parameters of continuous independent variables represent increasing effect on the dependent variables, while negative parameters indicate decreasing effects. The coefficients of the continuous variables also represent elasticities since these variables were log transformed before estimation. With reference to dummy variables, a positive parameter shows the increasing effect of the dummy coded one and negative represents the decreasing effects of the dummy coded zero.

The regression result in Table 4.12 below shows that there exists a strong positive relation between farm size and welfare which confirms the theoretical relationship. Farm size was found to influence welfare positively, while welfare had a positive effect on farm size. This implies that increasing farm size by an acre, increases the welfare of a household by 0.153, thus Ghanaian large scale farmers are richer than small scale farmers. On the other hand, a Cedi increase in welfare leads to 0.576acres increase in farm size. Thus large scale farmers are richer than small scale farmers, implying that richer farmers are able to own larger farms than poorer farmer

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Table 4.12: The Three Stage Estimates for Farm Size and Welfare

	Farm Size		Welfare	
Variables	**Coefficients**	**Standard Error**	**Coefficients**	**Standard Error**
Constant	-4.885*	1.007	8.179*	0.118
Sex of Household Head	-0.399*	0.050	0.110**	0.037
Age	0.004**	0.001	-0.001***	0.001
Household Size	0.102*	0.013	-0.111*	0.004
Locality	0.174**	0.056	-0.199*	0.032
Education			-0.001	0.002
Extension Service	-0.042	0.040	-0.004	0.025
Credit Access	-0.058	0.054	0.130*	0.031
Land Ownership			-0.150*	0.026
Marital Status			-0.053***	0.027
Welfare	0.576*	0.116		
household labor	0.232*	0.018		
hired labor	0.080*	0.011		
Off farm	-0.119**	0.039	0.065**	0.024
Participation cooperative			0.076**	0.027
Ownership equipment	0.236*	0.036		
ownership of vehicle			0.278*	0.046
Durable asset			0.066*	0.007
Distance	0.001*	0.000	-0.001*	0.000
farm size			0.153*	0.030
Wald chi2	1133.260		1331.930	
Adjusted R-squared	0.285		0.344	

***, ** and * represent 1%, 5% and 10% level of significance, respectively.

4.4.4: Other Factors Influencing Households' Welfare

With regards to the welfare function, most of the variables met their *apriori* expectations. The significant variables were age, sex, marital status, household size, locality, credit access, off farm work, cooperative participation, vehicle ownership, durable asset, land ownership and distance. The specific effect of each variable is provided below.

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***Age*:** The estimated coefficient of Age had a significant negative effect on welfare. This result implies that households headed by the old are less wealthy as compared to those headed by young counterparts, which is inconsistent with Ukoha et al.(2007) who observed a positive relation between farmers' welfare and age. This could be argued that old age is associated with lack of physical strength to undertake economic activities especially those that require a lot of physical strength, which leads to a reduction in their income earning ability.

***Gender of household head*:** The positive effect of gender of household head on welfare at a significance level of 5%, does not come as a surprise in the sense that structures in the Ghanaian society permit males to have greater access and control over resources especially lands, which is an essential income earning resource.

***Marital status*:** The estimated coefficient of marital status shows a negative effect, meaning households headed by the unmarried are better off than married ones. Although the overall welfare for crop farmers in the study is very low, figure 4.4, 4.5 and 4.6 confirm that unmarried household heads are richer than married heads. The result contradicts our *apriori* expectation. It was expected that households with married heads would be richer than the unmarried, due to a combination of factors, including combination of resources (asset and income), Couples have the advantage of division of responsibility in terms of household activities, which allows them to work overtime on their job to earn more income.

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Welfare Distribution by Marital Status

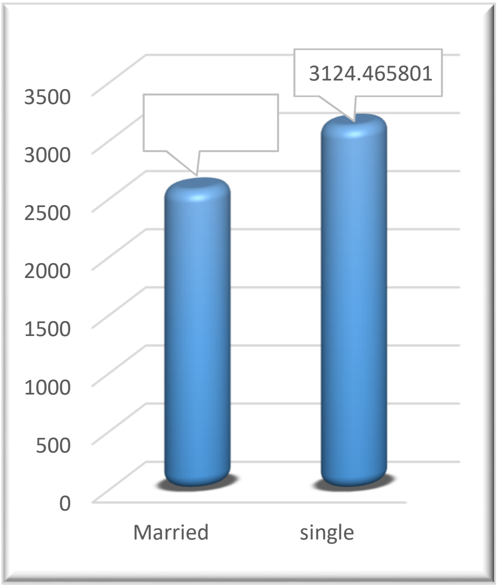

Fig 4.4 Average Welfare Distribution

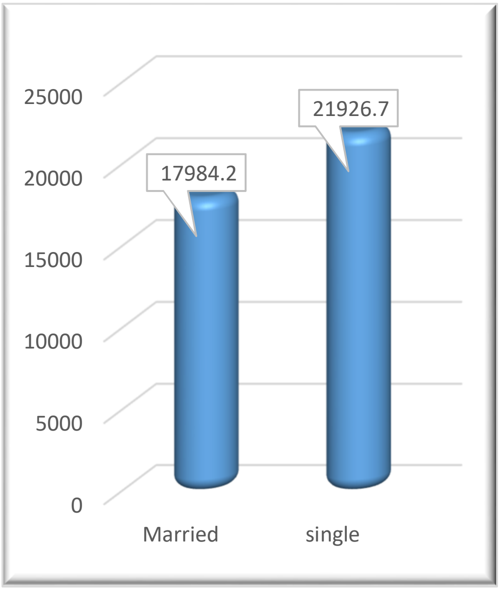

Fig 4.5: Maximum Welfare Distribution

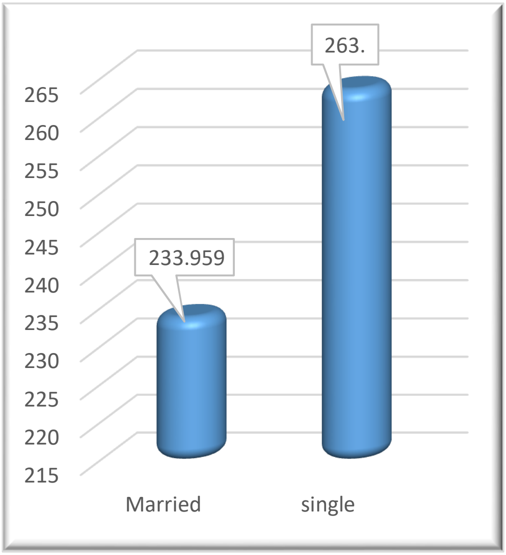

Fig 4.6: Minimum Welfare Distribution

Household Size: The coefficient of household size was negative and significant. This is an indication that as the size of the household increases, their welfare decreases since a larger number of household members puts pressure on households' resources

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or assets. This makes it more difficult for the household to meet their basic requirements such as education for their children, proper nutrition, and adequate housing, all of which tend to reinforce poverty. This finding confirms that of Gardiner et al. (2006) and Ukoha et al. (2007) who observed that larger families have higher poverty rates (lower welfare).

Credit Access: Credit access had a significantly positive influence on household's welfare. Thus, households with access to credit are wealthier than households without access to credit facilities. It can be argued that having access to credit facilities increases the capital and income generated by farm household which goes a long way to improve households' consumption expenditure. The result is consistent with that of Chigozie (2012) who observed that access to credit has a positive influence on household's welfare. Zeller (2001) also found access to credit to be a positive influencing factor on household welfare.

Off farm work: Off farm work had a positive impact on the welfare of households and significant at 5%. Off farm work is a form of diversification which reduces household's risks and enhances income mobilization. Some portions of off farm incomes are reinvested into farm activities to enhance farm incomes and improve household welfare. This is not an isolated finding, as Osarfo et al. (2016) also found that engaging in off farm activities leads to improved income and food security. Similarly, Katera (2013) argued that poorer households offer labour for off farm activities to complement low farm incomes.

Ownership of Vehicle: Ownership of vehicle positively influenced households' welfare, implying that households who own commercial vehicles are better off than

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their counterparts who do not own any. The reason is that these vehicles provide households with extra income, thus increasing their wealth and their standard of living. Among farm households, ownership of vehicle enhances farmers' ability to cart their goods timely and also transport them to markets where prices may be relatively high. On their part, Gurley et al. (2005) observed that vehicle ownership increases accessibility to a vehicle which intend increases the chances of finding jobs (well-paid), since vehicle could easily be used for commercial purposes and getting a well-paid job increases the wealth of individuals, other things being equal.

Durable Asset: Durable asset of a household had a positive influence on the household welfare at a significance level of 10%. This is due to the fact that in the Ghanaian setting, the acquisition and ownership of (durable) assets is an indication of wealth. This result is consistent with the findings in Donkoh (2011).

Locality: At a significant level of 10%, locality affected welfare negatively. The implication is that households located in rural areas are less wealthy than those located within urban areas. This is so because urban areas present households with more income earning opportunities than the rural areas, where there are very few options aside farming.

Distance: Distance had a negative significant impact on households' welfare. This implies that as households settle in a location away from the national capital, their welfare reduces. Proximity to the national capital presents so many opportunities (well paid jobs, diverse occupation and easy access to facilities that promotes well-being). This is in conformity with Ofori (2002), who revealed that households living closer to the southern part of Ghana have a higher standard of living than those in the

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north. Generally, southern Ghana is more developed than northern Ghana and this have negative implications on the welfare status of communities and households located in the north. Unsurprisingly, poverty levels in the three northern regions (most farthest from Accra) are higher than other regions (GSS, 2014).

Participation Cooperative: Membership of cooperative bodies had positive and significant effect on welfare, implying that farmers belonging to cooperative group(s) are wealthier than those who do not belong to a cooperative body. The result does not seem surprising, since membership of a cooperative body is a social capital serving as collateral and providing welfare enhancing assistance to members.

Land ownership**:** A negative relation exists between land ownership and welfare at 10% significance. Figure 4.7 and 4.8, indicate that households without land ownership rights have higher per capita consumption as compared to those with land ownership rights. This is unexpected considering the fact that those with land ownership right gain income earnings from sales or rental of land and collateral for credit facilities.

Distribution of welfare by land ownership status

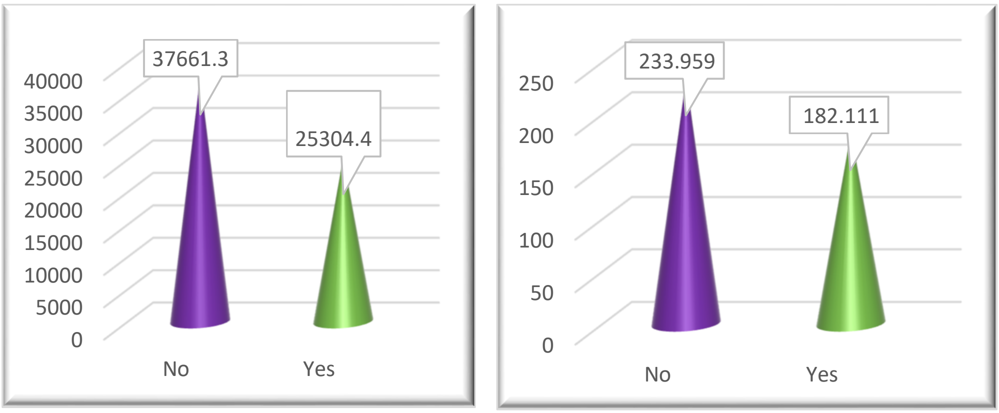

Fig4.7: Maximum welfare distribution **Fig 4.8: Mnimum welfare distribution**

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4.4.5: Determinants of Farm Size

In the previous section, we examined the effect farm size on welfare, however, the former is also an endogenous variable which is influenced by a set of factors, including welfare. In this section however, the influence of these factors on farm size are discussed. From Table 4.13, the variables that were significant in explaining variations in farm size were sex of household head, age, household size, household labour, hired labour, off farm, ownership equipment, locality and distance.

Gender of household head: There was a negative relationship between the gender of household head and the size of farm they cultivate. This implies that on average, households headed by females, have smaller farm holdings than their male. This result is not surprising, since male farmers have greater physical capacity to expand farm lands than female farmers. Male farmers also have more access to productive resources like land than female farmers in most developing countries like Ghana.

Age: The estimated coefficient of age of Ghanaian crop farmers is positive. This means that households headed by aged have larger farms than those headed by the young. Considering the high use of human labour and energy, it is expected that young farmers should own larger farms. However the findings show otherwise. As indicated earlier, the relatively old farmer tend to have greater access to farm inputs, especially farm land, through lobbing or inheritance.

Household Size: Household size had its expected significant positive effect on farm size. This shows that households with larger numbers have larger farm as compared to small size households. This could be explained that large household members is a

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source of incentive for increasing farm holding since they provide cheap and readily available family labour to the household heads.

Land Ownership: The effect of land ownership on farm size was significant and negative. This means that households with ownership right over lands they cultivate have smaller farms than those without ownership right. Although this is contrary to the research expectations, one can argue that land owners might consider other household members in their decision to expand their farm sizes. On the other hand, the only limiting factor to the size a rented farmer can use is financial, hence farmers who can afford will definitely rent larger sizes or that the rent on land is lower relative to increasing land sizes.

Household Labour: The estimated coefficient of household labour had a positive significant effect on farm size, meaning increasing family labour is an increasing factor to farm size. This is explained by the importance of household labour in Ghanaian agriculture. Most farmers, especially, household heads rely mainly on household labour for every activity, right from land preparation to harvesting and carting of agricultural products.

Hired Labour: Hired labour which was measured as the cost of labour was found to be positively related to farm size at 10% significance. Thus, farmers who incur high cost on hired labour have larger farm sizes. The reverse relationship also exists as larger farm sizes requires more labour for farm activities, thereby, higher overall labour costs. Perhaps, labour cost per unit area might differ.

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Ownership of Farm Equipment: Ownership of farm equipment was positively related to farm size at a significance level of 10%. This means farm size is an increasing function of ownership of farm equipment, meaning that farmers who are owners of farm equipment have larger farms than those who do not own farm equipment.

Locality: It was observed that the coefficient of locality (1 if household lives in urban center and 0 if in rural area) was positively related to farm size. This implies farmers located within urban areas have larger farms than those in the rural areas. This seems quite unusual since urban areas have limited and expensive lands, which is a disincentive to farming. However, it could be argued that farmers within the urban areas have access to resources such as credit facilities, capital and technologies, that empower them to overcome all these challenges, thus expanding their farms.

Off Farm Work: A negative relation was found between off farm work and farm size at 5% significance. It implies that as farming households get more engaged in off farm employment and activities in the sector increases, less time will be left for on-farm activities, which will limit households in expanding their farms. Also returns (income) from off farm engagements could be high that households would not need to expand their farms.

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CHAPTER FIVE

GENERAL CONCLUSIONS, SUMMARY AND RECOMMENDATION

5.1: Chapter Outline

This chapter presents a summary of the study by way of the conclusions drawn from the chapters. The general summary of the findings is presented in section 5.2, the conclusions which are drawn from the key findings which are also based on the specific objectives of the study, is also found in section 5.3, section 5.4 provides the policy recommendation of the study. The final section (5.5) contains the areas suggested for further studies.

5.2: General Summary and Major Findings

The study has examined the relationship between farm size and technical efficiency as well as farm size and welfare in Ghanaian agriculture. It also investigated the socioeconomic factors that influence these three variables.

The stochastic frontier model was used to analyze farmers' efficiency level and determinants of efficiency, while the 3SLS was used to investigate the relationship between farm size and welfare. Descriptive statistics was used to describe the socioeconomic characteristics of the farming households.

The descriptive statistics show that farming households in Ghana is dominated by middle aged heads since majority (38%) of them fell within the age brackets of 31 and 41 with an average of 7.4 years of formal education. Most of the heads (81%) were male while there were more married household heads comparable to unmarried ones. Similarly, majority of the households have 4 to 6 members with the average

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household size being 5.3. Farm size varied among farmers ranging from slightly above zero acres to over 32 acres with an average farm size of 10.6 acres.

Furthermore, the average annual output value for these farmers was GHC199.56 with an average welfare level of GHC 2,771.23. The average value of expenditure on crop, agricultural equipment (depreciated), household asset and hired labor were GHC 798.26, 80.57, 6688.98 and 276.70 respectively.

It was observed that credit was not accessible to most farmers (83%) and farmers are predominantly rural dwellers (82%). With regards to extension service, a higher proportion (61.04%) of the sampled farming households had no access to extension services. Membership of FBO was very low (18.3%) and more than half of these crop farmers were engaged in off farm work. A higher percentage (65%) of farmers were owners of farm lands with few number (37.36%) owning farm equipment. However, a very small percentage (5.82%) owned vehicle.

From the stochastic frontier, efficiency levels of farmers ranged from 7% to 83% with a mean efficiency score of 50%. Factors that significantly influenced farmers' technical inefficiencies positively were farm size, sex of household head, extension service and marital status. Technical inefficiency was negatively affected by age and household size. An inverse relationship between farm size and technical efficiency (small farm holders are more efficient than large farm holders) was established from the study. The study therefore accepted the null hypothesis that smaller farms are efficient.

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The regression results from the 3SLS also revealed a positive relation between farm size and welfare, and vice versa. The study therefore accepted the null hypothesis that small holders are poorer than larger farm holders. Other factors that had positive significant effect on farm size were age, household size, locality, hired labour, household labour, ownership of land and ownership of equipment. On the other hand, sex and off-farm had negative significant effect on farm size.

Similarly, the positive determinants of welfare are off farm work, membership of cooperative movement, durable asset and ownership of vehicle while credit access, land ownership, distance had a negative significant effect on welfare.

5.3: Conclusion

From the study, it can be concluded that technical efficiency levels were low among farming households in Ghana. The estimated results lead to a rejection of the alternate hypotheses and accepting the null that households with small farm holdings are more efficient than those with the relatively large farm holdings but small farm holders are poorer than larger farm holders. This means that technical efficiency of Ghanaian crop farmers does not necessarily translate into higher welfare of households. Possible reasons for this outcome include low output price due to lack of markets, poor post-harvest management as well as competition for inputs. Therefore, the study concludes that the fight for agriculture development must not end or target increasing efficiency of production, instead, these policies should be welfare inclusive.

5.4: Policy Recommendations

From the findings of the study, It is recommended that government (specifically, lands commission) and development agents implement appropriate policies and programmes to make more lands available to the crop farmers. Credit facilities (production and consumption) should also be extended to them to enable them purchase improved planting materials and hire more farm lands.

Since agricultural income serves as a source livelihood for farming households, there is a call on government to work through Ministry of Agriculture to address agricultural product prices challenges such as; lack of community commodity markets and also introduce favorable pricing policies like price flooring to ensure that farmers' efficiency is translated into higher welfare.

Off farm and credit had inverse relationship with farm size but a direct relationship with welfare. But since the 'end' objective is to enhance household welfare, off farm opportunities and credit facilities should be made accessible to all farmers. The financial and/or credit institutions and agricultural extension agencies should also strengthen monitoring of farmers to ensure that credits meant for farming are effectively utilized.

The findings suggested that female farmers do not only have larger farms but also, were more efficient than the male farmers. Therefore, government and traditional rulers, who have full control over resource must put in efforts through the implementation of projects and progammes such as Agricultural Development Strategy (GADS) to address gender challenges such as access to production resources. This would go a long way to make farming favorable for both men and women. This would indirectly help reduce unemployment and improve food security situation of the country.

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Consistent with national estimates, farmers located in the urban areas are wealthier than those located in rural areas. Similarly, those located close to Accra are wealthier than those far from Accra. Therefore, rural development as well as bridging developmental gaps between the urban and rural (for instance through the provision of credit and economic activities) remain a crucial option for Ghana's development, at least among farming households. Hence government and development agencies must put in place policies and also strengthen existing ones like SADA and NRGP that would eliminate or reduce unfavourable situations which hinder development, especially in rural areas.

5.5: Suggested Areas for Further Research

Due to the composite error term in the efficiency model, this study was unable to estimate the simultaneous relationship among farm size, technical efficiency and welfare. Therefore, future studies should focus on addressing this econometric challenge to make the findings more robust.

The reasons why small holder farmers were more efficient while large farm holders are wealthier needs exploration beyond the econometric output of this study. Future studies should consider qualitative approaches in unfolding these reasons.

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APPENDIX

EXTIMATION OUTPUTS

Testing the significance of farm size in the inefficiency function

```
Likelihood-ratio test                                 LR chi2(1)  =      2.73
(Assumption: model11 nested in model10)               Prob > chi2 =    0.0986

Akaike's information criterion and Bayesian information criterion
```

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
model11	2,507	.	-4374.022	35	8818.044	9021.984
model10	2,507	.	-4372.658	36	8817.316	9027.082

Note: N=Obs used in calculating BIC; see **[R] BIC note**.

name	command	depvar	npar	title
model11	frontier	lnoutput_v~e	35	
model10	frontier	lnoutput_v~e	36	

```
Likelihood-ratio test                                 LR chi2(1)  =      6.25
(Assumption: model12 nested in model10)               Prob > chi2 =    0.0124

Akaike's information criterion and Bayesian information criterion
```

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
model12	2,507	.	-4375.783	35	8821.567	9025.506
model10	2,507	.	-4372.658	36	8817.316	9027.082

Note: N=Obs used in calculating BIC; see **[R] BIC note**.

name	command	depvar	npar	title
model12	frontier	lnoutput_v~e	35	
model10	frontier	lnoutput_v~e	36	

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The Maximum Likelihood Estimates of the Stochastic Translog Production Frontier

```
Stoc. frontier normal/truncated-normal model     Number of obs    =     2,507
                                                 Wald chi2(20)    =    333.57
Log likelihood = -4372.6579                      Prob > chi2      =    0.0000
```

lnoutput_value	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnoutput_value						
lnfarmsize1	.3998336	.1598234	2.50	0.012	.0865855	.7130817
lnhd_lab	-.3766696	.19884	-1.89	0.058	-.7663889	.0130496
lntot_hhlab	-.0779654	.09327	-0.84	0.403	-.2607712	.1048405
lncrop_expd	.6583094	.2421017	2.72	0.007	.1837989	1.13282
lnexpdep1	-.0160836	.0616937	-0.26	0.794	-.137001	.1048339
capital_fm	-.0174524	.0110673	-1.58	0.115	-.0391439	.004239
capital_crp	.0292446	.0154131	1.90	0.058	-.0009645	.0594537
capital_hd	-.028965	.013603	-2.13	0.033	-.0556264	-.0023035
capital_hh	.0041351	.0072691	0.57	0.569	-.010112	.0183822
capital2	.0050982	.004561	1.12	0.264	-.0038412	.0140377
farm_hdlab	.0436412	.0386308	1.13	0.259	-.0320738	.1193561
farm_hhlab	-.0373506	.0188262	-1.98	0.047	-.0742493	-.000452
farm_crpexpd	-.0787274	.042649	-1.85	0.065	-.162318	.0048632
hdlab_hhlab	.054475	.0223058	2.44	0.015	.0107564	.0981937
lnhd_croexp	.0920132	.0517002	1.78	0.075	-.0093173	.1933436
lnhhcroexp	-.0326634	.025741	-1.27	0.204	-.0831147	.017788
farm2	.0626988	.0445685	1.41	0.159	-.0246538	.1500514
hhlab2	.0591871	.0165672	3.57	0.000	.026716	.0916581
hdlab2	-.0474368	.0508717	-0.93	0.351	-.1471435	.05227
crpexp2	-.1083241	.0679061	-1.60	0.111	-.2414177	.0247694
_cons	2.046236	22.99033	0.09	0.929	-43.01398	47.10646
mu						
farmsize	.002693	.0016282	1.65	0.098	-.0004982	.0058842
hhsize	-.0269631	.0104219	-2.59	0.010	-.0473896	-.0065366
Sex_HH_head	.1966095	.0864338	2.27	0.023	.0272024	.3660166
Age	-.0191126	.0113552	-1.68	0.092	-.0413684	.0031432
Age_Squared	.0001613	.0001054	1.53	0.126	-.0000453	.0003678
Education	-.0217444	.0598803	-0.36	0.717	-.1391076	.0956188
Off_farm	.0104092	.057549	0.18	0.856	-.1023847	.1232031
Extension_officer_visit	.1046493	.0576921	1.81	0.070	-.0084252	.2177238
credit_access	.0283352	.075589	0.37	0.708	-.1198165	.1764869
land_ownership	.0156549	.0607396	0.26	0.797	-.1033925	.1347022
marital_statuscat	.1215768	.0736962	1.65	0.099	-.022865	.2660186
lnasset_value	.018437	.0160209	1.15	0.250	-.0129634	.0498375
_cons	.8160627	22.98587	0.04	0.972	-44.23542	45.86755
/lnsigma2	.6504834	.0282447	23.03	0.000	.5951248	.705842
/ilgtgamma	-6.818133	230.671	-0.03	0.976	-458.9249	445.2887
sigma2	1.916467	.0541301			1.813257	2.025552
gamma	.0010926	.251748			4.9e-200	1
sigma_u2	.0020939	.4824668			-.9435236	.9477114
sigma_v2	1.914373	.4854868			.9628366	2.86591

Order and Rank Condition of 3SLS

The estimation by the 3SLS must satisfy the order and rank conditions. The order condition for the estimation of the 3SLS is $k = g - 1$. Where k = all missing variables

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from a particular equation; g = number of endogenous variable in simultaneous equation system. The rank condition (sufficient condition) is g = number of matrix column.

The Three Stage Estimates for Farm Size and Welfare

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
lnfarmsize1	2,507	13	.931447	0.2846	1133.26	0.0000
lnwelfare	2,507	15	.574263	0.3438	1331.93	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnfarmsize1						
Age	.0036618	.0013004	2.82	0.005	.001113	.0062105
Sex_HH_head	-.3993471	.050342	-7.93	0.000	-.4980157	-.3006785
land_ownership	-.047275	.0489124	-0.97	0.334	-.1431415	.0485915
lnhd_lab	.2315895	.0177016	13.08	0.000	.196895	.266284
lntot_hhlab	.0796896	.0114891	6.94	0.000	.0571713	.1022079
loc2	.1744841	.0561687	3.11	0.002	.0643955	.2845727
hhsize	.1020426	.0132959	7.67	0.000	.0759832	.128102
Distance	.0014732	.000122	12.08	0.000	.0012342	.0017123
credit_access	-.0580888	.0539305	-1.08	0.281	-.1637906	.0476131
Extension_officer_visit	-.041794	.040148	-1.04	0.298	-.1204825	.0368946
Off_farm	-.1186587	.0393117	-3.02	0.003	-.1957082	-.0416091
lnwelfare	.5762745	.1160924	4.96	0.000	.3487376	.8038114
ownership_farm_eqpt	.2359177	.036404	6.48	0.000	.1645672	.3072682
_cons	-4.885253	1.00712	-4.85	0.000	-6.859172	-2.911335
lnwelfare						
loc2	-.198705	.0315452	-6.30	0.000	-.2605324	-.1368776
hhsize	-.1108365	.0044195	-25.08	0.000	-.1194986	-.1021743
Distance	-.0008171	.0000662	-12.35	0.000	-.0009468	-.0006874
Sex_HH_head	.1100306	.0369894	2.97	0.003	.0375328	.1825284
Age	-.0014812	.0008126	-1.82	0.068	-.0030739	.0001115
marital_statuscat	-.052508	.0269691	-1.95	0.052	-.1053665	.0003505
years_education	-.0013308	.0016026	-0.83	0.406	-.0044718	.0018102
land_ownership	-.1497471	.0255027	-5.87	0.000	-.1997316	-.0997627
Extension_officer_visit	-.0035424	.0250888	-0.14	0.888	-.0527156	.0456308
credit_access	.1301242	.0312666	4.16	0.000	.0688429	.1914056
Off_farm	.0646825	.0240153	2.69	0.007	.0176135	.1117515
vehicle_ownership	.277821	.0464086	5.99	0.000	.1868618	.3687802
participation_cooperative	.07564	.0270729	2.79	0.005	.0225781	.1287019
lnfarmsize1	.1525575	.0303454	5.03	0.000	.0930816	.2120335
lnasset_value	.0657553	.0066263	9.92	0.000	.052768	.0787427
_cons	8.179068	.117996	69.32	0.000	7.9478	8.410336

Endogenous variables: lnfarmsize1 lnwelfare
Exogenous variables: Age Sex_HH_head land_ownership lnhd_lab lntot_hhlab loc2 hhsize Distance credit_access Extension_officer_visit Off_farm ownership_farm_eqpt marital_statuscat years_education vehicle_ownership participation_cooperative lnasset_value

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