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FARMER INNOVATIONS IN AGRICULTURAL FINANCING AND ECONOMIC EFFICIENCY OF MAIZE PRODUCTION IN THE NORTHERN REGION OF GHANA

MARK APPIAH-TWUMASI

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FARMER INNOVATIONS IN AGRICULTURAL FINANCING AND ECONOMIC EFFICIENCY OF MAIZE PRODUCTION IN THE NORTHERN REGION OF GHANA

BY

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

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DECLARATION

I hereby declare that this thesis is the result of my original work and that no part of it has been presented for another degree at this University or elsewhere.

Signature: ___________________ **Date:** ____________________

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Supervisors

We hereby declare that the preparation and presentation of this thesis was supervised following the guidelines on supervision of thesis writing laid down by the University for Development Studies.

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ABSTRACT

The main objective of this study is to identify the innovative agricultural finance practices of maize farmers in the Northern region and how they affect economic efficiency (EE) of production. Credit markets in rural Ghana are woefully inadequate or missing, and some smallholder farmers have been observed to desist from participating in same even when they are available. These phenomena necessitate a shift in the focus of agricultural financing studies towards assessing how farmers innovatively finance their activities using their own resources. To this end, farm household data from 347 respondents was collected in a quasi-experimental survey for analysis from six districts in the Northern region. The decision to use innovative financing is made non-randomly and this creates the possibility for self-selection and selectivity bias. A matched group of user and nonuser farmers is determined using Propensity Score Matching to mitigate biases from observed variables. Also, possible self-selection due to unobserved variables is addressed using the Selectivity Correction Model for Stochastic Frontiers. From the results, average EE is significantly higher for user farmers while the presence of selectivity bias cannot be rejected. Mean EE is 0.7572 for users and 0.6607 for nonusers. The results indicate a wide scope for reducing production costs at the current output level and also that users of innovative financing exhibit higher EE enforcing its viability as alternative means of increasing maize productivity in Ghana. The study recommends that credit-constrained farmers be encouraged to join VSLAs in order to access the credit facilities they present. Also, essential services and technologies like AEA contact and tractor services should be made available to farmers timely as they were found to significantly increase economic efficiency.

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DEDICATION

To all the fathers I have been blessed with – Frank Appiah-Twumasi, Prof. Samuel A. Donkoh, and Mr. Isaac Gershon Kodwo Ansah – and the beautiful families they have given me.

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LIST OF ACRONYMS

ACDEP/PAS	Association of Church Development Programme/Presbyterian Agricultural Services
ADB	Agricultural Development Bank
ADVANCE	Agricultural Development and Value Chain Enhancement
AE	Allocative Efficiency
AEA	Agricultural Extension Agent
ATT	Agricultural Technology Transfer
CAADP	Comprehensive African Agriculture Development Programme
CD	Cobb-Douglas
DEA	Data Envelopment Analysis
ECOWAP	ECOWAS Agriculture Policy
ECOWAS	Economic Community of West African States
EE	Economic Efficiency
ERP	Economic Recovery Programme
FASDEP	Food and Agriculture Sector Development Policy
FAW	Fall Armyworm
FBO	Farmer Based Organisation
FtF	Feed the Future
GAPs	Good Agronomic Practices
GCAP	Ghana Commercial Agriculture Project
GPRS	Growth and Poverty Reduction Strategy
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy and Research Institute
IMF	International Monetary Fund
METASIP	Medium Term Agricultural Sector Investment Plan
MFI	Microfinance Institution
MIDAS	Managed Inputs Delivery and Agricultural Services
MLE	Maximum Likelihood Estimation
MMDAs	Metropolitan, Municipal, and District Assemblies
MoFA	Ministry of Food and Agriculture
MTADP	Medium Term Agricultural Development Programme
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental Organisation
NORRIP	Northern Region Agricultural Development Programme
OFY	Operation Feed Yourself
PFJ	Planting for Food and Jobs
PSM	Propensity Score Matching
RCC	Regional Coordinating Council

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SCF	Stochastic Cost Frontier
SFA	Stochastic Frontier Analysis
SFC	State Farm Cooperation
SFM	Stochastic Frontier Model
SGDs	Sustainable Development Goals
SHGs	Self-Help Groups
SPF	Stochastic Production Frontier
SSA	Sub-Saharan Africa
STK	Sawla-Tuna-Kalba
TE	Technical Efficiency
TFP	Total Factor Productivity
UGFC	United Ghana Farmers Council
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
URADEP	Upper Region Agricultural Development Programme
USAID	United States Agency for International Development
VORADEP	Volta Region Agricultural Development Programme
VSLA	Village Savings and Loans Association

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

According to projections by GSS (2013), Ghana's population will reach nearly double of its current figures by the year 2050. Given that Ghana's total land area will remain fixed (with the level of arable lands reducing due to population pressure), there is a need to pay even more attention to increasing the total factor productivity in the country's agriculture in order to meet the food needs of the population. Food and nutrition insecurity has been recognized as a major threat to Ghana's development drive since the 1970s with successive governments pursuing various agenda to curb any negative effects arising from this phenomena (Nyanteng and Asuming-Brempong, 2003). Ghana's commitment to achieving food security is evidenced by its ratification of global and regional development initiatives like the Millennium Development Goals (and its successor, the Sustainable Development Goals), the Comprehensive African Agriculture Development Programme (CAADP) of the New Partnership for Africa's Development (NEPAD).

At the national level, Ghana's agricultural sector policies and programmes, such as the Food and Agriculture Sector Development Policy (FASDEP I & II) and its implementation plan; the Medium Term Agricultural Sector Investment Plan (METASIP I & II) as well as the more recent Planting for Food and Jobs (PFJ) programme, are past and ongoing efforts to modernize the country's agricultural sector and achieve food security.

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A common theme among these programmes and projects is the recognition of the prevalence of low productivity in the food crop subsector and the need to mitigate this situation.

In Ghana, food crop production is mostly undertaken by smallholder rural farmers on family-operated landholdings averaging less than 2 hectares (Ha). This production is largely dependent on rainfall and typically employs rudimentary tools with minimal use of mechanized implements or improved production inputs and technologies. Despite these obvious shortcomings, it is estimated that the smallholder farming system produces about 80% of the nation's food needs and employs more than 60% of the active labour force directly and indirectly (MoFA, 2007; MoFA, 2016). The major food crops cultivated in Ghana can be grouped under cereals (maize, rice, millet, and sorghum), legumes (soybean, cowpea, and groundnuts), roots and tubers (yam, cassava), and fruits (pineapple, mango, banana, citrus) and vegetables (tomatoes, pepper, okra).

Maize is Ghana's most important cereal in terms of cultivation and constitutes more than 50% of total cereal production (Angelucci, 2013). Maize is grown in all agro-ecological zones of Ghana, mostly in association with other crops, and by both male and female farmers. The national average annual area planted to maize between 2006 and 2015 was 936,800 Ha – this represents an increase of over 18% compared to the base year. Average annual production over the same period is 1,622,900Mt and represents a growth rate of 36.5% in comparison to the base year. These estimations (computed from MoFA, 2016) reveal an increasing trend in the production of maize although this growth can mostly be attributed to expansion of land area as opposed to increases in land productivity. This data is summarized in Figure 1.1.

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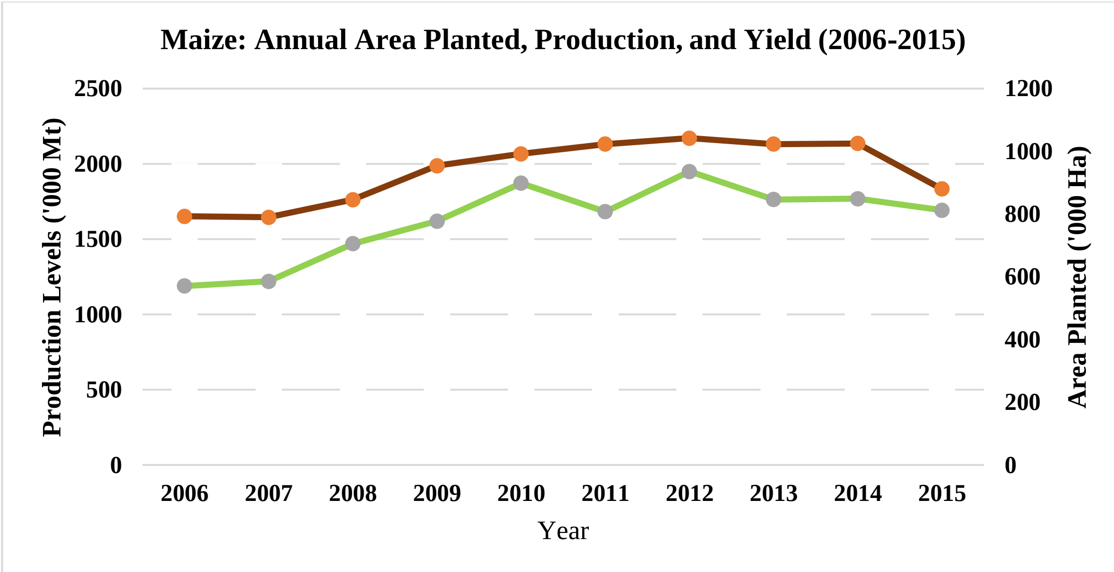

Figure 1. 1: Trend of Annual Area Planted, Production, and Yield of Maize between 2006 and 2015

Source: Author's Construct, 2018.

As a key food security crop, maize is widely consumed in Ghana and forms a dietary component among all the ethnic groups in the country. It is also demanded by the livestock subsector as a feed constituent, and Ragasa *et al*., 2014 asserts that the poultry industry's demand for maize grew by 10% annually between 2000 and 2009.

Successive governments and development partners such as the USAID Feed the Future Programme, have over the years, invested both efforts and funds to enhance the productive performance of maize and other grains, like rice, soybean and cowpea in Northern region. Many non-governmental and parastatal bodies have joined this course to complement the efforts to address challenges and areas of weakness in the maize value chain in the region in order to improve production, productivity, and the general welfare of individuals and institutions engaged in the value chains, but especially farmers.

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Due to the high levels of consumption, which in itself suggests a potential for economic gain, there is the need to increase the production levels of maize, given its poor productivity (average on farm maize yields is only 35% of potential) (MoFA, 2016). Considering that majority of maize produced in the region is channeled to household consumption and feeding the livestock industry, it is imperative that greater efforts be employed to increase maize productivity. This is expected to boost the food security of the people in the region as well as contribute to growth in the livestock and poultry subsectors. Improving productivity will require the removal of all sources of inefficiencies in production and barriers (institutional or otherwise) to improved technology adoption.

Some of the key challenges faced by farmers in the maize value chain include excessive dependence on rain-fed production, low productivity and yield, which are caused by poor soil quality, disease and pest infestation, and poor agronomic practices (Grewer *et al*., 2016). Other factors include poor market integration, poor production and pricing policies that lead to gluts during harvest seasons and shortages for most parts of the year, and inadequate technology transfer and adoption (Wolter, 2009).

Removing these challenges and encouraging the adoption of improved technologies in production, storage, and general postharvest handling require significant levels of farm investment. The literature vocally communicates that funds for these critical farm investments are not often readily available to the poor rural farmers. Therefore, these farmers would have to manage their own sources of finances in order to meet their numerous household needs while setting aside funds for farm investment in the production season.

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Specifically, the literature establishes that the provision of timely and affordable financing or credit could mitigate credit constraints on production, marketing, and consumption (Kedir, 2003; Steiner *et al*., 2009; Anang, 2015; and Owusu, 2017). Due to this view, a lot of the studies considering the impact of agricultural financing or credit provision on the productivity of maize and rice have often reported a positive relationship (Diagne *et al*., 2000; Awotide *et al*., 2015).

Essentially, capital for farm investment by the resource poor rural farm household could be sourced from own income, credit from financial institutions (or other lending bodies and agents), or grants from donor agencies and development partners (Abdul-Jalil, 2015; Wenner, 2010). Among these sources, credits from financial institutions and other lending agencies have received much attention in the literature. In many developing countries, Ghana inclusive, credit markets especially for rural crop farming is largely undeveloped. However, recent upsurge in the involvement of the private sector has boosted credit availability and access in some remote parts of developing countries. While the current agricultural credit system has been attributed with success stories of empowerment and progress (Dittoh, 2006; Martey *et al*., 2015), several fundamental challenges still exist that inhibit farmers' access to and control over essential farm investment capital. The participation of Ghanaian smallholders in the formal financial sector is limited by lack of collateral, perceived high risk of lending, and high transaction cost of loans (Boniphace *et al*., 2015; UNCTAD, 2015). Ultimately, the credit needs of farmers are, to a large extent, unfulfilled (Zeller & Sharma, 1998; UNDP, 2004)

Ultimately, the commonest and most readily-available source of capital for agricultural financing remains the farm households' own income (either from farming activities or non-

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farm economic activities). IFAD (2010) defines agricultural finance as "financial services used throughout the agricultural sector for farming and farm-related activities including input supply, processing, wholesaling, and marketing"; we find that our operational definition for agricultural finance is exactly in line with the above. Also, this study defines innovative agricultural financing as measures and methods initiated and pursued by rural farm households aimed at generating revenue specifically for farm investment. These innovative initiatives are aimed at improving farmers' access to and control over farm resources such as land, labour, inputs, and market channels. In other words, they are aimed at supplementing the traditional sources of finance.

With the obvious constraints that smallholder farmers face in accessing credit and loans from formal institutions, there is a need to shift the focus of research to understanding farmers' indigenous knowledge and practices in farm financing. This would help to tailor solutions that are actually available and achievable to farmers' needs. Unfortunately, not enough research have considered the innovative ways in which credit-constrained farm households finance their agricultural activities, with specific interest in maize farming.

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1.2 Research Problem

Improving agricultural productivity of rural farmers is crucial for Ghana's aim of meeting Goals 1, 2, and 3 of the Sustainable Development Goals (SDGs). This is because more than 80% of domestic food needs is supplied by the resource poor rural farmer (MoFA, 2011). Therefore, Ghana's bid to end poverty in all its forms everywhere, end hunger, achieve food and nutrition security, and ensure healthy lives and wellbeing for all at all ages for the

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people requires a concerted effort at increasing the production and productivity of the staple food crops. Food crop production is mainly done on land holdings that average two hectares and less, and employ rudimentary traditional technologies (Seini & Nyanteng, 2005). Due to these, productivity levels for most crops fall far below the frontier yields, often resulting in shortages in domestic supply that have to be met through costly imports (Wood, 2013). For example, the national average actual yield of maize is 1.92Mt/Ha while its potential yield is 5.50Mt/Ha (MoFA, 2016), implying that the current productivity level is 65% below potential and emphasizes the need for efficient technology development and transfer bolstered by overt efforts at increasing adoption.

Improving the productivity and efficiency of maize farmers does not appear to be feasible without a significant level of farm investment. This investment may be geared towards expanding the area of arable land under irrigated cultivation, adopting new production and postharvest technologies, and increasing access to farm inputs and products markets. Consequently, non-governmental and state institutions have been pursuing policies and programmes aimed at improving the level of investment in maize farms. For example, the USAID's Agricultural Development and Value Chain Enhancement Activity II (ADVANCE II) programme drives private sector investment in the maize value chain to increase competitiveness and food security of rural households in northern Ghana (Grewer *et al*., 2016).

In developed countries, credit markets are viable sources of capital for agricultural financing. In many developing countries, Ghana inclusive, credit markets for agricultural investment are either missing or less developed and the finding of Poulton *et al*. (2010) that credit markets are barely available for the farm financing needs of Ghanaian smallholders

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is one such evidence. Also, where credit markets exist, the cost of borrowing are sometimes prohibitively high and the requirements for qualification to access credit are too cumbersome for many smallholder farmers. Furthermore, most of the financial institutions discriminate against smallholder, resource-poor farmers for fear of fungibility (Wenner, 2010; Ellis, 1998). Credit institutions often justify this discrimination by citing the numerous risks and uncertainties that characterize smallholder farming (Dorward *et al*., 2009).

The inadequacy of formal financial services as sources of capital for agricultural financing is further proven by findings from recent studies by Anang *et al*. (2015) who investigated the factors influencing smallholder farmers' access to credit in northern Ghana and Owusu (2017) who examined the factors affecting farm households' access to credit in the Afigya-Kwabre District of Ghana. Evidence from these papers indicate that less than 50% of sampled respondents had access to agricultural credit. Despite the limited access by majority of these farmers, they still engage in agricultural production, often relying on their own income to finance their agricultural activities. But the household income has to be allocated over several competing demands, including payments for utilities and school fees, just to cite few.

What remains an interesting knowledge and entry point for developing self-financing in agriculture is how farmers allocate their incomes over competing household demands, and how this in turn influences the amounts allocated to agricultural financing. This is not yet addressed in the empirical literature to the best of the researcher's knowledge.

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The amount of household income allocated to agricultural financing is dependent on several factors. For example, commercial and subsistence farmers may have different motivations for investing in their farms from own finances. How does farmers' level of market participation influence the decision and amount to invest in agriculture from own financial sources? These factors and the aforementioned financing constraints faced by smallholder farmers create a necessity to investigate the innovative ways resource-poor farmers finance their farming activities. Ultimately, these decisions can be expected to influence farmers' economic efficiencies. Many smallholder farmers are intelligent and develop interesting mechanisms for farm financing which could be useful lessons for other farmers and influence policy makers to develop interventions that better meet the needs of these smallholder farmers.

Consumer theory postulates that household expenditure among competing needs should be done rationally, such that each expenditure provides an equal level of utility. From a utilitarian standpoint, smallholder farmers' decisions to pursue innovative farm financing mechanisms is directly related to the level of their expected utility. It is therefore also interesting to investigate how expectations influence farmers' decisions and actions on agricultural investment. To this end, this study seeks to identify the innovative farm financing strategies put in place by maize farmers in the Northern region and how this affects their production levels and economic efficiency.

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1.3 Research Questions

In order to address the issues raised in the Problem Statement, the main research question is "what are the innovative ways in which maize farmers in Northern region finance their farming activities and how does this affect their productivity and economic efficiency? From this, the following specific research questions are pursued:

1. What are the traditional and innovative methods of agricultural financing of maize production in the study area?
2. What are sources and magnitudes of agricultural finance in maize production?
3. What factors influence the adoption of innovative methods of agricultural financing?
4. What is the effect of the innovative methods of agricultural financing on the economic efficiency of maize production?
5. What other factors influence the economic efficiency of maize production?

1.4 Research Objectives

1.4.1 Main Research Objective

The key objective of this study is to identify the innovative agricultural finance practices of maize farmers in the Northern region and how they affect economic efficiency.

1.4.2 Specific Research Objectives

1. Identify the traditional and innovative sources and magnitudes of agricultural finance in maize production.
2. Identify the factors that influence the adoption of innovative agricultural financing.

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3. To estimate the effect of innovative agricultural financing use on the economic efficiency of maize farmers.
4. Determine the other factors influencing the economic efficiency of maize production.

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1.5 Research Justification

The study of the economic efficiency of maize farmers in the Northern region has wide policy and poverty reduction implications. Given that other studies limit their focus to analyzing only the technical efficiency (loosely defined as obtaining maximum output from a given set of inputs) of maize farmers without considering how farmers use these inputs to their optimal proportions, given their respective prices and the production technology, this study goes a step further in analyzing the efficiency of maize production in the Northern region.

Specifically, this study estimates the technical and economic efficiencies of maize farmers and uses these outcomes to estimate the allocative efficiency in maize production residually. Understanding the determinants of technical efficiency and the sources of inefficiencies in maize production will help to boost the productivity of maize farmers, consequently improving the food security situation of the region.

In addition, through the estimation of the cost function, the study reveals how maize farmers could effectively relate factor costs to the marginal value product of inputs. This would help farmers to reduce unnecessary costs (through proper resource allocation) and increase the welfare of the farm household. Furthermore, this study remains essential

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because it approaches solving the financing needs of farm households quite differently; by identifying farmers' own existing practices in order to apply them in designing financing packages for adoption in other areas. This will provide an added dimension to the agricultural financing literature.

With regards to the findings from this study, identifying the main sources of finance will help address challenges that may exist in accessing them to boost maize production and productivity. Findings from other factors that increase cost efficiency will inform institutional policy regarding their provision. Knowing the effect of innovative financing on economic efficiency will provide an empirical basis for replication or discontinuance. Knowledge of the extent of cost inefficiency will help in designing input packages that reduce costs, without reducing outputs, resulting in surplus household income and encourage the sustainable use of inputs among maize farmers.

Finally, from a methodological perspective, the use of Propensity Score Matching (PSM) (explained in chapter 2) to create a homogenous sub-sample for comparison and further subjecting this to Greene's (2010) (also explained in Chapter 2) approach of estimating stochastic frontier with selection bias is relatively novel in economic literature and has not been applied in any efficiency study in the Northern region to the best of the Researcher's knowledge. This will therefore serve as a guide to other researchers in efficiency analysis of agriculture in the study area.

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1.6 Structure of the Thesis

The content of this thesis is divided into five (5) chapters. The first chapter presents an introduction to subject of the study and is set out in six (6) subsections. The Background of the Study introduces maize production in the Ghanaian setting, trends, challenges, various government and efforts and how all these fit into the achievement of national policy goals. The Research Problem sets out how the production challenges outlined in the Background limit achievement of the first of three SDGs and reduce farmers' economic efficiency. Here, the study proposes timely financing is a veritable option to mitigate these challenges but dissents from the usual agricultural credit proposition that characterize previous studies and instead appeals for a shift in focus to farmers' own innovations in raising capital for farm financing. To this end, the research objectives are translated from questions arising in the research problem. The penultimate section presents the justification for the study.

In the second chapter, a review of literature surrounding the tenets of the study is undertaken in four subsections. The first two presents the role of maize production in the food security drive of Ghana and outlines selected policies and programmes pursued by successive governments in pursuit of food security. The third subsection deals with agricultural financing in Ghana and points out innovations in this area from both the demand and supply sides of the financial market. In the final subsection, the chapter presents the theoretical framework for the study, concentrating on the theory of production, cost theory, and measurement of efficiency maize production. This latter endeavour also reviewed methods employed in the analysis; the Propensity Score Matching and the Sample Selection Framework as applied to Stochastic Frontier Models.

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The Methodology and Research Design is presented in five subsections in Chapter Three. Information on the study area, sources and types of data employed, the sampling method and sample size determination procedure, and the data collection tools and methods are outlined in the first four subsections of this chapter. The final subsection presents the conceptual framework showing the interrelations between innovative financing use, economic efficiency of maize production, and the diverse variables that contribute to determinations. The theories reviewed in the Chapter 2 are given their econometric forms; random utility theory is linked to the determinants of innovative financing use; the theory of production to the measurement of technical efficiency; and the theory of cost to the measurement of economic efficiency.

Chapter four (4) presents, in a logical sequence, the results of the data analysis according to the Objectives outlined in Chapter 1. The first half of the chapter presents discussions on respondents' demographic and socioeconomic characteristics; findings on the sources and magnitudes of agricultural financing in maize production; innovative methods of agricultural financing and the factors that influence the use of these methods; and correction of observed biases. In the second half, the chapter presents the results of the various stochastic frontier models estimated in the study.

Chapter five (5) summarizes the main findings of the study and conclusions drawn from them. This chapter also provides recommendations for policy decision and future research.

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CHAPTER TWO

LITERATURE REVIEW

2.0 Chapter Outline

This chapter reviews literature on some topics related to the subject of this thesis. It presents the role of maize production in the food security drive of Ghana in Section 2.1. This analysis dovetails into assessing some selected agricultural policies implemented in the country over time and attempts to link the present state of national food security to these policies in Section 2.2. Section 2.3 reviews literature on agricultural financing methods identified in Ghana, pointing out some innovations that have been initiated on both the demand and supply sides of the financial market. The main interest of this study; estimating farmers' economic efficiency, is outlined in the final section of this chapter. The section attempts to address the methods employed in this undertaking. Also, recent extensions of the stochastic frontier model to include measuring the impact of an intervention on farm performance is addressed. Section 2.4 culminates in a review of methods to address observed and unobserved biases using the Propensity Score Matching (PSM) method and the sample selection framework applied to stochastic frontier models.

2.1 Food Security and Maize Production in Ghana

Addressing food security issues among developing country populations is the enduring inspiration for several agricultural intervention programmes and projects. Bruce (2003) characterized food security as the availability of food in the global marketplace.

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This definition is clearly a narrow one because it assumes that macro-level food availability implies same in less developed and hamstrung African countries. Thus, the above definition fails to factor food accessibility as a defining parameter in individuals' food security.

FAO (2006) provides a more rounded definition of food security as household's physical and economic access to sufficient, safe, and nutritious food that meets the household's dietary needs and food preferences for living a healthy and active lifestyle. Another difference that assessing food security from this dimension presents is the focus on a more homogenous subgroup of the population – the household – and this microeconomic outlook gives a more realistic picture of the food security status of citizens in a country.

Generally, four pillars of food security have been identified; availability, access, utilization, and stability. Utilization examines the individual's capacity to derive optimal nutrition – energy, macro- and micro-nutrients – from the food one consumes. Food safety, hygiene practices (in all stages of food transfer from the farm gate to the plate), and diet quality and diversity are all determinants of this pillar. Food safety connotes food that is not deleterious to human health as a result of absence or acceptable levels of contaminants, adulterants and substances such as toxins that occur naturally in food. Ensuring diet quality and diversity among people helps in the eradication of the so-called "hidden hunger" that is prevalent in most countries due to deficiencies of essential micronutrients like Vitamin A, Iron, and Iodine.

In Ghana, Nyanteng and Assuming-Brempong, (2003) assert that food and nutrition security has been in the national consciousness as a threat to development since the 1970s.

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Both chronic undernourishment and transitory food insecurity have been observed in parts of Ghana especially in the resource-constrained areas of northern Ghana. Chronic food insecurity exists when a household is persistently unable to access adequate food while transitory food insecurity is more temporary in its effect and results from shocks and failures that create food shortages in all or parts of the country population (Quaye, 2008).

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Various governments have pursued programmes and policies with the aim of improving agricultural productivity and consequently improve the nation's food security status. Some of the major agricultural interventions/programmes have focused on production because of its ability not just to avail food but also income for the farm household. Key crops targeted for improving food security have been maize, rice, cassava, and more recently, sorghum and soybean.

The fact that this issue still dominates the national discourse is evidence that programme goals and objectives have not been achieved to the extent envisaged. This study discusses some of these agricultural programmes and objectives in the next section.

2.2 Selected Agricultural Policies and Programmes

Ghana's history of agricultural policy is closely aligned to the political regime/system in place. Considering the fact there have been a significant number of political regime changes in the past, Seini (2002) discusses agricultural policies in Ghana along the lines of five (5) political epochs;

1. Pre-independence policies
2. Era of mass government participation

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3. Era of capitalist means of production
4. Slide to economic chaos
5. Stabilization and adjustment.

Agricultural policies from the pre-independence era focused on export crop production to meet the raw materials demands of the Great Britain. This focus on export crop sidelined non-export food crop producers – these were mainly constituted of women and food crop farmers in northern Ghana.

To push this agenda, the colonial government imposed Poll Tax laws at the beginning of the twentieth century which compelled peasant farmers and fishermen to find wage employment in the emerging mining industries or enter into cocoa production. Since the main export crop promoted in this period, cocoa, was ill-suited to the climate in northern Ghana, the effect of this policy was to induce migration of workers from the northern territories into southern export-based economy of southern Ghana.

Dapaah (1998) concludes that agricultural policies from the colonial period were designed to make the Gold Coast (Ghana) colony an export crop and food import dependent economy. One remarkable feature of this policy era was the ability and ingenuity of small farmers in the south to transform Ghana into a leading world producer of cocoa from 1911.

Towards the end of colonial rule, and the early years of independence, agricultural policies were aimed at first, satisfying the unemployed and/or underemployed urban youth whose efforts had led to achieving independence and secondly to promote the idea that

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industrialization was the most prudent means of transforming the economy and achieving economic independence.

To obviate the negative outcomes of overdependence on costly food imports while creating jobs in agriculture, the state government elected to pursue mechanized farming by establishing the Agricultural Development Corporation (ADC). This action plan continued to sideline small scale agriculture as it was not suitable for promoting the Socialist ideas of the government. Token interventions to promote small scale agriculture was channeled through the United Ghana Farmers Council (UGFC) which had oversight responsibilities of organizing small farmers for mechanized farming through cooperative efforts. Another feature of the era of mass government participation was the establishment of State Farms Cooperation (SFC) to undertake large scale mechanized farming.

Seini (2002) reports that many writers judged government's experiment to modernize agriculture through large scale farms to have been a costly and wasteful venture that ultimately failed to curb the rising food production deficit in the economy rising from rapid population growth.

Following the change in government in 1966, the focus on large scale agricultural production was substituted for more private capitalist development of agriculture. Focus during this era was shifted to food crop production, especially for rice, in the northern sector of the country. The era of capitalist means of production was characterized by sale of the State Farms to private rice farmers, resurrection of extension services to smallholder farmers across the country and promotion of relatively modest farm holdings and bank financing. The government position was that the ingenuity noticed among smallholder

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cocoa farmers could be inculcated in small scale food crop farmers through the provision of advice and incentives. Single commodity (cotton, kenaf, and grains) development boards established during this era were tasked with this undertaking.

Basic infrastructure such as roads, water, and electricity were targeted for development in rural areas to augment the efforts of this policy effort.

This era spawned productivity-increasing programmes like Operation Feed Yourself (OFY – focused on improving maize and rice yields for household consumption) and Operation Feed Your Industries (with emphasis on production of agricultural industrial raw materials like cotton, sugar cane, and kenaf) in 1972. Among the achievements from the 1970s was Ghana's attainment of self-sufficiency in rice production between 1974 and 1975.

The 1980s introduced greater efforts to improve the welfare of small farmers through small scale development programmes. Agricultural Development Programmes were established for the Upper Regions (URADEP), Northern region (NORRIP), and the Volta Region (VORADEP). The aim of these programmes were to improve agricultural productivities in these areas.

The Managed Inputs Delivery and Agricultural Services (MIDAS) was established during this period as well to provide timely inputs and services on a regular basis to small scale farmers in the mentioned areas.

The early 1990s saw a continuation of agricultural development with the International Fund for Agricultural Development (IFAD) especially playing a key role through the design and implementation of programmes aimed at improving small-scale farmers' productivity in the Northern, Upper East, and the transitional zones of Brong-Ahafo, Ashanti, and Volta

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Regions. Women traders played a crucial role during this era by marketing agricultural produce between and among the various regions.

The marketing activities ensured that purely subsistent production was a rarity in most parts of Ghana. The importance of women in Ghanaian agriculture now spreads beyond marketing of food crops and permeates all aspects such as production, processing, and agricultural administration.

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From the early 1960s, the agricultural policies adopted by subsequent regimes contributed to a gradual collapse of the economy. The situation came to a head in 1983 when the economy of Ghana suffered serious economic crises. While fair portions of the blame for this situation could be attributed to domestic economic reforms, some level of external factors also contributed to this economic crises. A decline in cocoa output from 400 MT in 1975 to 159 MT in 1983, along with fall in world prices of other primary exports, resulted in a worsening of the country's terms of trade and led to Ghana recording three-digit inflations in three separate years between 1977 and 1983. Food imports became prohibitively costly due to a deterioration of the Cedi and the situation was further worsened by severe droughts and fire outbreaks that destroyed several crops. These events contributed to a total crippling of the Ghanaian economy with devastating consequences for agriculture.

The Era of Stabilization and Adjustment began after the 1983 crises. The "stabilization" phase aimed at halting the decline in the tradeables sectors. Pertinent among the policy changes in the period was the focus on exchange rate reforms which embarked on a series of devaluations between 1983 and 1986. Accompanying this was tighter monetary and

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credit control policies which helped keep average annual inflation levels at between 15 and 35 percent.

The economic crises of the former era had led to persistent problems in the nation's agricultural sector such as inadequate research and extension services, inadequate and untimely supply of inputs like fertilizer, cutlasses, and insecticides, collapse in the fishing sector as a result of shortage in marine and fishing gears, and a contract cocoa sector. Reforms in the agricultural sector therefore gave these areas priority status.

The International Monetary Fund (IMF) and the World Bank supported Ghana in introducing an Economic Recovery Programme (ERP) in 1983 to help address the economic bottlenecks outlined earlier. As part of the ERP, an agricultural programme dubbed "Ghana Agricultural Policy – Action Plans and Strategies (1984)" was implemented. The plan targeted self-sufficiency in the production of cereals like rice and maize, maintenance of adequate buffer stock levels for these cereals especially and price stability.

The ultimate target of this plan was to eliminate food security by ensuring food availability during the lean season (March - July) and preparedness for unforeseen crop failure and other natural hazards. Maize, Rice, and Cassava were the three key food security crops selected for attention in terms of increasing yield. Significant efforts were also made to stabilize cocoa prices in order to shift the domestic terms of trade in Ghana's favour.

The second phase of the economic reforms (1986-1988) saw the implementation of policies aimed at moving the economy towards sustained long-term growth. Investment came in the form of export-promotion and infrastructural development. Food security objectives

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were actively pursued by the government through the promotion of cereal production. Efforts in this regard included the resuscitation of guaranteed minimum prices for maize and rice (these were raised every year).

Also, subsidies on essential farm inputs like fertilizers, tools and implements, and agricultural chemicals were used to complement other sector development efforts.

In 1989, the third phase of the adjustment process was implemented. This phase focused on liberalisation and growth; this spelled an end to protectionist policies that had been pursued earlier. The export and import markets were liberalized; commodity and service markets were deregulated to reduce domestic market distortions; and the programme for guaranteed minimum price for maize and rice was abolished. Crucial to the recession in growth gains made in the agricultural sector were the removal of all subsidies on inputs like fertilizer, insecticides, and farm machinery. This move was particularly detrimental to agricultural growth because it led to inflations in the prices of these inputs and made them unaffordable for rural farmers.

Assuming-Brempong (1994) asserts that average prices of inputs used in cereal production increased in excess of 40% per annum for the period 1986-1992. The case for fertilizer was even direr with prices tripling between 1990 and 1992. The Medium Term Agricultural Development Programme (MTADP) was the development strategy for agriculture.

The year 1995 saw the launch of Ghana's Vision 2020 programme by the government. The aim was to usher Ghana into an era of sustained growth marked by Ghana's transition from an indebted poor low income country into an industrialised middle income nation by the year 2020. Agriculture was expected to play a key role in this drive towards improved

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quality of life in Ghana. This would obviously require an increase in production levels of all crops, especially the foreign exchange earner; cocoa, and staples like maize, cassava, and rice.

Following the shortcomings of the MTADP, there was a need for a new strategic framework for the socio-economic development of the country. The national policy document, the Vision 2020, contained strategies to guide this development. A review of this document in 2001 resulted in the Food and Agricultural Sector Development Programme (FASDEP). FASDEP was developed in 2002 based on the Accelerated Agricultural Growth and Development Strategies prepared in 1996. The strategies were designed to modernize the agricultural sector by forging linkages in the value chain. FASDEP was meant to serve as a catalyst for rural transformation. However, an analysis of its impact on poverty and society concluded that the policy was incapable of achieving its impact on poverty because of its flawed targeting of the poor in society, weak problem analysis that misrepresented the needs and priorities of clients, and poor outline of collaboration channels between the Ministry of Food and Agriculture (MoFA) and other stakeholders whose domain covers those areas that MoFA has limited jurisdiction over. FASDEP was thus revised after four years of implementation to reflect lessons learned and to realign it to the emerging needs of the sector.

The new FASDEP II followed a direction with more focus on greater effectiveness, sustainability, and equity in impacts. It adopted a value chain approach to agricultural development with more attention on value addition and market access. One of the criticisms leveled against FASDEP I was its failure to recognize the different categories of farmers and the fact that smallholders are not a homogenous group. In pursuing a

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modernized agriculture, FASDEP II would target subsistence farmers with greater vulnerability to risks, as well as established large scale farms, helping them to improve their productivity. The objectives of this sector policy was outlined in six steps in MoFA (2007) as;

- Food security and emergency preparedness;
- Improved growth in incomes;
- Increased competitiveness and enhanced integration into domestic and international markets;
- Sustainable management of land and environment;
- Science and technology applied in food and agriculture development; and
- Improved institutional coordination.

The national vision for which the FASDEP II was formulated was the Growth and Poverty Reduction Strategy (GPRS II) which was in itself aligned to the Comprehensive Africa Agriculture Development Programme (CAADP) of the New Partnership for Africa's Development (NEPAD). It must be noted that Ghana had ratified the Millennium Development Goals (MDGs) as well the regional programmes mentioned above.

The Medium Term Agricultural Sector Investment Plan (METASIP) was the investment plan to implement the medium term (2011-2015) programmes of the FASDEP II. The METASIP was developed to achieve a targeted agricultural GDP growth of at least 6% annually, halving poverty by 2015 in consonance with MDG 1, based on government expenditure allocation in the national budget of at least 10% within the Plan's period (2011–2015).

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METASIP is consistent with the ECOWAS Agriculture Policy (ECOWAP) and NEPAD´s CAADP which provides an integrated framework to support agricultural growth, rural development and food security in the African region.

The six Programmes of the Plan which correspond to the six FASDEP II objectives were each presented along development themes termed Components. POCC analysis was applied to the development issues of the themes to derive outputs and activities.

Implementation of the METASIP to reach the goals set for the agriculture sector required a significant financial commitment from the public sector and was estimated to cost GH₵ 1,532.4 million for the six programmes over the course of five years. This did not include operational costs such as personal emoluments and administration of the implementing agencies.

Following the expiration of the implementation period of the GSGDA, and Ghana's signing onto the terms of the Malabo Declaration in 2014, the Medium Term Agricultural Sector Investment Plan (METASIP II) 2014-2017 was developed using the Ghana Shared Growth and Development Agenda (GSGDA II) guidelines. It was also based on the Maputo and Malabo declarations of government expenditure allocation of at least 10% of the national budget into the agricultural sector, and expected GDP growth of at least 6% within the plan period. The targets mentioned above are in conformity with the agricultural performance targets of the ECOWAP of ECOWAS, CAADP of NEPAD and were expected to contribute significantly to the achievement of the SDGs of the United Nations.

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The plan was developed with a strong emphasis on the Accelerated Agriculture Modernization and Sustainable Natural Resource Management which would transform the agricultural sector to increase productivity and output, create jobs, increase incomes, and ensure food security over the medium term. Innovative interventions, planned based on the adopted objectives and key strategies that would be systematically implemented under the programme areas to ensure that the goals set for the agricultural sector under the GSGDA II were achieved.

The formulation and implementation of the METASIP II was especially important given the realisation that the sector had, as a result of some key challenges, performed poorly between 2010 and 2013, growing at an average annual rate of 3.4%. Some of these key development issues of the sector identified and analysed in the document included; low average yield of staple crops and high post-harvest losses; poor management along the agriculture value chain; low level of agriculture mechanisation and adoption of appropriate technology; low use of improved planting materials; low productivity of smallholder farms, degraded landscapes; inadequate investments in agriculture business ventures; inadequate access to appropriate finance by smallholder farmers; overreliance on rain-fed agriculture; and low productivity in the livestock and poultry industry.

Since the year 2017, the new Ghanaian government has been pursuing a new sector development programme dubbed the Planting for Food and Jobs (PFJ) Programme which is scheduled to run for a four-year period between 2017 and 2020. The programme is set to cost a little under GH₵ 3.5 billion over the implementation period.

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The PFJ is composed of five pillars; seed access and development, fertilizer access and fertilizer systems development, extension services, marketing, and e-agriculture. These pillars are directed at achieving the Programme's seven objectives spanning timely access to key inputs like improved seeds and fertilizer, access to support services like extension and market channels, and broad-based engagement with the private sector to provide the input delivery and output marketing services. The Ministry of Food and Agriculture is the agency responsible for implementing this crop subsector programme.

A common theme among all agricultural policies pursued in Ghana is modernisation of agriculture through the promotion and adoption of improved production, processing, and storage technologies. Each agricultural programme incorporates a system to enhance the achievement of this aim by providing varying levels of incentives to the target farmers. In recent times, the focus of Ghana's agricultural policies and programmes have targeted smallholder farmers whom MoFA (2002) describes as using rudimentary technologies on small farm holdings that are poor in fertility because of continuous nutrient mining.

Thus, to improve the productivity levels of these farmers, there is the need to increase the amounts of modern technologies used by all actors across all commodity value chains. Any hopes of realizing the nation's agricultural policy objectives is built on an increase in farm production and productivity improvements which are themselves dependent on a rise in the adoption and correct use of these improved technologies among farmers. This requires significant financial outlay on the side of farmers.

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As discussed, farmers in Ghana and particularly in the Northern region are not in the ideal financial position to cover these expenses on their own, no matter how much they desire these inputs. Government is aware of this plight of Ghanaian farmers in this regard and (ir) regularly undertakes measures to ease the burden. The establishment of the Agricultural Development Bank (ADB) and more recent efforts like the PFJ which allows farmers to access a certain amount of inputs adequate for 2 hectares of maize, rice, or soybean with an initial down payment of half the cost and the remaining half after harvesting the crop, are some of government's efforts to supplement the financial needs of farmers in adopting technologies (MoFA, 2017).

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2.3 Agricultural Financing in Ghana

Almost all the agricultural policies implemented in Ghana have had a financing component; either in the policy document itself or as an appendage investment plan. Agricultural financing is to policy effectiveness what breath is to the human body. The importance of financing is perfectly summed up by Seini (2002) who avers that agricultural financing is central to agricultural production growth in that it offers farmers a means to use productivity enhancing technologies irrespective of the scale of farming. The same author identifies equity funds and agricultural credit as the main sources of funds for farm financing and concludes that the share of agricultural lending in total lending was declining in 1994 compared to 1991 figures.

The commoner source of farm funds is agricultural credit. Agricultural Credit is the amount of investment funds made available for agricultural production from resources outside the farm sector.

This kind of credit is given for production and development. Production credit is provided to enhance access to agricultural inputs such as seeds, pesticides, fertilizer, animal feeds, and labour. Development loans are towards purchase of agricultural equipment such as tractors, threshers, and hydrological implements (Saqib *et al*., 2016). The Ghanaian agricultural finance market is made of formal and informal credit providers whose operations dovetail but ultimately do not mix. Formal credit providers include commercial and agricultural banks, Microfinance Institutions (MFIs), agricultural non-governmental institutions, and donor agencies. In the absence of these, informal financial providers like moneylenders, pawnbrokers, rotating savings and credit associations, and relatives present viable sources of funds for financing agricultural activities.

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2.3.1 Microfinance, Microcredit, and Agriculture

Ghana's post-independence agricultural policies followed global trends; the State took responsibility for providing "cheap" productive credit to farmers who had no access to credit facilities in the past. However, poor management and frequent delinquencies created sustainability problems for this model of agricultural financing. Loan defaults were exacerbated by borrowers' failure to repay loans they viewed as coming from the government (Hoff & Stiglitz, 1990).

Ledgerwood (1999) reports that microfinance became popular in the 1980s as a market-based solution to the problem of large loan losses and its consequent need for recapitalization of the existing government system. This new financial system was founded on the beliefs that subsidized credit undermines development, poor people can afford interest rates that cover transaction costs of credit provision, and recovery of costs and

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profit generation were essential in increasing the focus and efficiency of financial institutions.

The terms microfinance and microcredit are often used interchangeably although they are different. Microfinance refers to financial transactions and services for agricultural and non-agricultural firms while microcredit refers to limited amounts of credit offered to poor people usually at low costs (Meyer, 2013; Anang *et al*., 2016).

The importance of providing farmers a means of financing their activities is recognized in the literature as well as in the corridors of policy makers. There seems to be an unwritten consensus that extending credit to farmers is the sure way of enhancing farmers' productivity and efficiency. Studies abound on the importance of credit in achieving the stated objectives of efficiency and productivity in crop farming.

Dittoh (2006) is one of the earlier modern incursions into the effect of credit on small farmers' productivity in Ghana. Akudugu (2012), Anang *et al*. (2015), and Abdallah (2016) represent more recent analysis of the effect of credit access on agricultural performance in Ghana.

Traditionally, the country's financial and agricultural sectors had been operationally distinct with minimal overlaps in their activities. With the liberalization and decentralization of agricultural financing, these two seemingly unrelated fields found they have some common interests, and have been attempting to find interlinkages in their operations to create synergies. This symbiosis has not been smooth, with credit provision to the Ghanaian agricultural sector fraught with some serious challenges.

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Agriculture is, by nature, a risky economic activity; this is even more pronounced for rural farmers. The economic success of any production season is dependent on a vast array of factors that are largely out of the control of farmers; poor rainfall, outbreak of diseases and pests (the Fall Army Worm infestation in 2016 is a more recent example), and a change in consumers' preferences are all highly plausible factors that can reduce farmer's economic returns from farming.

In Ghana, the absence of effective risk mitigation measures like crop insurance and guaranteed prices for most small-scale farmers increases their vulnerability to these external shocks and pressures.

The Microfinance Institutions (MFIs) are themselves plagued with challenges that limit their ability to serve the agricultural sector. Unfavourable policy environment, poor financial management systems, and a broad spectrum of adoption of successful business models without recourse to social contexts and local adaptations have led to the collapse of several of these MFIs. MFIs service to the agricultural sector is further hampered by the wide geographical spread of farmers especially in rural settings, information asymmetry – where farmers have more information about their potential risk of default, and moral hazard. Others include lack of branch networks, perception of low profitability of agriculture, lack of collateral, high levels of rural poverty, or low levels of farmer education and financial knowledge/literacy. These challenges influence the decision of MFIs to adopt credit rationing policies by limiting their operations to areas with high population density, limiting the share of agricultural loans in their portfolios, and setting high interest rates to cover their risks of default (Boucher and Guirkinger, 2007).

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Fortunately, these failures on the part of formal lenders to meet the credit needs of small farmers have created avenues for informal lenders to enter the financial market. Moneylenders, traders, and financial Self-Help Groups (SHGs) – designed along the lines of the Grameen Bank model – have stepped into the rural agricultural markets to provide credit for smallholder farmers. These informal sources have the advantage of being more conversant with the debt capacity of farmers and are therefore able to eliminate the problem of information asymmetry.

They are thus more able to adjust their products and "effective" interest rates on loans to suit the lender, depending on the expected market outcomes (Njeru *et al*., 2016).

Despite these advantages, Bell *et al*. (1997) noticed that farmers limited to informal credit sources are more vulnerable to exploitation because of the monopoly power enjoyed by informal credit providers. To sustain their supply of credit to rural farmers, credit providers have adopted innovative measures to reduce their risks and lower their transaction costs while increasing their service coverage; some of these are discussed in the next section.

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2.3.2 Recent Innovations in Agricultural Lending in Ghana

This section briefly outlines areas and programmes designed and adopted by credit providers to improve the efficiency of their activities in light of organizational goals. Some of these innovations may overlap in terms of operations and timeframes. The more common practices include;

- Group (Peer) Lending: this method has become popular in Ghana due to the success of the Grameen Bank model from India. Interviews with members of these groups reveal that agricultural and financial NGOs are the main proponents of formation of these

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groups among farmers. Loan disbursement is done on group basis with group members guaranteeing the repayment of each other's loans.

This eliminates the need for individual collaterals with peer pressure and collective responsibilities taking its place. Group members screen new members and determine the credit-worthiness of new members. Where farmers commit moral hazard in Group Lending Schemes, further access to credit and other auxiliary benefits are withheld until full payments are made. In extreme cases, memberships are revoked completely. In principle, these farmers have completely lost their access to credit from this group and other such groups in their communities. The problem with this system is that loan sizes are uniform for all members and attract the same rate of interest irrespective of the purpose of the loan. This leads to membership dropouts, delinquencies, and borrowing from multiple sources (Meyer, 2002).

- Individual Lending: MFIs assess each client's financial situation, debt capacity, and personal risks. Information on a farmer's cash flow, expected production, yields, and management capacity are used to determine whether a loan will be granted, the loan size, and duration of loan – this process presents high transaction costs for MFIs. Along with the insistence that farmers own assets that can be easily liquidated as collateral, these requirements imply that households with low net worth are automatically excluded from financial markets. To avert this, some MFIs have started using existing farmer groups to expand their coverage; joint liability is substituted for individual responsibility but group meetings are used for repayment purposes. Farmers who exhibit good repayment behaviour are given larger loans and other incentives at these meetings to enforce similar behaviour among group members. A notable negative

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lender behaviour in this scheme is fungibility – diversion of loan funds taken for agricultural inputs to other household needs like education, daily consumption, non-farm business, and social events.

- Value Chain Financing: IFAD (2010) defines this as financial services and products that flow to/through any point in a value chain in order to increase returns on investment, growth, and competitiveness of that chain.

  Value chain finance is especially important for farmers for whom actors (input suppliers, traders, and food processors) along the chain may be the only realistic source of credit – other sources may be available in the community but inaccessible to particular farmers because they fail some of the qualification criteria. Value chain financing presents opportunities to provide farmers with technical training and access to ready market. An example of successful value chain financing in the study area is the ACDEP/PAS maize value chain (Abdul-Rahman & Donkoh, 2015).

- Outgrower Schemes: this is a business model where a commercial actor (Nucleus farmer) identifies and manages marginalized farmers (known as Outgrowers) in production and marketing activities. The Nucleus farmer keeps a registry of outgrowers and supplies them with inputs and other services on credit in return for payment at the end of harvesting. All transactions (inputs and produce) are usually in-kind and therefore reduce the likelihood of fungibility. Interventions like those of the Ghana Commercial Agriculture Project (GCAP) and USAID's Agricultural Development and Value Chain Enhancement programme (USAID-ADVANCE II) have all used this system to finance maize farming to good effect in the Northern region (MoFA, 2015).

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Across Africa, a new innovative form of agricultural financing known as Blended Financing is gaining traction. OECD/WEF (2015) defined Blended Financing as “the strategic use of development finance and philanthropic funds to mobilize private capital flows to emerging and frontier markets”. Enclude (2017) analysed the feasibility of linking blended financing to technical assistance to enhance Africa’s agricultural transformation drive and found that with a few modifications to existing technical assistance provision practices, blended financing can be used to transform agriculture in Africa.

Despite all these innovations and efforts put into agricultural financing for smallholders in Ghana, the agricultural credit situation does not seem to have improved any significantly. Recent studies on farmers’ access to credit have shown vast numbers who are unable or unwilling to access credit. Dzadze *et al*. (2012), Akudugu (2016), and Abdallah (2016) each reported credit access of less than 40% among the farmers sampled in their studies. Dzadze *et al*. (2012) sought to identify factors that limit or increase smallholder farmers’ access to formal credit in the Central Region of Ghana; they found 35% of sampled farmers had access to formal credit.

Akudugu (2016) used Ghana as a case study in his analysis of the nexus in agricultural productivity, credit, and farm size. His findings revealed 39% credit coverage among the sampled farmers in the study. By selecting Ghanaian maize farmers, Abdallah (2016) employed unique dataset to find evidence of impact of credit access on production performance. Key among his findings was that less than 25% of farmers of this key food security crop had access to credit.

These findings show that the problem of credit access among smallholder farmers in Ghana is truly pervasive and detrimental to their food security and poverty alleviation prospects.

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Minton & Barrett (2008) paint this inconvenient truth thus, "… *significant proportion of farmers in low-income countries have to buy some of the crops they produce themselves. They have to sell some of the crops at harvest to be able to raise funds to meet their cash needs and given that prices are usually low around harvest; farmers always have to sell in large quantities to be able to raise the desired amounts. Having sold large quantities at low prices at harvest, they run out of stock during the lean season and have to buy the same crops at higher prices.*

This makes many farm households trapped in the vicious cycle of poverty as the phenomenon repeats itself on yearly basis and this affects their agricultural productivity…" It is saddening to find the "feeders" of the nation going hungry themselves, especially considering the efforts invested in areas like the Northern region of Ghana.

Given this abject portrayal, one would expect an ever upward spiral in the numbers of smallholders transferring their economic efforts towards off-farm ventures. Indeed, while there is a recognized increase in the tendency of farmers to diversify their income sources by engaging in non-farm businesses, this may be more as a result of a restriction to a single cropping season due to limited irrigation facilities and the natural climate of northern Ghana than dissatisfaction with farm returns.

The only alternative explanation for farmers' continuation in agricultural production is that they must possess skills and knowledge which they apply to ease the burden of being credit-constrained. Indeed, some smallholder farmers have been known to be so well-integrated into their coping strategy that they refuse credit offers no matter how flexible the terms are designed.

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This observed behaviour of smallholder farmers stands as proof that there is the need to readjust the dimensions through which rural agricultural financing is tackled. As Ayamga *et al*. (2006) report, the assumption that farm folks will automatically participate in microcredit schemes given the opportunity is clearly flawed with studies (Diagne, 1998 & Ayamga, 2004) suggesting that rural farmers in the Northern region, similar to those in Malawi, may refuse to borrow due to low liquidity in the household and unwillingness to bear the risk of indebtedness.

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Past studies in Ghana have attempted to answer the question of what makes credit participation attractive to rural farmers. The agenda has been to identify potential credit users and tailor credit facilities to their needs. While this has helped in increasing the efficiency of credit provision, it has created a knowledge gap that needs to be filled. In trying to understand farmers' insistence on producing under such repressive conditions, it is important to understand the characteristics of these credit-rationed farmers by analyzing the coping strategies they engage in to sustain/thrive in their production drive.

Given that figures from MoFA (2016) support the conclusion that crop output levels have been relatively constant for the major food security crops with outputs for maize actually increasing in the decade between 2006 and 2015 (Table 2.1), it stands to reason that future research investigates the innovations that the underserved majority generate to increase their productivities in maize production.

There is an expanding body of literature devoted to efficiency and productivity analysis of smallholder farms in Ghana. Different researchers have used wide varieties of methods to estimate these productivities.

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The majority have expanded the frontiers by estimating farmers' efficiency of production using diverse methods as their data and interests permit. The following section reviews literature on farm efficiency and its measurement.

Table 2.1: Annual Area Planted, Production, and Yield of Maize between 2006 & 2015

Year	Area Planted ('000 Ha)	Annual Production ('000Mt)	Annual Yield (Mt/Ha)
2006	793	1189	1.4994
2007	790	1220	1.5443
2008	846	1470	1.7376
2009	954	1620	1.6981
2010	992	1872	1.8871
2011	1023	1683	1.6452
2012	1042	1950	1.8714
2013	1023	1764	1.7243
2014	1025	1769	1.7259
2015	880	1692	1.9227
Average	**936.8**	**1622.9**	**1.7324**

Source: MoFA, 2016; with further computations by the Author.

2.4 Models and Methods of Efficiency and Productivity Analysis

The terms productivity and efficiency have been used interchangeably in society, this is unfortunate since they are precisely not the same. A commonality in the discourse is the aim of painting a picture of the performance of the firm, farm, or industry under discussion. Performance measurement takes many forms and uses diverse methods depending on the outcome desired and the data available.

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Performance is defined as the process or manner of operating or functioning; of doing something successfully; using knowledge as distinguished from merely possessing it (The Sage Dictionary VII).

Coelli *et al*. (1998) assert that performance is a relative concept; the performance of a farm could be measured relative to the performance of another farm or it could be measured relative to its own performance in the previous season.

A natural measure of farm performance is the productivity ratio – the ratio of outputs produced to inputs expended in this process – where higher values connote better performance. Thus,

$$productivity = \frac{outputs}{inputs} \tag{2.1}$$

For smallholder maize farms, the production process involves combining inputs such as land, labour, capital (seeds, fertilizer, chemicals, and mechanized implements) and managerial acumen to produce an amount of output; maize. The productivity referred to in equation 2.1 refers to total factor productivity in that it considers all factors of production used by a farmer. It is also possible to estimate partial productivities for the individual inputs to establish their contributions to the total maize output.

In simple language, efficiency describes a production unit's skillfulness in avoiding wastage in efforts. Whiles it is desired that farms increase their productivity, it is even more crucial that they do not sacrifice their limited resources at the altar of improved yields. It is therefore important to complement measurements of farm productivity with efficiency

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analysis. Productivity and efficiency analysis are built on the neoclassical theories of production and cost.

2.4.1 Theory of Production

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This section presents a recap of the theory of production. Production is the transformation of input resources into finished products. To present this transformation intelligibly, the production function is used. The first empirical analysis of a production function was by Cobb and Douglas (1928). Koutsoyiannis (1979) defined the production function as a purely technical relation which connects factor inputs into outputs. This technical relation describes the law of proportions at any particular time period, assuming a constant technology state. Coelli (1995) posits that the production function is actually also a production frontier since it defines the relationship between inputs and outputs. It is a bounding function heavily influenced by the best performing farm and representing the best practice technology which serves as a benchmark for measuring the efficiency of firms/farms. Mathematically, the production function is presented as:

$$y = f(x_1, x_2) \tag{2.2}$$

where y is output

x_1 *is labour input*

x_2 *is capital input*

To simplify the discussion, this study considers the production function for maize using a simple two-input and single output relation such as is depicted in equation 2.2. It relates the quantity of output to the quantities of labour and capital exhausted in producing it.

The relation expressed above can be a simplification for all production processes.

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To operationalize the above, Beattie and Taylor (1985) make the following assumptions about the production function;

1. The production process is mono-periodic;

2. Homogeneity in all inputs and outputs;

3. The production function is twice differentiable;

4. The production function, input, and output prices are known with certainty;

5. There is no budget constraint; and

6. The firm aims at maximizing profit (or minimizing cost for a specified output level).

Graphically, a production function can be represented by a 2-dimesional graph. A curve (isoquant) on this graph depicts the various sufficient input combinations required to produce a given level of output (see Debertin (1986) and Pindyck & Rubinfeld, (1995) for extensive graphical presentations of production functions and product curves).

Since the production process is a technical one, efficiency estimated using the quantities and combinations of input used to produce an output is known as *technical efficiency*. The methods used in this estimation are presented in later sections; the immediate looks at the dual of the production function; the cost function, and its theoretical underpinnings.

2.4.2 Theory of Cost

Costs are expenses incurred in executing the production process and include money spent on procuring production inputs and essential services like renting capital. The literature

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identifies two types of costs; short run cost and long run costs. Generally, fixed costs accrue from use (or even mere possession) of fixed inputs while variable costs are as a result of successfully acquiring control over inputs such as seeds, labour, fertilizer, and other chemicals necessary for maize production. Thus, in the long run, all costs are variable since all factors of production are variable.

Cost theory relies on the formulation and estimation of cost functions. Cost functions are derived from the production function under study. They show the relationship among output levels, the existing production technologies, price of factor inputs, and the total cost of production (Koutsoyiannis, 1979). The cost function shows the minimum cost at which a given level of output can be produced. It is symbolically represented as;

Long-run cost function: $$C_i = f(y_i, P_{ik}) \quad (2.3)$$

Short-run cost function: $$C_i = f(y_i, P_{ik}, \bar{K}) \quad (2.4)$$

where

C_i *is the observed cost for farmer i*

y_i *is the output level*

P_{ik} *is a vector of unit prices of input k*

$\bar{K}$ *is a fixed factor*

While the production function is capable of producing estimates of a farm's productivity performance, it is sometimes necessary to consider the cost function. Where the prices of inputs and outputs are known, Coelli (1995) identifies 3 reasons this consideration may be warranted;

1. To reflect alternative behavioural assumptions (such as cost minimisation)

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2. To account for multiple inputs

3. To simultaneously predict technical and allocative efficiency

An assessment of Beattie and Taylor's (1985) assumptions about the production function show they are rarely applicable in agriculture, and indeed, maize farming. At the beginning of the production season, both output prices and output quantities are not known with certainty.

The farmer is more likely to have a targeted level of output when making production decisions on how much of each input to use, and when. In this case, the assumption of profit maximization must be traded for one of cost minimization. A direct estimation of a production function under this condition will produce biased and inconsistent estimates of the parameter if the behavioural assumption is inappropriate.

Also, the neoclassical production function maximises outputs for a given level of inputs, and assumes that there are no inefficiencies in production (Førsund, 2015). All discussions so far point to the fact that a significant majority of smallholder maize farmers do not produce on the frontier and there exists some level of inefficiency for every production technology – outputs produced are less than the maximum possible for the specific input combinations and prices. From a cost function perspective, the cost of production is usually higher than the least possible for the given level of output. The presence of inefficiency thus leads to lower outputs, or increased cost, which inadvertently lead to less profits for the farmer.

Since the end of the Economic Recovery Programme pursued by the Ghanaian government, substantial amounts of funds have been committed to improving the national food security

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situation. Efforts have been aimed at increasing agricultural productivity for key food security crops like maize.

With the knowledge that inefficiencies plague the achievement of these policy goals, it is important to properly characterize these inefficiencies by identifying the types, sources, and extent of inefficiency effect in maize production in the study area.

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2.4.3 Measuring Efficiency in Maize Production

The efficiency of a maize farmer is measured by comparing the observed output to the best feasible output given the production technology and the prices of inputs. With information on the prices of inputs and imputing an assumption of cost minimization on maize farmers, it is possible to consider and predict simultaneously, both technical efficiency and allocative efficiency. The concept of technical efficiency is as has already been discussed. Allocative efficiency in input selection refers to selecting that mix of inputs which produce the target level of maize output at minimum cost. By simultaneously predicting technical and allocative efficiencies, it is possible to give an overall measure of a farmer's efficiency – commonly known as economic efficiency in the literature.

Recent growth spurt in efficiency measurement can be traced to Farrell (1957). This original work was inspired by the works of Koopmans (1951) and Debreu (1951) to define a simple measure of firm efficiency that accounted for multiple inputs. Farrell (1957) suggested that the degree to which a firm was operating above minimum cost could be attributed on one hand, to the use of inputs in wrong proportions, given the prevailing

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market prices (allocative inefficiency), and on the other hand, to operation below the productive frontier (technical inefficiency).

These ideas on efficiency measurement were illustrated for a farmer using two inputs (labour and capital) to produce a single output under the assumptions of constant returns to scale.

From Figure 2.1 (adapted from Donkoh (2013)) below, a firm operating at M is technically efficient because it is operating on the isoquant IS-IS'. However, if a firm is operating at N, it is not efficient because it is far away from M and indeed the origin 0. In this case, the technical inefficiency of this firm may be measured by the distance MN, which is the amount by which the firm's inputs can be proportionally reduced without reducing output. Thus, in the ratio form, the technical efficiency (TE) of this firm is measured by $TE_i = 0M / 0N$ $TE_i = 0M / 0N$ which is equal to $1-(MN/0N)$. This implies that technical efficiency lies between zero (0) and one (1). A firm is fully efficient when its efficiency equals one and has no technical efficiency if its estimated technical efficiency equals 0.

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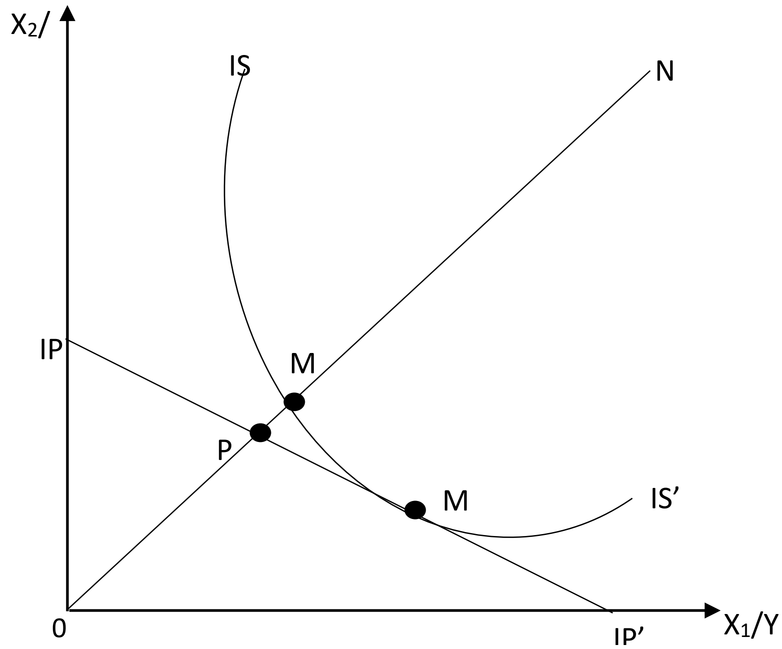

Figure 2. 1: Technical, Allocative, and Economic Efficiency

The slope of the straight line, $IP - IP'$ represents the input price ratio of inputs X_1 and X_2. With this, the allocative efficiency (AE) of the firm can also be calculated. At point N, the AE is defined as the ratio of $0M/0P$ (i. e. $AE_i = 0P/0M$) since the distance PM represents the reduction in production costs if production were to occur at the allocatively and technically efficient point *M'* instead of the technically (but not allocatively) efficient point M.

The product of TE and AE is the economic efficiency (EE) given as:

$$EE = TE_i \times AE_i = (0M / 0N) \times (0P / 0M) = (0P / 0N) \qquad (2.5)$$

Like technical efficiency, allocative and economic efficiencies are bounded by zero and one (Donkoh *et al*., 2010).

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Coelli (1998) identifies four major methods of undertaking efficiency measurements;

1. Least squares econometric production models;
2. Total factor productivity (TFP) models;
3. Data envelopment analysis (DEA); and
4. Stochastic frontiers

Least squares production models and the TFP models are applied to time series data to measure technical change and/or TFP. Forgoing the time series data requirement, both models are still not appropriate for this present study because they are based on average response estimators and thus assume that farmers are fully technically efficient.

DEA (developed by Boles (1966), Afriat (1972) and Charnes, Cooper, and Rhodes (1978)) is a non-parametric method that uses mathematical programming to construct a frontier for efficiency measurement. This frontier usually represents the efficiency of the best-performing farmer and serves as the benchmark for comparison. Any deviation from this frontier is captured as inefficiency by the DEA; it does not consider the possibility of random noise in the data (Ray and Chen, 2015).

Attribution of all inefficiency to a farmer's managerial ineptitude may not be representative of the real situation considering the multitude of factors that influence the success of a production season are outside the control of farmers. Using the best performance as the frontier may reflect poor judgment since the best farmer in a population of averages may not be the target of agricultural intervention programmes.

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The DEA's shortcomings are roundly addressed by the stochastic frontier model. The stochastic frontier model can accommodate both inefficiency and random noise through a composite error term. This study opts for the stochastic frontier model due to the belief that ignoring the effect of data noise in the model will lead to overestimation of the mean level of technical efficiency while shifting allocatively efficient points some distance from their "correct" positions (Coelli *et al*., 2003).

2.4.3.1 Theoretical Framework for the Stochastic Frontier Model

Aigner and Chu (1968) were the first to attempt estimating a parametric frontier production function of Cobb-Douglas form. Their data was based on a sample of N firms, and their model was defined as;

$$\ln(\mathrm{y_i}) = x_i\beta - u_i, \qquad i = 1, 2, ..., N, \qquad (2.6)$$

where $\ln(\mathrm{y_i})$ is the logarithm of the (scalar) output for the *i*th firm;

x_i is a (k+1)-row vector, whose first element is 1 and the remaining elements are logarithms of the K-input quantities used by the *i*th firm;

$\beta = (\beta_0, \beta_1, ..., \beta_K)'$ is a (K+1)-column vector of unknown parameters to be estimated; and

u_i is a non-negative random variable, associated with technical inefficiency in production of firms in the industry.

From equation 2.6, the Authors propounded that technical efficiency for the *i*-th firm, can be estimated by comparing its observed output to the potential output defined by the production function, given the input vector x_i;

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$$TE = \frac{y_i}{\exp(\mathrm{x_i}\ \beta)} = \frac{\exp(\mathrm{x_i}\ \beta - u_i)}{\exp(\mathrm{x_i}\ \beta)} = \exp(-u_i). \qquad (2.7)$$

The above measure is output-oriented and takes a value between zero and one. Technical efficiency, which is captured by the amount of deviation from the output that could have been produced by a full-efficient firm, was obtained using linear or quadratic programming.

Afriat (1972) proposed a similar model to 2.6 and assumed that the $u_i s$ followed a gamma distribution and the parameters were estimated using maximum-likelihood (ML) method. Schmidt (1976) pointed out that Aigner and Chu's (1968) programming estimators can be ML estimators if the $u_i s$ are distributed as exponential (for linear) or half-normal (for quadratic) random variable. The models so far are bounded from above by the non-stochastic quantity, $\exp(\mathrm{x_i}\ \beta)$. This deterministic specification does not take into account the possible effect of measurement errors and other noise upon the frontier.

Aigner, Lovell, and Schmidt (ALS) (1977) and Meusen and van den Broeck (1977) independently prescribed the stochastic frontier models (equation 2.8). They included an additional random error term, v_i, to be added to the non-negative random variable, u_i in equation 2.6 to provide:

$$\ln(\mathrm{y_i}) = x_i\beta + v_i - u_i, \qquad i = 1, 2, ..., N, \qquad (2.8)$$

This random error, v_i, accounts for measurement errors and other random factors such as weather, natural disaster, and climate (Donkoh *et al*., 2010). ALS (1977) assumed that the $v_i s$ were independent and identically distributed (i.i.d.) normal random variables with zero mean and constant variance, σv^2, and independent of the i.i.d. exponential or half-normal

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random variables, $u_i s$. Since the random variable, v_i, can be positive or negative, the deterministic part of the frontier model, $\exp(\mathrm{x_i}\,\beta)$, becomes varied for all observed outputs, and this make the production function stochastic (Al-hassan, 2012).

Estimation of the stochastic frontier model usually employs the maximum likelihood estimation method because it is more efficient that all other alternatives. One of the main advantages of the deterministic model outlined in equation 2.6 over the stochastic frontier model (equation 2.8) is the need to specify a functional form for the model and make assumptions about the distribution of the error terms in 2.8. The decision on the functional form is guided by a choice between the Cobb-Douglas and the translog functional forms. The Cobb-Douglas functional form is the most common in the efficiency literature. Coelli (1995) suggest this attractiveness is due to its simplicity – a logarithmic transformation provides a model that is easy to estimate econometrically because it is linear in logs of the inputs. This simplicity comes at the cost of some restrictive properties; returns to scale are assumed to be constant across the firms in the sample while elasticities of substitution between inputs are assumed equal to one.

To correct these, the translog (e.g. Greene, 1980; Adzawla *et al*., 2013; Asravor *et al*., 2016) and the Zellner-Revankar generalized production function are the two most popular alternatives suggested in the literature. The latter removes the returns to scale restrictions while the translog provides a means to work around both restrictions but is also susceptible to multicollinearity and degrees of freedom problems.

Regarding the choice of distributional assumption for the error terms, Kumbhakar and Wang (2015) report that choosing a zero-mean normal distribution for the random error

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variable v_i is widely accepted for cross-sectional data models. The choice is however more difficult for the u_i because the distribution choice must be in the non-negative domain, and must ideally have a close form for its joint distribution with v_i.

The closed form is necessary to derive a likelihood function of the model. The half-normal distribution, truncated normal, truncated normal with scaling properties, and the exponential distribution are some of the commonest distributional assumptions used in the literature (see Kumbhakar and Wang, 2015 for details on these distributions).

The review so far has focused on estimating the production frontier function using single equation methods. However, the case has been made for estimating a cost function instead, especially for analysis in agricultural firms. The stochastic cost frontier can take the form;

$$\ln(C_i) = C(y_i, P_k; \alpha) + v_i + u_i, \qquad i = 1, 2, ..., N, \qquad (2.9)$$

where C_i is the observed cost for the i-th farm; C(.) is a suitable functional form; P_k is a vector of exogenous input prices; α is a vector of unknown parameters to be estimated; u_i is a non-negative random variable reflecting cost inefficiency, and v_i is as defined.

Earlier foundations in cost frontier estimations favour specifying a Cobb-Douglas function (despite its rigidities) over the translog because it is self-dual (e.g. Schmidt and Lovell, 1979). Flexible functional forms present problems associated with linking allocative inefficiency errors in the cost function with those in the input demand equations.

Other than in cases where the study is commissioned for a specific purpose, the decision on whether to estimate a production or cost frontier and the functional form employed is

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dependent on the data available, the interest of the researcher, and the appropriateness of the underlying behavioural assumption.

In Ghanaian agriculture, there have been many studies on estimating the efficiency of various aspects of the sector. Majority of the studies have focused on smallholder crop production with the stochastic frontier model being the preferred estimation method. Cross-sectional data has been the dominant type of data used. In such studies, the format has been to select a crop of interest, determine a study area and an appropriate sampling technique and sample size, and estimate farmers' technical efficiency. It is common practice to identify and jointly estimate sources of technical inefficiency – usually using observed demographic and socioeconomic characteristics of farmers. Some of these studies are summarized in Table 2.2.

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Table 2. 2 Summary of Selected Studies on Farm Efficiency in Ghanaian Crop Farming

Authors	Study Area	Crop Type(s)	Estimation Technique (Functional Form)
Asravo *et al.*, 2016	Volta Region	Chili Pepper	SFA (Translog)
Al-hassan 2008	Northern Ghana	Rice	SFA (Translog)
Abatania *et al.*, 2012	Northern Ghana	All Household crops	Bootstrap DEA
Donkoh *et al.*, 2013	Upper East Region	Rice	SFA (Translog)
Abdullai *et al.*, 2013	Northern Ghana	Maize	SFA (Translog)
Kuwornu *et al.*, 2013	Eastern Region	Maize	SFA (Translog)
Djokoto, 2011	Ghana	Agriculture	Time Series SFA
Donkoh *et al.*, 2013	Upper East Region	Tomato	SFA (Cobb-Douglas)
Essilfie *et al.*, 2011	Central Region	Maize	SFA (Cobb-Douglas)
Awunyo-Vitor *et al.*, 2016	4 agro-ecological zones	Maize	SFA (Translog)

Another common feature in the literature is estimation of the impact of a characteristic or an intervention on the efficiency of smallholder farmers. Some studies focus on a state of being (inherent characteristics like gender, age, and education status are some likely examples) and how it affects farm efficiency (see Al-hassan, 2012 and Owusu *et al.*, 2018 for examples of studies on gender dimensions in efficiency studies).

A growing trend in efficiency studies deals with evaluating the effect of exposure to an exogenous event on farm efficiency. Access to specific services like agricultural extension and credit are common fodder in this regard. Often, these studies follow a more specific direction by evaluating the impact of participation in activities like off-farm employment, intervention programmes, or adoption of production technologies.

Studies that attempted to link credit access and technical efficiency have been cited earlier while Abdulai and Huffman (2000) was one of the earlier works in analyzing the effect of macroeconomic policy (the Structural Adjustment Programme) on economic efficiency of rice farmers in Northern Ghana.

In these extensions of SFA, the scope of analysis involves including the variable of interest (for example, credit access) as a dummy either in the deterministic component of the model (the production function) (Bravo-Ureta *et al*., 2012) or in the inefficiency model (Abdallah, 2016). The purpose of including this variable in the estimation is to account for possible variations in efficiency estimates in the sample resulting from heterogeneity. These variations may be observed – resulting from measured characteristics – or unobserved. Unobserved heterogeneity usually results from innate characteristics which are difficult to measure but invariably affect the outcome of the estimation process.

In impact evaluation studies, selectivity bias is one key unobserved heterogeneity that besets outcome estimations.

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The major concern for researchers is to figure out possible heterogeneity and how to treat them since failure in this regard will cause false attribution of variation to inefficiency and hence bias any estimation (Erkoc, 2012).

In the literature, methods for treating observed heterogeneity in evaluation studies involving efficiency estimation have evolved since Pitt and Lee (1981)'s two stage approach.

Using randomized experiments wherein one group is given the "treatment" and to the other, the placebo, is touted as the most ideal method for comparing the effect of an intervention on the treated group (Duflo *et al*., 2008). However, cost and inadequate expertise in conducting randomized experiments have necessitated the need for adoption of quasi-experimental methods that yield similarly reliable results.

In this study, for example, there is the need to isolate the effect of using innovative financing on the economic efficiency of maize farmers. To achieve this, intuition suggests calculating the difference in farmers' efficiency outcomes when they use innovative financing and when they do not. Unfortunately, observing both states of nature is not possible and this presents a missing data problem known as the "counterfactual" (World Bank, 2006). This difficulty can be overcome by selecting a group of farmers comparable to those that use innovative financing in every way except that they abstained from using innovative financing.

Using a matching method like the Propensity Score Matching (PSM), has become the most widely acceptable means of assessing the effect of a treatment on a sample under study. The PSM creates a condition of an experiment in which the treatment condition (innovative

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financing use) is randomly assigned and provides a causal link between the treated group and the outcome of interest (economic efficiency).

This is done by estimating the probability that a farmer would use innovative financing – the propensity score – and then matching users to nonusers based on this estimated score. Rosenbaum and Rubin (1983) defined the propensity as the "conditional probability of assignment to a particular treatment given a vector of observed covariates". The PSM is expressed as;

$$p(\mathrm{X}) = \Pr\left\{L = 1 \middle| X\right\} = E\left\{L \middle| X\right\} \tag{2.10}$$

where

$L = \{0, 1\}$ *represents the treatment indicator variable – use of innovative financing*

X *is a vector of pretreatment characteristics*

E *is the expectation sign (expected value)*

Based on the results from equation 2.10 and some further estimation rigours, observed biases can be eliminated or seriously reduced in the sample; yielding more credible and efficient estimates of farmers' economic efficiency.

The issue of correcting selection bias in the sample (as a result of self-selecting into participation in innovative financing use) presents a more daunting dilemma. In the literature, the common approach employed in tackling sample selection bias is the Heckman (1979) sample selection model.

The Heckman (1979) model deals with problems that arise when the data for a survey was generated by a non-random selection process. Non-random sample selection may result

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from individual decisions by the agents under study (self-selection), but may also arise from administrative rules, or decisions on the part of the researcher.

For example, selection bias occurs when analyzing earnings of university graduates in that they can only be observed for those who are working. Also, assessing the impact of access to irrigation on household expenditure may result in selection bias as observations can only be made for farmers and households that decide to access irrigation, and so on.

The selection problem can be viewed as a problem of missing observations. There is lack of information on the earnings of workers who are not working; likewise, the economic efficiency of maize farmers that do not use innovative financing cannot be observed, by the analyst, because of their abstention (Heckman, 1974).

The conventional approach to incorporating selectivity follows the procedure proposed by Heckman (1976) which follows two steps thus;

1. Fit the probit model for the sample selection equation

2. Fit the second step model (Ordinary Least Squares or Weighted Least Squares) by adding the Inverse Mills ratio from the first step as an independent variable to correct for selectivity bias. After testing for the significance of the Inverse Mills ratio, a decision can be made on the null hypothesis of no selectivity bias (Rahman, 2011).

According to Greene (2006), the above steps are an inappropriate approach for non-linear estimations such as those undertaken with the stochastic frontier model. Three reasons given for this assertion are;

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1. The impact on the mean of the model of interest may not take the form of an Inverse Mills ratio as this only applies for linear models.

2. The assumption of bivariate normality which justifies the inclusion of the Inverse Mills ratio does not appear anywhere in the model.

3. In the absence of selection, the dependent variable is unlikely to have the distribution described by the model, conditioned on the sample selection.

Greene (2010) therefore proposed an internally consistent method of incorporating sample selection in a stochastic frontier framework using a simulation based approach. The model estimates the familiar half-normal normal stochastic frontier model using maximum simulated likelihood.

In the next somewhat complicated approach, the technique is extended to the model for sample selection – the log likelihood does not exist in the closed form. This model is adopted in this study and is elaborated as follows.

Maize farmers are assumed to opt for innovative agricultural financing as a means of gaining access to inputs and other services they require based on some observed characteristics.

The decision of the *i*th farmer to choose innovative agricultural financing is described by a latent selection criterion function, L_i^*. L_i^* is postulated to be determined by a vector of socioeconomic, biophysical, and environmental factors. L_i^* is not observed on its own (because it is a latent variable); a dummy variable L_i is instead observed. L_i takes a value of 1 for users of innovative financing and 0 otherwise. This model is specified as;

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$$p(L_i^* = 1|Z_i) = \gamma Z_i + w_i, \qquad L_i = 1(L_i^* > 0) \qquad (2.11)$$

where Z_i is the vector of observed characteristics explained earlier and w_i is the error term distributed as $N(0,\sigma^2)$.

The cost behaviour of maize farmers in the Northern region can be modeled by postulating a Cobb-Douglas cost function of the form;

$$C_i = CD\left(\alpha' \mathrm{q}_i + \beta' w_i + v_i + u_i\right) \qquad iff\ L_i = 1 \qquad (2.12)$$

where C_i represents cost of production; w_i represents input prices, q_i is the level of maize output, α and β are parameters to be estimated, with v and u representing the decomposed error terms of the stochastic frontier model as defined in equation 2.8.

In the sample selection framework proposed by Greene (2010), the selection bias arises as a result of correlation of the noise (v) in the stochastic frontier function with the error term in the financing option equation (w, in equation 2.11). Thus, w and v are distributed as bivariate normal distribution with $\left[(0,0),\left(\sigma_v^2, \rho\sigma_v, 1\right)\right]$. The vectors $(C, \mathrm{q}, \mathrm{w})$ in equation 2.12 are only observed when $L_i = 1$.

Development for the maximum simulated estimator for this model is detailed in Greene (2010). To reduce complexity, this study only reports the final log likelihood function to be estimated:

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$$\log L_{s,c}(\beta,\sigma_{\mathrm{u}},\sigma_v,\rho)=\sum_{i=1}^{N}\log\frac{1}{R}\sum_{r=1}^{R}\ L_i\left[\left(\frac{-\frac{1}{2}(\mathrm{C_i}-\alpha' q_i-\beta'\mathrm{w_i}+\sigma_{\mathrm{u}}|U_{ir}|)^2/\sigma_v^2)}{\sigma_v\sqrt{2\pi}}\right)\right]$$

$$\times\left[\Phi\left(\frac{\rho(\mathrm{C_i}-\alpha' q_i-\beta'\mathrm{w_i}+\sigma_{\mathrm{u}}|U_{ir}|)/\sigma_\varepsilon+a_i}{\sqrt{1-\rho^2}}\right)\right]$$

where $a_i=\hat{\alpha}' z_i$.

(2.13)

The integral of this function does not exist in the closed form and this necessitates the computation by simulation. The parameter ρ measures the correlation between the error term from equation 2.11 and "noise" parameter; testing for the existence of selectivity bias. When $\rho=0$, the model reduces to that of the conventional stochastic frontier model (Rahman *et al.*, 2012). The model is estimated using NLOGIT 6 Statistical Package.

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CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Chapter Outline

This Chapter presents details on the methods employed in analyzing innovations in maize production and its effect on farm economic efficiency. The first section discusses physical and administrative features of the study area. The sources and types of data used in the study are presented in Section 3.2. Section 3.3 details the sampling techniques and methods employed. Here, the discussion focuses on presenting the methods used in selecting the study districts as well as determining an appropriate sample size. In Section 3.4, the narrative revolves around the tools used in the data collection for the cross-sectional survey. The final section outlines the theoretical underpinnings of the empirical models discussed in Chapter 2. The links between the Theory of Random Utility and the probit model, the Theory of Production and technical efficiency, and Cost Theory and cost efficiency estimations are summarized in this section.

3.1 Study Area

The research focuses on maize farmers in the Northern region of Ghana. The Northern region is the largest in Ghana in terms of land mass; it is a major player in the agricultural sector of Ghana and contributes very significant shares to the country's food crop production despite having only one rainfall peak season. The region is located between latitudes 8^0N and 11^0N and has a land area of 70,384 km^2, covering almost a third of the nation's total land area. It is bordered to the east and west by Ghana's international neighbours; Togo and la Cote d'Ivoire respectively.

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To the north, the region shares boundaries with the Upper East and Upper West regions, while the Volta and Brong-Ahafo regions are its southern neighbours. The regional climate is mostly dry, with one rainfall peak between May/June and November. The annual precipitation amount varies between 750mm and 1,050mm, with minimum and maximum temperatures recorded at 14^0C and 40^0C. The region is the highest producer of cereals like sorghum and millet and is ranked in the top 5 producers of maize and rice. Similar to most other regions, maize forms a large portion of the calorific demands of the people and is consumed all year round.

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The region also hosts the largest production levels of maize among the Ghana Feed the Future (FtF) intervention regions. With nearly seven (7) months of dry season, the main economic activity of the people – agriculture – is severely hampered as almost 95% of production is dependent on rainfall. The Black and White Volta Rivers drain the region with some of the tributaries dammed for agricultural irrigation purposes.

The Botanga and Golinga Irrigation Schemes in the Tolon and Kumbungu Districts are key examples of these formal irrigation projects in the Northern region (GSS, 2013; Azumah *et al*., 2017).

In recognition of the importance of the Northern region in the food security drive of Ghana, it has been the target of many projects and programmes aimed at improving the production and productivity local staples as well as cash crops like soybean.

Despite the militating effect of the local climate on agriculture, the Northern region is an important player in the food production drive of the nation, leading in the average

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production levels of cereals like millet and sorghum while performing creditably in maize (5th) and rice (2nd) production (MoFA, 2015).

These significant contributions to the food crop sector have led to the widespread regard of the Northern region as the bread basket of the nation.

The Northern region is similarly indispensable in the livestock sub-sector of the country, recording significant percentages of national total in cattle, sheep, goat, and pig production. The region is also popular for its large population of guinea fowl; a domestic poultry that has received serious economic consideration and investment in recent times.

The importance of agriculture to the Northern region is further evidenced by its constitution of nearly 10% of the population of national agricultural households. The average agricultural household size of 8.5 is higher than the national average of 5.3 persons. Unfortunately, the region's prowess in agriculture has failed to translate into wealth and well-being for its people.

The Northern region is administratively divided into 28 Metropolitan, Municipal, and District Assemblies (MMDAs). These administrative areas are headed by their respective Chief Executives who are members of the Regional Coordinating Council (RCC) and report to the Regional Minister. Prior to the General Elections in 2012, the region had 20 MMDAs; 6 more of these were created shortly before the elections. In 2018, 2 more – Nanton District and Yunyoo-Nasuan District – were carved out of the Savelugu-Nanton Municipal and Bunkpurugu-Yunyoo District respectively.

The creation of new administrative regions is aimed at enhancing the efficient running of the government structure in the country through the decentralization and the provision of

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key economic and agricultural-support services like extension access, administration of the national fertilizer subsidy programme and the recent Planting for Food and Jobs Programme.

Six districts with high performance in maize production were selected for this study. These include Karaga, Gushegu, Kumbungu, Nanton, West Gonja, and the Sawla-Tuna-Kalba districts. The geographic spread of the selected districts (Fig. 3.1) covers nearly the entire breadth of the Northern region and can be viewed as being representative of the state of innovative agricultural financing use and economic efficiency of maize production in the region. Respondents were randomly drawn from these locations for the survey.

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3.2 Data Sources and Types

The study relied on primary data for analysis. This primary data which was obtained from a cross-sectional survey in the study area conducted between February and April, 2018. Data on the per-unit costs (market prices) and quantities used of production inputs were collected on continuous scales. Some factors that were believed to influence the use innovative financing among maize farmers such as farmers' gender, access to credit and extension services, and membership of farm cooperatives were collected as categorical variables. Data on farmers' sociodemographic and economic characteristics which could influence economic efficiency and innovative financing use were also collected during the survey.

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3.3 Sampling Technique and Sample Size

As stated earlier, six maize producing districts in the region were purposively selected for the survey with consideration made for their performance in the crop, geospatial location in the region, and logistics available for the survey. The survey sampled a total of three-hundred and sixty (360) maize farmers from the six districts.

The ideal respondent is a maize farmer with more than one season's experience in maize farming, producing on a relatively small landholding with production technologies and inputs representative of the target population. Integration in a household setting with some level of commercial focus (participation in the maize crop market) and being a female producer were added bonuses.

A multi-stage sampling technique was employed to select respondents for the survey. In the first stage, two communities from each district were selected usually on the advice of local agricultural sector players who had had implementation collaborations with The Feed the Future Ghana Agriculture Technology Transfer (ATT) Project. Proportionate samples of maize farmers were randomly selected from these communities in the second stage. Because of the patriarchal nature of most communities in Ghana, special attention was given to the inclusion of female farmers in the survey in order to reduce any gender biases and to get comparable data from both sexes.

To determine the appropriate sample size, the study referred to GSS (2013b) report on the total population of the sampled districts and for the Northern region. The population of Northern region was reported to be 2,479,461 and the total for the six districts was 625, 072.

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This means about 25.21% of the population could be used in calculating the sample size with a z-value of 1.96 at a margin of error of 0.05. The Cochran (1977) sample size determination formula was adapted in this calculation and is outlined thus;

$$n = \frac{z^2 \times p(1-p)}{d^2} \tag{3.1}$$

n= initial sample

p=proportion of population under study (0.2521)

z=value of z at 5% sig. level (1.96)

d= margin of error (0.05)

$$n = \frac{1.96^2 \times (0.2521)(1-0.2521)}{0.05^2}$$
$$= \frac{3.8416 \times 0.1885}{0.0025}$$
$$= 289.66 \approx 290$$

Considering that these figures were taken in 2010 and that the population of the Region increased by 36.1% between 2000 and 2010, the study added an extra 70 respondents to the calculated sample size to cater for population growth. This yielded a total sample size of 360 respondents.

The selection of households in the communities to interview was done quasi-systematically; an absent household or the absence of a suitable respondent for interview led to the replacement of such household with one within close proximity from which a respondent had not been previously selected. In total, eleven (11) communities were selected for the survey (only one community was selected in the Sawla-Tuna-Kalba District

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due to extenuating circumstances) and the distribution of respondents is discussed in the next chapter.

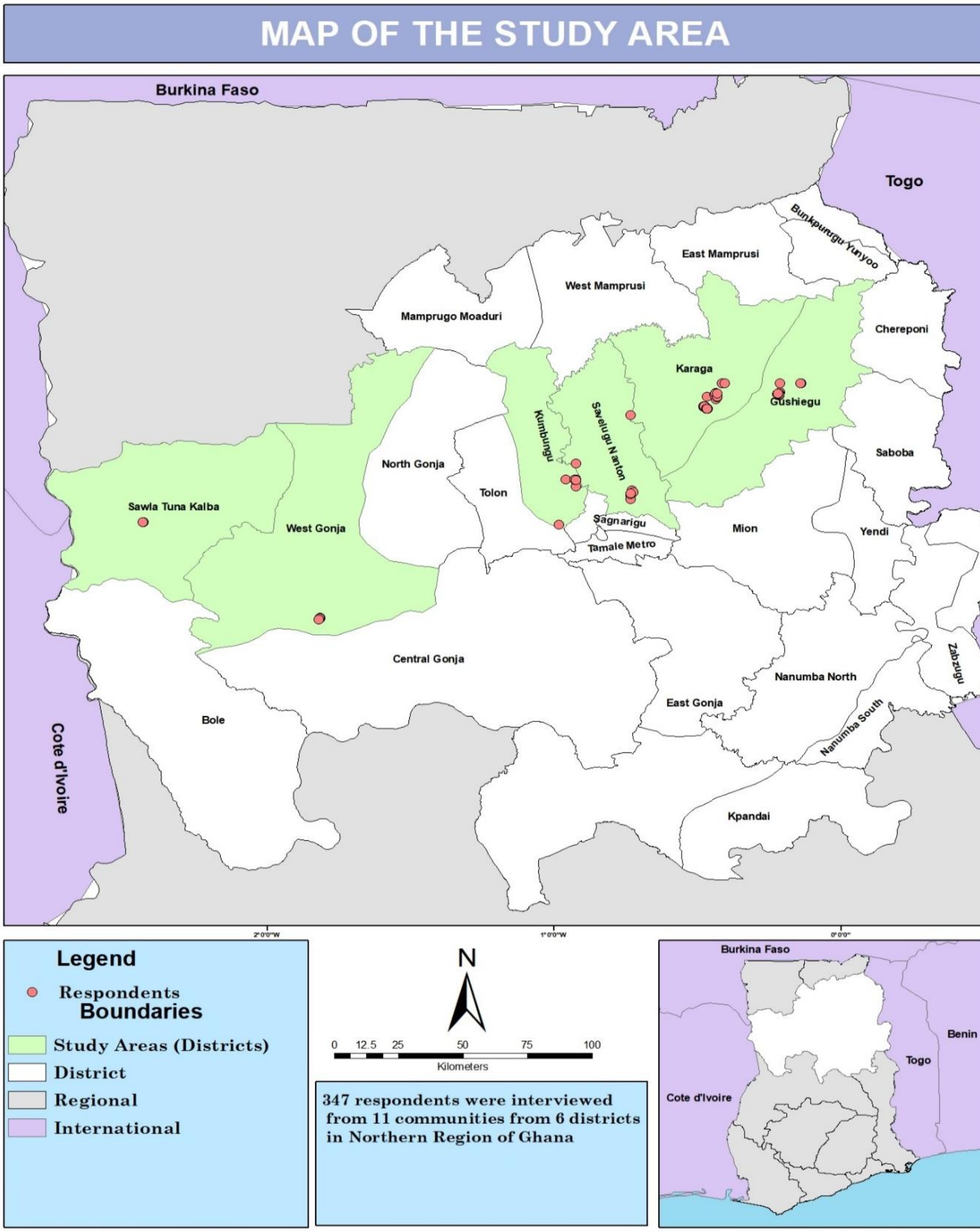

Figure 3. 1: Map of the Study Area

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3.4 Data Collection Tools and Methods

Data from the survey was collected using a semi-structured questionnaire as the key instrument through personal interviews. A team of enumerators were given an initial 2-day intensive training on the administration of the questionnaire to enhance their understanding of the goals of the study and how to incorporate these in their interview processes. This training was followed by a pre-test of the survey instrument in a conveniently selected community in the Kumbungu District. This activity led to the discovery of areas of difficulties in interpreting the questions and shortcomings in the questionnaire; these challenges were addressed with modifications to the questionnaire. The modified questionnaire was again tested in the same community (using different respondents and translators) to ensure that initial challenges were resolved – data from this exercise was not used in the final estimations as they are significantly incompatible with the final data.

When the researcher and the enumerators were satisfied with the state of the questionnaire and understanding of the interview questions, the enumerators were dispatched to the actual sampled communities with the author actively participating in the data collection process (both as an enumerator and coordinator). This helped in promptly addressing any issues arising on the field.

3.5 Analytical Framework

3.5.1 Conceptual Framework

In this project, the interest lies in examining the linkage between innovative financing usage and economic efficiency. This is conceptualized in Figure 3.2 below, which outlines

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the interrelations between the innovative financing use, economic efficiency of maize production, and their main determinants. In a production system with limited financial options for farmers, use of innovative financing methods is expected to present viable sources of generating funds to meet farm needs. These funds are expected to boost farmers' propensity to purchase inputs required to boost productivity per cultivated area. This implies that users of innovative financing will operate at a higher production technology level than nonusers and will therefore have better technical efficiency. Also, with the assumption that farmers in general and user farmers specifically, are rational consumers who seek to derive the maximum possible utility from the last Ghana Cedi allocated to farm expenditure, it can clearly be adduced that use of innovative financing will increase farmer's allocative efficiency. Consequently, use of innovative financing is expected to have a positive effect on economic efficiency of maize production for farmers in the Northern region.

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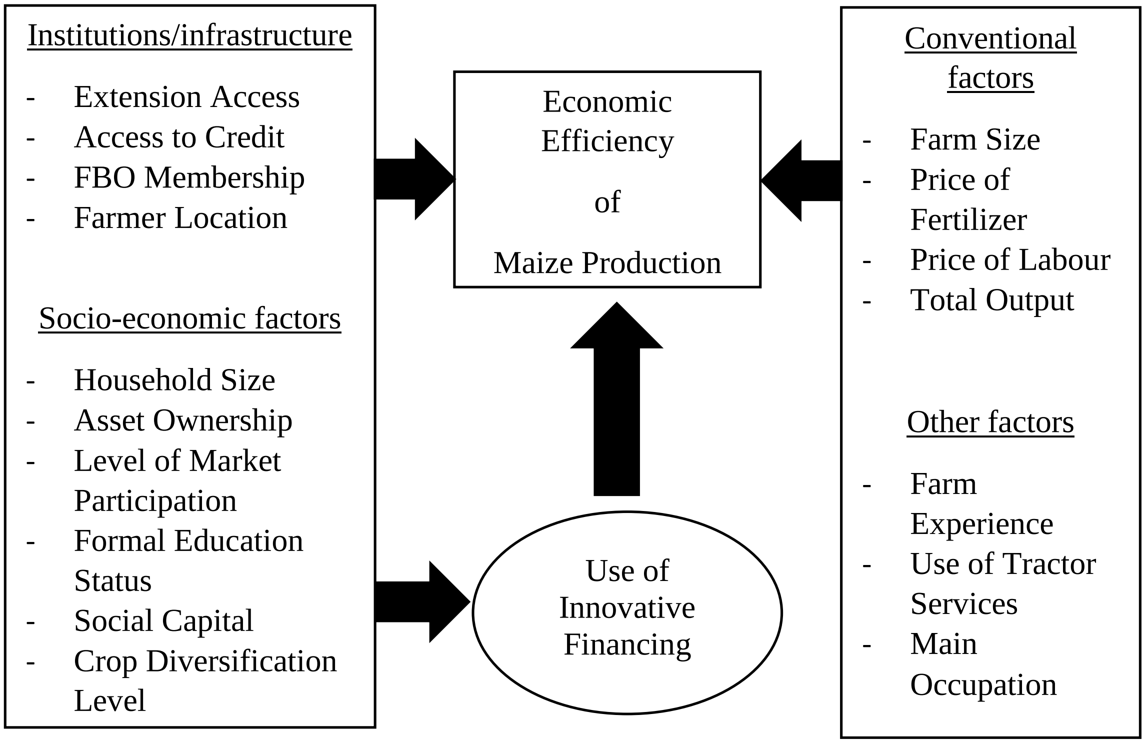

Figure 3. 2: Conceptual Framework linking innovative financing use, economic efficiency and their determinants

Source: Author's Conception

The main variable explaining economic efficiency, which is the use of innovative financing, is influenced by variables that can be broadly categorized as institutional or infrastructural and socioeconomic variables. The institutional or infrastructural variables describe those factors that are externally established and have the potential to increase farmers' propensity of using innovative financing.

These variables include contact with Agricultural Extension Agents (AEAs), credit access, and farmers' geographic location. Socioeconomic variables like household size, level of market participation, level of crop diversification, and extent of asset ownership by the farm household are all expected to influence farmers' disposition to using innovative financing in one way or the other.

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Economic efficiency of maize production is determined by conventional factors like farm size and total output as well as the unit prices of inputs like fertilizer and labour. These conventional variables are captured in the deterministic component of the Stochastic Cost Frontier model. The inefficiency model of the stochastic cost function enjoins, alongside use of innovative financing, exogenous variables such as farm experience, use of tractor services, and some of the institutional and socioeconomic variables discussed earlier.

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3.5.2 Determinants of Innovative Financing Use

The random utility model is employed as the theoretical framework to examine the factors influencing respondents' decision to use innovative financing. A smallholder maize farmer's decision to use innovative financing is driven by the need to generate income due to limited financial resources. This decision is initiated by the farmer and is one that creates a certain amount of utility for the farmer.

The originality of the stimuli for that decision is what makes the choice "farmers' own innovation" as opposed to participation in a formalized agricultural intervention/ programme. Thus, the farmer is faced with a discrete (binary) choice on which action, with regard to innovative agricultural financing, is likely to produce the greatest satisfaction (satisfaction could be in terms of achieving minimum total production cost or maximum total productivity).

Armed with knowledge on the constraints farmers face in accessing financing for farm investment, the questionnaire specifically elicited information on what farmers do when faced with limited resources. These questions yielded two key responses thus;

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- to join a Village Savings and Loans Association (VSLA) group specifically to take advantage of the possibility of accessing credit at short notice, at a relatively cheap cost, and with minimal processing requirements or (and)
- to take informal farm and off-farm jobs in order to raise funds to meet the input needs of the farm when the production season begins.

The study uses a choice model to examine the determinants of maize farmers' decision on either (or a combination) of the above choices. A farmer who uses either or both of these agricultural financing methods is deemed to have used innovative financing and is assigned to the "treatment" group; failing to use either method translates to being a non-user and is accompanied by assignment to the "control" group.

In modeling utility maximization of farmers, the Rational Choice Theory can be used and the general assumption is that farmers have a preference among the available choice alternatives that allows them to state which option they prefer. These preferences are assumed to be complete (the person can always say which of two alternatives they consider preferable or that neither is preferred to the other) and transitive (if option A is preferred over option B, and option B is preferred over option C, then A is preferred over C).

The farmer is assumed to take account of available information, probabilities of events, and potential costs and benefits in determining preferences, and to act consistently in choosing the self-determined best choice of action. Cascetta (2009) formalizes the assumptions underlying random choice theory as follows;

a) the generic decision-maker, in making a choice, considers a finite set of *mutually exclusive* alternatives and these make up the choice set *I*;

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b) The decision-maker assigns to each alternative in his choice a perceived utility or attractiveness and bases on this assignment to make the choice that maximises this utility;

c) The utility assigned to each alternative depends on the number of "attributes" of the alternative itself and of the decision-maker: $U_{ij} = U_i\left(\mathrm{X}_{\mathrm{ij}}\right) where\, \mathrm{X}_{\mathrm{ij}}$ is the vector of attributes relative to alternative *j* and decision-maker *i*;

d) The utility assigned by the decision-maker *i* to alternative *j* is not known with certainty by an external observer who is looking to model this decision; this necessitates the representation of the utility by a random variable.

Further, the above assumptions dictate that it is usually not possible to predict with certainty the alternative that the farmer will select. However, it is usually possible to express the probability that the perceived utility of electing to use innovative financing is greater than all other alternatives conditional on the farmer's choice set *I*. This is expressed as:

$$p_i\left(j\middle|I\right) = \Pr\left[U_{ij} > U_{ik} \forall k \neq j, k \in I\right] \tag{3.2}$$

A farmer's decision to use innovative financing is aimed at achieving the maximum level of maize output at the minimum cost. This motivation holds true for all farmers irrespective of their socioeconomic and demographic characteristics like age, sex, and market participation.

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Achieving this aim brings the farmer some level of utility that increases with higher maize yields and lower production costs. A maize farmer is said have maximised her utility when the decision to use innovative financing leads to increased productivity and lowered costs.

Thus, a maize farmer with limited financing options is faced with a 0/1 decision and we can model the decision to use innovative agricultural financing as a function of some of the characteristics discussed above. Other factors that influence this decision may be generally applicable to the entire (or homogenous subsets of) population. Examples of these are climatic and location variables. A final category of variables that affect use of innovative agricultural financing may be idiosyncratic and specific to individual farmers. Examples of these include the farmer's access to agricultural extension services and level of social integration (proxied by the count of social groups membership). The binary nature of the decision means the result of the parameter estimate can be read as a probability that a farmer chooses to use innovative agricultural finance (Ansah *et al.*, 2014). The Probit model is fitted to this function and is of the form;

$$p(L_i^* = 1 | Z_i) = \gamma Z_i + w_i \quad (3.3)$$

$$L_i = \begin{cases} 1 \, if \; L_i^* > 0; \; farmer\,uses\,innovative\;financing \\ 0 \, if \; L_i^* \leq 0; \; farmer\,does\,not\,use\,innovative\;financing \end{cases}$$

where

Z_i *is a vector of observed characteristics*

w_i *is the error term of the binary estimator*

Empirically, the model is specified as;

$$p(L_i = 1 | Z_i) = \gamma_0 + \sum_{i=1}^{22} \gamma_i Z_i \quad (3.4)$$

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Z_i *is as defined in* 3.2;

γ_i *is the coefficient of the independent characteristic to be estimated*

The explanatory variables used in this estimation, their units of measurement, and their *a priori* expected direction of influence are summarized in Table 3.1 below:

Table 3. 1: Description of Variables in the Probit Model and their a priori Expectations

Var.	Description	Measurement	-/+
Z_1	Access to Formal Credit	Dummy; 1 if farmer has access to credit	-
Z_2	Farming as Main Occupation	Dummy; 1 if main occupation is farming	+
Z_3	Extension Access	Dummy; 1 if farmer had contact with AEA	+
Z_5	FBO Membership	Dummy; 1 if farmer is a member of a FBO	-
Z_6	Assets ownership	Count of assets owned by the farmer	-
Z_7	Household Size	Count of farmer's household members	+
Z_8	Formal Education Status	Dummy; 1 if farmer is formally educated	-
Z_9	Maize as main crop	Dummy; 1 if maize is the farmer's main crop	+
Z_{10}	Social Capital	Number of social groups farmer belongs to	+
Z_{11}	Household Position	Dummy; 1 if farmer is the Household Head	-
Z_{12}	Level of Crop Diversification	Number of food crops cultivated by farmer	+
Z_{13}	Personal Tragedy	Dummy; 1 if farmer faced a tragic incident	+
Z_{14}	Manure Use	Dummy; 1 if farmer uses farmyard manure	-
Z_{D1}	Karaga District	Dummy; 1 if farmer is from Karaga District	+/-
Z_{D2}	Gushegu District	Dummy; 1 if farmer is from Gushegu District	+/-
Z_{D3}	Kumbungu District	Dummy; 1 if farmer is from Nanton District	+/-
Z_{D5}	West Gonja District	Dummy; 1 if farmer is from West Gonja	+/-
Z_{D6}	STK* District	Dummy; 1 if farmer is from STK* District	+/-
Z_{MP2}	Only Commercial	1 if farmer is solely commercial	+
Z_{MP3}	Largely Subsistence	1 if farmer is largely subsistence	+
Z_{MP4}	Largely Commercial	1 if farmer is largely commercial	+
Z_{MP5}	Both Equally	1 if equally commercial and subsistence	+

**STK= Sawla-Tuna-Kalba*

The estimate of L_i from equation 3.3 is actually a latent variable that can only be observed by examining the probability that the event of interest occurs – a farmer uses innovative agricultural financing. Due to observed heterogeneity that may exist among the sampled farmers with respect to these selected characteristics, the estimated probabilities may be

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biased. The bias mainly stems from farmers whose characteristics make them more likely than usual to use innovative agricultural financing for maize farming. These farmers are outliers whose inclusion in the study sample may lead to overestimation of these probabilities.

To correct these biases, the study employed a matching approach (the Propensity Score Matching or PSM). This calculates a conditional probability based on which farmers are assigned a treatment given a set of pretreatment observed characteristics (Anang *et al.*, 2016). The PSM is expressed as;

$$p(\mathrm{X}) = \Pr\left\{L = 1 \middle| X\right\} = E\left\{L \middle| X\right\} \tag{3.5}$$

where

$L = \{0, 1\}$ *represents the treatment indicator variable* $-$ *use of innovative financing*
X *is a vector of pretreatment characteristics*
E *is the expectation sign* (*expected value*)

The conditional probabilities ($p(X)$) estimated in equation 3.4 is a propensity score (a measure of the probability of using innovative agricultural financing) and is estimated for both innovators and non-innovators of agricultural fnancing. Based on these scores, we are able to, match users and nonusers in a sub-sample among whom biases stemming from observed heterogeneous characteristics are significantly reduced (or even totally removed).

Using this subsample in any further estimation that seeks to establish causal effect will yield unbiased parameters that are more relevant for policy.

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3.5.3 Tests of Hypothesis

In estimating the effect of innovative financing use on the cost efficiency of maize farmers in the Northern region of Ghana, three key (3) hypothesis need to be tested. As indicated in Section 2.8, estimation of the Stochastic Frontier Model requires specifying a functional form for the model. Thus, the first hypothesis test deals with the appropriateness of the functional form adopted for the study. The null hypothesis for this test that the Translog is more appropriate than the Cobb-Douglas functional form for this study. After deciding on the appropriate functional form, the subsequent tests deal with establishing the presence or otherwise of inefficiency effects in the model and whether the socioeconomic variables included in the inefficiency component of the model have any explanatory power in observed inefficiency in the estimation. The null hypothesis for these tests are presented thus;

1. $H_0 : \beta_{ij} = \beta_{ji} = 0$

The coefficients of the square and interaction terms in the Translog model have a zero sum.

2. $H_0 : \gamma = \sigma_0 ... = \sigma_{22} = 0$

There are no inefficiency effects

3. $H_0 : \sigma_0 ... = \sigma_{22} = 0$

The effect of socioeconomic variables on the inefficiency term, u_i is zero (0)

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3.5.4 Measurement of Technical Efficiency

Maize farmers in the Northern region of Ghana are involved in the transformation of farm inputs like cultivated land area, labour, and capital inputs like fertilizer into maize outputs. This is done through a production process that is mono-periodic. The theory of production is the theory underlying this transformation of inputs into finished outputs. The theory of production works through the production function – technical relationship between the inputs and outputs of a production process.

Classical economic theory considers producers (decision-making units) as efficient operators who are fully able to maximise their output (revenue) and profit, and minimize their cost while also pursuing other objectives (Kumbhakar and Wang, 2015). This would imply that smallholder maize farmers achieve the highest possible yields (equal to the maximum attainable yields; frontier) and would allocate inputs like fertilizer to their farms in optimal proportions and so were immune to wastage. The discussions presented so far show that these assumptions are flawed as far as maize production in Northern region (and indeed most productions in other parts of the world) is concerned. It is a truism that production is fraught with inefficiencies. Some of these inefficiencies may be acceptable in the economy (especially where the cost of removing the inefficiency outweighs the value of benefits (Leibenstein, (1966)).

The inefficiency may result from managerial incompetence as result of variations in individual farmers' ability to convert inputs into useful outputs and natural and institutional events that limit the ability of a farmer to achieve full efficiency in production.

Since the level of inefficiency varies from farmer to farmer, even in the presence of same production technology, climatic conditions, and policy environment, it is inadequate to measure this inefficiency in aggregate terms. This makes it necessary to estimate the technical efficiency of individual farmers. The study uses the Stochastic Production Frontier (SPF) model because it is able to account for deviations from the frontier resulting from exogenous factors and statistical noise through its composed error term. The stochastic frontier production function is given as;

$$y_i = \beta' x_i + v_i - u_i \tag{3.6}$$

where

y_i *is the maize output,*

x_i *is the vector of inputs,*

u_i *is one – sided error term indicating technical inefficiency;*

$$u_i = |\sigma_u U_i| = \sigma_u |U_i|, U_i \sim N[0,1^2],$$

v_i *is stochastic error indicating effects of pure random factors on production*

$$v_i = \sigma_v V_i, V_i \sim N[0,1^2].$$

Since technical efficiency (TE) is the ratio of observed output to the frontier output, it can be specified as;

$$TE_i = E\left(\frac{y_i}{y_i^*}\right) = E\left(\frac{\beta' x_i + v_i - u_i}{\beta' x_i + v_i}\right) = E(-u_i) \tag{3.7}$$

where

y_i *is observed output*

y_i^* *is frontier output*

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A key feature of the SPF model is the need to specify a functional form for the production function and a distribution for the error term. After conducting a Likelihood Ratio test, this study selected the Cobb-Douglas functional form to model the maize production technology in Northern region. Empirically, this is modelled as;

$$\ln Y_i = \ln \beta_0 + \beta_i \sum_{j=1}^{3} \ln X_{ij} + v_i - u_i \qquad (3.8)$$

The vector of inputs used in the estimation are land area and quantities of fertilizer and labour employed. The quantities of maize seed planted and pesticide used are not included in this estimation for various reasons. For both inputs, majority of the farmers interviewed planted their reserved seeds from the previous season and so did not purchase seeds leading to a serious case of missing observations. A similar case exists for quantity of pesticides used.

Thus, the observed output after estimation becomes;

$$\ln Y_i = \ln \beta_0 + \beta_i \sum_{j=1}^{3} \ln X_{ij} + v_i \qquad (3.9)$$

The inefficiency variable is assumed to follow a half-normal distribution $(u \sim N[0, \sigma_u^2])$ as is typically the case in applied stochastic frontier literature (Khan and Saeed, 2011). The inefficiency effects can be obtained such that:

$$u_i = \sigma_0 + \sum_{n=1}^{22} \sigma_n Z_{ni} \qquad (3.10)$$

where

Z_i *is farmer – specific independent characteristics*

σ *is vector of coefficients to be estimated*

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The vector of inputs and other farmer characteristics included in this model and their a priori expectations are presented in Table 3.2. For the inefficiency variables, a positive sign implies an increase (or presence) in (of) the variable contributes to technical *inefficiency*.

Table 3. 2: Description of Variables in the SPF Model and their *a priori* Expectations

Var.	Description	Measurement	-/+
Deterministic Component of SPF Model			
X_1	Farm Size	Area of farm plot cultivated to maize in acres	+
X_2	Quantity of Fertilizer	Quantity of inorganic fertilizer used (kg)	+
X_3	Quantity of Labour	Quantity of maize farm labour (mandays)	+
Z_{D1}	Karaga District	Dummy; 1 if farmer is from Karaga District	+/-
Z_{D2}	Gushegu District	Dummy; 1 if farmer is from Gushegu District	+/-
Z_{D3}	Kumbungu District	Dummy; 1 if farmer is from Kumbungu District	+/-
Z_{D5}	West Gonja District	Dummy; 1 if farmer is from West Gonja	+/-
Z_{D6}	STK District	Dummy; 1 if farmer is from STK District	+/-
Inefficiency Model			
Z_1	Extension Access	Dummy; 1 if farmer had contact with AEA	-
Z_2	Household Size	Dummy; 1 if farmer is male	-
Z_3	FBO Membership	Dummy; 1 if farmer is a member of a FBO	-
Z_4	Main Occupation	Dummy; 1 if farming is main occupation	-
Z_5	Household Size	Count of farmer's household members	-
Z_6	Years of Education	Number of Completed Years of Education	-
Z_7	Farm Experience	Number of Years in Maize Farming	-
Z_8	Use of Innovative Financing	Dummy; 1 if farmer uses innovative financing	-
Z_{MP2}	Only Commercial	1 if farmer is solely commercial	+/-
Z_{MP3}	Largely Subsistence	1 if farmer is largely subsistence	+/-
Z_{MP4}	Largely Commercial	1 if farmer is largely commercial	+/-
Z_{MP5}	Both Equally	1 if equally commercial and subsistence	+/-
Z_{10}	Manure Use	Dummy; 1 if farmer uses farmyard manure	-
Z_{11}	Access to Formal Credit	Dummy; 1 if farmer had access	-
Z_{12}	Use of mechanized inputs (tractor)	Dummy; 1 if farmer used mechanized inputs	-
Z_{13}	Level of Crop Diversification	Number of food crops cultivated by farmer	+

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3.5.5 Measurement of Economic Efficiency

The production of any level of output is made possible by the proportionate combination of inputs at a particular time. Given an output level, it is sometimes easier to determine the minimum cost of production given the market prices of the inputs used. The combination of inputs given their prices in such a manner as to achieve the minimum cost at any time is the basis of cost theory. This theory makes the assumption that producers have a cost-minimising objective. It works through the formulation and application of the cost function.

Since cost functions are derived from production functions, they can be said to be the dual of production function. The short and long run cost functions are presented as;

Long-run cost function: $$C_i = f(y_i, P_{ik}) \quad (3.11)$$

Short-run cost function: $$C_i = f(y_i, P_{ik}, \bar{K}) \quad (3.12)$$

where

C_i *is the observed cost for farmer i*

y_i *is the output level*

P_{ik} *is a vector of unit prices of input k*

$\bar{K}$ *is a fixed factor*

The dual of the production frontier, cost frontier can be formulated by applying an extended Cobb-Douglas cost function to equation 3.10, we obtain the following;

$$\ln C_i = \alpha_0 + \beta_1 \ln X_1 + \sum_k \alpha_k \ln P_{ik} + \gamma \ln y_i + v_i + u_i \quad (3.13)$$

where

C_i *is the observed cost for output* y_i

P_{ik} *is a vector of unit prices of* k^{th} *input*

$v_i + u_i$ *is the composed error term for the cost function*

$\alpha, \beta,$ *and* γ *are parameters*

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Because any inefficiency will lead to an increase in the cost of production, u_i is given an additive property. In this study, the one-sided error term is assumed to have a half-normal distribution in the production function estimation. As usual, it is further assumed that u_i is independent of v_i and that maize farmers in all sampled districts are faced with similar production technologies. Table 3.2 discusses the variables used in both the deterministic and the inefficiency component of the Stochastic Cost Frontier (SCF) model. The cost frontier will help us estimate the economic efficiency and allocative efficiency of maize farmers.

Just as for the production function, this study estimates the cost function for individual maize farmers and compares this outcome to the minimum cost at that output level (cost frontier) in estimating farmer's cost efficiency. This defines the farm-specific economic efficiency (EE).

$$EE = \frac{C^*}{C} = \frac{E(C_i | u_i = 0, y_i, P_i)}{E(C_i | u_i, y_i, P_i)} = e^{[E(u_i | \varepsilon_i)]} \tag{3.14}$$

With estimates for both economic and technical efficiency, it is possible to estimate the allocative efficiency of maize farmers residually through the following relationship;

$$EE = TE \times AE$$
$$AE = \frac{EE}{TE} \tag{3.15}$$

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Table 3. 3: Description of Variables in the SCF Model and their *a priori* Expectations

Var.	Description	Measurement	-/+
Deterministic Component of SCF Model			
X_1	Farm Size	Area of farm plot cultivated to maize in acres	+
P_2	Price of Fertilizer	Unit price of organic fertilizer used (GH₵)	+
P_3	Price of Labour	Unit price of maize farm labour (GH₵)	+
y_i	Output	Observed maize output for farmer *i*	+
Inefficiency Model			
Z_1	Extension Access	Dummy; 1 if farmer had contact with AEA	-
Z_2	Farm Experience	Count of farmer's seasons in maize production	-
Z_3	Farming as Main Occupation	Dummy; 1 if farming is main occupation	-
Z_4	Household Size	Count of farmer's household members	-
Z_5	Use of Innovative Financing	Dummy; 1 if farmer uses innovative financing	-
Z_{MP2}	Only Commercial	1 if farmer is solely commercial	+/-
Z_{MP3}	Largely Subsistence	1 if farmer is largely subsistence	+/-
Z_{MP4}	Largely Commercial	1 if farmer is largely commercial	+/-
Z_{MP5}	Both Equally	1 if equally commercial and subsistence	+/-
Z_6	Distance to Farm	Distance from homestead to maize plot	-
Z_7	Use of Mechanised Services	1 if farmer used tractor services for maize production	-
Z_8	Manure Use	Dummy; 1 if farmer uses farmyard manure	-
Z_9	FBO Membership	Dummy; 1 if farmer is a member	-
Z_{10}	Access to Formal Credit	Dummy; 1 if farmer had access	-
Z_{11}	Maize as Main Crop	Dummy; 1 if maize is farmer's main crop	+
Z_{12}	Social Capital	Number of social groups farmer belongs to	-
Effects of Random Factors			
Z_{D1}	Karaga District	Dummy; 1 if farmer is from Karaga District	+/-
Z_{D2}	Gushegu District	Dummy; 1 if farmer is from Gushegu District	+/-
Z_{D3}	Kumbungu District	Dummy; 1 if farmer is from Kumbungu District	+/-
Z_{D5}	West Gonja District	Dummy; 1 if farmer is from West Gonja	+/-
Z_{D6}	STK District	Dummy; 1 if farmer is from STK District	+/-

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Thus, the discussed model is sufficient in estimating the economic, technical, and allocative efficiencies of maize farmers. In order to check the absence of inefficiency effects, we use a test of the lambda (λ) parameter. If the value of (λ) is equal to zero (0), there are no cost inefficiencies and all deviations from the cost frontier can be attributed to "noise" (Aigner, Lovell, & Schmidt, 1977). Khan and Saeed (2011) specify the λ parameter as;

$$\hat{\lambda} = \frac{\sigma_u}{\sigma_v} \tag{3.16}$$

where,

σ_u is the standard error of u σ_v is the standard error of v.

Based on equation 3.5, it is possible to estimate the effect of cost (and technical) inefficiency on the total cost of production (or on maize output). This effect is measured through a gamma parameter specified as;

$$\hat{\gamma} = \frac{\hat{\lambda}^2}{1+\hat{\lambda}^2} \tag{3.17}$$

The estimated gamma parameter is interpreted as a percentage of the total variation in the cost of producing maize attributable to cost inefficiency.

By a simple specification process, one could estimate separate efficiencies for users and nonusers of innovative financing. A simple t-test can be used to test the null hypothesis of no differences in the estimated economic efficiency. One issue which may arise from our estimation is biases resulting from unobserved heterogeneity among the sampled farmers.

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While the inclusion of an indicator variable for farmers who use innovative financing may help capture the differences in efficiency between users and nonusers, it may not be sufficient to attribute this difference solely to farmer's choice between the financing options.

The stochastic frontier model, in and of itself, is not equipped to correct for biases stemming from observed differences in farmer characteristics (e.g. access to agricultural support services). By assuming the same technology for all farmers without regards to these differences, we risk over- or under-estimating the economic efficiency of maize farmers and the differences estimated for users and nonusers.

A correct attribution of any difference in the estimated efficiency to the choice of financing requires that the outcome for users (beneficiaries) of the treatment and the outcome for users had they not benefited from the treatment be known with certainty; the only difference in observed characteristics of users (treated group) and nonusers (control group) be their choice of financing. This is called the 'counterfactual' in impact evaluation studies (Bravo-Ureta *et al.,* 2012).

Since it is impossible for both states of nature to exist at same time, the standard practice is to select another sample which shares similar pretreatment characteristics with the treatment group and only differ in the fact that they did not receive the treatment under study. This other sample provides a credible enough group against whom comparisons can be made. As it stands, the subsample generated from the Propensity Score Matching technique discussed earlier meets these requirements in every way possible.

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Using this sample for estimating the economic efficiency of users and nonusers will yield results that are free from biases stemming from observed heterogeneity, especially when the observed biases are time invariant.

Assignment into the treatment group requires the farmer to make, at least, a choice to use a financing option; this assignment is not done randomly since the decision-making process is not exogenous. The factors influencing either of these decisions may be innate or perhaps only available to farmers with certain unobservable traits with higher managerial ability. These imply that there is the possibility of self-selecting into the treatment group. Failing to correct this possible selectivity results in biased estimates. Thus, after correcting for biases resulting from observed characteristics, it is also important to check and correct for biases stemming from unobserved heterogeneity and selection bias. In the context of the stochastic frontier model, there are many options in attempting to correct for possible selectivity bias. The best approach, in our opinion, is the model introduced by Greene (2010).

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The sample selection and stochastic cost function model, and their error structures, are expressed as;

Sample selection: $L_i = 1[\gamma Z_i + w_i > 0], w_i \sim N[0,1]$ (3.18)

Cost Function: $\ln C_i = \alpha_0 + \beta_1 \ln X_1 + \sum_k \alpha_k \ln P_{ik} + \gamma \ln y_i + \varepsilon_i, \varepsilon_i \sim N[0,1]$ (3.19)

$$C_i, y_i, X_i, P_{ik} \text{ are observed only when } L_i = 1$$

Error Structure: $\varepsilon_i = v_i + u_i$

$$u_i = |\sigma_u U_i| = \sigma_u |U_i|, where U_i \sim N[0,1]$$

$$v_i = \sigma_v V_i, where V_i \sim N[0,1]$$

$$(w_i, v_i) \sim N_2[(0,1),(1, \rho\sigma_v, \sigma_v^2)]$$

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A quick examination of the above equations reveals that equations 3.15 and 3.2 share striking similarities. Also, 3.16 is the same as the cost function presented in 3.12. The error structures are as discussed before. All notations maintain their original meanings. The sample selection bias arises from a correlation of the unobservable residuals (stochastic noise) in the cost frontier function (v_i) with the residual of the financing choice equation (w_i) (Greene, 2008). The parameter ρ captures the presence of selectivity bias; the model returns to the normal stochastic frontier when ρ=0.

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CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Chapter Outline

This chapter presents and discusses the results from the analysis of the cross-sectional data. The chapter is outlined thus; Section 4.1 presents the results on respondents' sociodemographic characteristics, Section 4.2 discusses the descriptive statistics on the magnitude and sources of agricultural finance in maize production. The two subsequent sections outline some sources of financing that maize farmers use in the study area as well as the magnitudes of funds from these sources. Further information is provided on the methods of financing that this study classified as innovative financing and the factors influencing their use among respondents. After identifying the determinants of innovative financing use, sections 4.7 to 4.10 bring to fore the effect of innovative financing use on farmers' economic efficiency using diverse estimation methods.

4.1 Sociodemographic Characteristics of Respondents'

4.1.1 Age distribution of respondents

The results indicate an average age of 42 years. This points to a population that is on average, relatively strong and is within the active working age group, capable of continuing in the production of maize for at least two more decades, given the current situation or even better. The youngest respondent was 19 years, while the oldest was 80 years.

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Majority of the respondents (32.85%) were between the 35-44 years age range. With over 60% of the respondents being below the age of 45 years, the astute human resource capacity of the region is given a glowing portrayal.

Table 4. 1: Age of Respondents

Age Group	Frequency	Percent (%)
15-24	7	2.02
25-34	89	25.65
35-44	114	32.85
45-54	74	21.33
55-64	48	13.83
65 and over	15	4.32
Total	**347**	**100.00**
Mean= 42.03	**SD=11.41**	**Min=19 Max=80**

Source: Field survey, 2018

At the district and community levels, on the basis of their estimated average ages, the youngest district is Karaga, followed by Gushegu with Sawla-Tuna-Kalba turning out to be the district with the highest mean age. In contrast, the town with the least mean age of respondents is Zantili in the Gushegu District with 40.7 years. Cheyohi in the Kumbungu District, with an average age of 50 years, is the community with the highest average age.

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Table 4. 2: Age of Respondents by Districts and Communities

District of Survey	Name of Community	15-24	25-34	35-45	45-54	55-64	65+	Total	Summary Statistics
Karaga μ=41.03 SD=11.67 Min=19 Max=80	**Monkula**	2	11	15	11	4	1	44	μ=40.77 SD=10.31 Min=19 Max=65
	Kupali	2	11	8	5	4	2	32	μ=41.38 SD=13.49 Min=22 Max=80
Gushegu μ=41.14 SD=9.94 Min=24 Max=65	**Nakohagufong**	1	4	8	4	3	2	22	μ=42 SD=11.98 Min=24 Max=65
	Zantili	0	11	16	12	4	0	43	μ=40.70 SD=8.84 Min=25 Max=60
Kumbungu μ=41.83 SD=13.19 Min=23 Max=70	**Yipeligu**	1	15	12	5	3	3	39	μ=39.10 SD=12.52 Min=23 Max=70
	Cheyohi	0	2	2	3	5	1	13	μ=50 SD=12.09 Min=29 Max=67
Savelugu-Nanton μ=42.12 SD=11.47 Min=25 Max=70	**Nanton Botingli**	0	8	13	5	9	2	37	μ=44.22 SD=11.78 Min=27 Max=70
	Sanvuli	0	8	11	6	4	0	29	μ=39.66 SD=10.70 Min=25 Max=62
West Gonja μ=42.61 SD=9.87 Min=24 Max=65	**Alhassankura**	1	5	14	12	0	0	32	μ=41.16 SD=7.49 Min=24 Max=53
	Atributu	0	4	10	3	5	2	24	μ=44.54 SD=12.27 Min=27 Max=65
STK μ=45.16 SD=13.02 Min=26 Max=70	**Dani-ur**	0	10	5	8	7	2	32	μ=45.16 SD=13.02 Min=26 Max=70
Total		**7**	**89**	**114**	**74**	**48**	**15**	**347**	

Source: Field survey, 2018

4.1.2 Sex distribution of respondents

Males dominated the sample (66.57%), while females formed about 33.43% (see Table 4.3). This shows the dominance of males in maize crop production sector. Also, being a key staple of households in the region, and indeed the nation, the production of maize is widely undertaken by males who are usually the heads of these households. This notwithstanding, there is a significant population of female maize farmers whose output contributes to the subsistence needs of the farm family and where surpluses exist, they are sold to complement the household's income needs.

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The results show that for Kumbungu and West Gonja Districts especially, there is a wide gap between the representations of the sexes, with males dominating females in a near perfect one-sided affair. Sawla-Tuna-Kalba (53.12%) and Savelugu-Nanton Districts (51.16%) are the only districts with higher female representation in the sample than males – Gushegu and Karaga districts are fairly balanced in terms of representation with 56.92% and 61.84% of males respectively.

At the community level, Zantili in the Gushegu District has the highest female representation, with 55.81%, among the sampled communities. Respondents in Yipeligu in the Kumbungu District constitute an overwhelming majority of males at 94.87%, representing the highest male percentage among the communities. Respondents from Monkula in the Karaga District were split perfectly between males and females and represents the ideal scenario we envisaged prior to the survey.

Comparing these findings to statistics on these districts in the regional report of the 2010 Population and Housing Census (GSS, 2013), we find that none of the districts recorded female population less than males although there is no census on farmers to corroborate or dismiss our finding of male dominance in maize production.

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Table 4. 3: Sex of respondents

District of Survey	Sex distribution of respondents in district		Name of Community	Sex distribution of respondents in community	
	Male %	**Female %**		**Male %**	**Female %**
Karaga			Monkula	50.00	50.00
	61.84	38.16	Kupali	78.13	21.87
Gushegu	56.92	43.08	Nakohagufong	81.82	18.18
			Zantili	44.19	55.81
Kumbungu	94.24	5.76	Yipeligu	94.87	5.13
			Cheyohi	92.31	7.69
Savelugu-			Nanton Botingli	64.86	35.14
Nanton	48.84	51.16	Sanvuli	74.36	25.64
West Gonja			Alhassankura	93.75	6.25
	81.07	8.93	Atributu	77.50	12.50
STK	46.88	53.12	Dani-ur	46.88	53.12

Source: Field survey, 2018

4.1.3 Education Level of Respondents

Much has been said about the importance of formal education, or at least the attainment of aptitude in literacy, to the capacity for success of individuals involved in any venture. Bearing in mind that this study seeks to assess respondents' ingenuity and innovativeness in financing their farming activities and how this contributes to their efficiency in production, it was deemed imperative to examine the educational level of the respondents.

The results reveal that majority of the respondents (72.62%) did not have any form of education with nearly half of the remaining 27.48% having primary level education. All other levels (Junior High, Senior High, Diploma, 1st Degree, Non-formal, and Others) received some amount of representation. Table 4.4 summarizes the distribution of education.

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Table 4. 4: Distribution Respondents' of Education

Level of Education	Frequency	Percent (%)
None	252	72.62
Primary	45	12.97
JHS	21	6.05
SHS	18	5.19
Diploma	7	2.02
1st Degree	3	0.86
Non-formal	1	0.29
Total	**347**	**100.00**
Number of years of Education		
Obs=95 Mean= 7.54	SD=4.32 Min=1	Max=19

Source: Field survey, 2018

For the 95 respondents with some form of formal education, the mean number of completed years of education was 7.42, indicating a 7th Grade level of education, which could be quite adequate for handling the managerial affairs of the household farm.

Table 4. 5: Summary Statistics of Years and Level of Education of Respondents across communities

		Education Level of Respondents							
District of Survey (Literacy %)	**Name of Community**	**None**	**Primary**	**JHS**	**SHS**	**Diploma**	**1st Degree**	**Non-formal**	**Total**
Karaga (28.95)	**Monkula**	29	11	1	3	0	0	0	44
μ=5.41 SD=3.57 Min=1 Max=12	**Kupali**	25	5	0	2	0	0	0	32
Gushegu(41.54)	**Nakohagufong**	12	3	2	3	1	1	0	22
μ=6.93 SD=3.93 Min=1 Max=18	**Zantili**	26	13	2	2	0	0	0	43
Kumbungu (21.15)	**Yipeligu**	30	6	1	1	1	0	0	39
μ=5.64 SD=4.20 Min=1 Max=14	**Cheyohi**	11	0	1	0	0	0	1	13
Savelugu-Nanton (12.12)	**Nanton Botingli**	30	2	1	2	1	1	0	37
μ=9.88 SD=4.05 Min=4 Max=16	**Sanvuli**	28	0	1	0	0	0	0	29
West Gonja (35.71)	**Alhassankura**	25	1	4	2	0	0	0	32
μ=10.4 SD=3.73 Min=2 Max=19	**Atributu**	11	1	6	3	2	1	0	24
STK (21.88) μ=8.71 SD=5.22 Min=3 Max=16	**Dani-ur**	25	3	2	0	2	0	0	32
Total	**Total**	**252**	**45**	**21**	**18**	**7**	**3**	**1**	**347**

Source: Field survey, 2018

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From Table 4.5 above, we find that Gushegu District has the highest percentage of literate maize farmers with 41.54%, West Gonja and Karaga Districts follow second and third respectively with 35.71% and 28.95% of the respondents.

In relation to the years of formal education, West Gonja District has the highest average years of education of 10.4 years, followed closely by the Savelugu-Nanton District with 9.88 years and 8.71 years for Sawla-Tuna-Kalba District.

Considering that Savelugu-Nanton District has the least percentage of literate respondents among our sampled districts but with the second highest mean years of education, one could infer a disparity in respondents' access to eduction and efforts should be put into bridging the literacy gap in the District.

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4.1.4 Marital Status of respondents

The importance of marriage from a cultural and religious perspective is widely documented (Quinn, 2006; Grover and Helliwell, 2017) and is illustrated in the key religious books of the two (2) main religions in the study area, Islam and Christianity. Believers are entreated to marry in order to "complete their faith" and to "receive blessings" from their deity (Qur'an 24:32; Prov. 18:22). Socially, the welfare and continued sustenance of the family is perpetuated through the institution of marriage. Marriage, through procreation, ensures that ageing household members (and economic agents) are replaced in the household's workforce. In line with this, the study found that majority (90.37%) of the maize farmers interviewed were married, 7.93% of the respondents were single, with the remaining 1.70% of respondents either divorced or widowed (Table 4.4). Due to the attendant responsibilities that marriage places on farmers and how this may influence the production practices of

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farmers, we tested the hypothesis that there is no difference between the market orientation of married and unmarried farmers.

The chi-squared results show that there is indeed a difference in whether a farmer would be a subsistence only (coded as 1) or a commercial-oriented farmer (coded 0); (chi^2= 9.88; Pr.> chi^2= 0.002)

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Table 4. 6: Marital status of respondents

Group	**Frequency**	**Percent (%)**
Single	28	8.07
Married	314	90.49
Divorced	1	0.29
Widowed	4	1.15
Total	**347**	**100.00**

Table 4. 7: Marital Status by Market Participation Level of Respondents

	Level of Market Participation		
Marital Status	**Market-Oriented (%)**	**Purely Subsistence (%)**	**Pooled (%)**
Married	5.61	15.69	9.51
Unmarried	94.39	84.31	90.49
Total	100.00	100.00	100.00
	214	**133**	**347**
Significance: 9.8814**			

4.1.5 Household Composition and Characteristics

Agriculture in rural Africa tends more towards a socio-cultural activity than being commercial; for this reason, it is largely influenced by kinship and familial ties. In assessing the financing behaviour of maize farmers in the Northern region of Ghana, it is

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important to consider the effects that household composition may have on farmers' decision-making regarding production and general farm management.

Towards this, the study examined how household size is distributed across the sample communities given various age groupings.

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The results revealed an average household size of 15.25 persons which is higher than the regional average of 7.7 persons and the national average of 4.4. The results show that 54.18% of respondents were the heads of their households with 90.96% of these being male and the remaining 9.04% being female. The average age of respondents who were heads of their households is 45.26 years which is in line with the estimations of GSS (2013), that 60 percent of male-headed households in the Northern region were within the age group of 30-54 and 50% of female-headed households were in this same age bracket. Regarding respondents who were not the heads of their households, the average age was 38.21 years; 62.20% of these had spousal relationships with the household heads, 20.73% were the children, while the remaining 17.07% were either a brother or an in-law of the household heads. The general and disaggregated details of these findings are presented in Tables 4.6 and 4.7 respectively.

Generally, the large mean household size recorded in the region can be attributed to the practice of nuclear households residing in the same house as extended relations. This practice blurs the distinctions in the living arrangements of both the nuclear and the extended families. One could also assert that this phenomenon could be due to the practice of polygyny among most tribes in the region, the basic concept of a household as consisting of a man, *a* wife, their children, and any other persons, related or otherwise living with them does not hold true because of the multiplicity of wives (and their children). In an agrarian society where income sources are not always diversified, a relatively large household size may be desired over a smaller one since the household members can provide labour for farm activities and/or be in a position to contribute to the financing of farm operations through incomes earned from off-farm and non-farm sources.

Table 4. 8: Household Size by District, and Community

District of Survey Summary stats of Household Size	Name of Community	Household Size of Respondents 1-10	11-20	21-30	31 & above	Total
Karaga	**Monkula**	18	23	3	0	44
μ=12.61 SD=5.69 Min=3 Max=27	**Kupali**	17	11	4	0	32
Gushegu μ=23.35 SD=13.79	**Nakohagufong**	3	5	11	3	22
Min=5 Max=60	**Zantili**	6	20	8	9	43
Kumbungu	**Yipeligu**	12	22	5	0	39
μ=13.44 SD=5.49 Min=6 Max=31	**Cheyohi**	8	7	0	1	13
Savelugu-Nanton	**Nanton Botingli**	7	21	8	1	37
μ=16.05 SD=7.97 Min=4 Max=47	**Sanvuli**	12	14	2	1	29
West Gonja	**Alhassankura**	12	12	4	4	32
μ=12.16 SD=8.88 Min=1 Max=40	**Atributu**	18	5	1	0	24
Sawla-Tuna-Kalba μ=11.84 SD=8.61 Min=2 Max=30	**Dani-ur**	18	9	5	0	32
Total	**Total**	**128**	**149**	**51**	**19**	**347**

Among the districts, Sawla-Tuna-Kalba had the least average household size with 11.84 persons although this is still higher than the findings reported by Mbanya (2011) and Dakare (2013) in their study on the constraints in soybean production and the determinants of cattle sale in the Sawla-Tuna-Kalba District, respectively. Gushegu District recorded the highest average household size with 23.35 persons.

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The finding that majority of the respondents in all the study districts had household sizes in excess of 10 persons corroborates the same findings from the statistics on household composition and structure in the Northern region as captured by GSS (2013).

Table 4. 9: Distribution of Household Headship by Sex of Head and Relations to Head

	Sex of Respondent		
Household Head Status	**Female**	**Male**	**Total**
Yes	99	171	188
No	17	60	159
Total	**116**	**231**	**347**

Relationship of respondent to Household Head	**Frequency**	**Percent (%)**
Spouse	96	60.38
In-law	6	3.77
Child	24	14.47
Brother	10	6.29
Total	**159**	**100.00**

Source: Field survey, 2018

4.1.6 Respondents' Occupational Orientation and Experience

The study sought to identify the primary occupation of respondents and how long they have been engaged in their current enterprise. The rationale for this examination is grounded in the findings of various studies (Smale *et al*., 2016 & Ahmed and Melesse, 2018) that farmers' enterprise orientation and farm experience affect farm performance. Specifically, the survey queried whether farming was the major occupation of respondents and in the event of a negative response, what enterprise respondents were primarily engaged in. The results show that more than 90% of respondents reported farming as their major occupation with only 8.65% reporting other activities as their primary occupation (Table 4.8). Trading (43%) is the most popular employer of respondents whose major occupation lies outside farming followed by ventures such as driving, operating a grinding mill, and agricultural

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services provision like tractor operation and spraying other farmers' farms. These other occupations besides farming constitute 30% of these respondents.

Regarding farmers' experience, the results reveal a pooled average maize farming experience of 17 years, which suggests a wealth of knowledge accumulated over years of constant production that should positively influence farmers' efficiency. Farmers in the West Gonja District recorded the highest mean experience of 18.28 years while those in the Gushegu District had the least average farm experience of 15.83 years; the details are presented in Table 4.9.

Table 4. 10: Major Occupation of Farmers

Major Occupation: Farming	Frequency	Percent (%)
Yes	317	91.35
No	30	8.65
Total	**347**	**100.00**

Major Occupation (if not farming)	Frequency	Percent (%)
Trading	13	43.33
Teaching	2	6.67
Shea Butter Processing	4	13.33
Artisan	2	6.67
Other	9	30.00
Total	**30**	**100.00**

Source: Field survey, 2018

Table 4. 11: Farm Experience by District

	Farm Experience of Farmers			
District	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Karaga	16.48	11.61	1	60
Gushegu	15.83	11.24	2	40
Kumbungu	18.07	12.52	4	60
Savelugu-Nanton	16.43	11.80	2	50
West Gonja	18.28	9.99	3	40
Sawla-Tuna-Kalba	16.76	12.92	3	40
Pooled	16.90	11.55	1	60

Source: Field survey, 2018

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4.1.7 Major Crop Cultivated and Production Aim

The study further analyzed farmers' responses on the main crop they cultivate and their main aim for producing maize. The latter is especially important because farmers with purely subsistence focus are likely to have different motivations for investing in their farms compared to those with some level of commercial focus. Also, whether or not maize is a farmer's major crop may influence farmers' level of expertise and commitment to its production.

The results show that a little over 74% of farmers were primarily engaged in maize production with the remaining 26% engaged in cassava, groundnut, yam, and soybean production as primary crops. The analysis further reveal that majority of the sampled farmers have a commercial focus with only 38.33% producing for subsistence purposes only. With this, it is possible to infer that majority of the farmers will be quite willing to invest in their farms to realize high output and surplus levels for the market.

Table 4. 12: Major Crop Cultivated and Level of Market Participation

Major Crop	**Frequency**	**Percent (%)**
Maize	257	74.06
Soybean	12	3.46
Groundnut	41	11.82
Rice	5	1.44
Yam	14	4.03
Other	18	5.19
Total	**347**	**100.00**
Level of Market Participation	**Frequency**	**Percent (%)**
Only subsistence	133	38.33
Only commercial	34	9.80
Largely subsistence	139	40.06
Largely commercial	11	3.17
Both Equally	30	8.65
Total	**347**	**100.00**

Source: Field survey, 2018

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4.1.8 Agronomic and Cultural Practices Undertaken in Maize Farming

Recognizing the importance of good agronomic practices (GAPs) to the productivity of maize, the survey sought to elicit from farmers their knowledge and practice of some known agronomic practices on their maize farms. Twelve agronomic practices identified from the literature and field observations were presented to farmers and their responses on whether they practiced each of them were collated. The most popular of these practices, according farmers' responses was planting in rows, followed by crop rotation and bush burning as part of land preparation. While the row planting and crop rotation are to be encouraged, the continuing practice of bush burning before planting presents a worrying occurrence and farmers should be educated on the counter-productive effects it could have on the soil and the risks it poses to the environment.

Unsurprisingly, the least practiced agronomic method is irrigation farming, with only 2.88% of farmers irrigating their maize farms. This is because none of the sampled communities has a formal irrigation scheme within its vicinity. Considering the unimodal rainfall peak prevalent in the Northern region, greater institutional efforts should be put into providing small-scale irrigation schemes in the districts and villages to enhance farmers' year round production to improve the farm household's welfare. The current government's planned project dubbed "1 Village 1 Dam" would be especially welcome in this regard to boost crop production and complement the efforts of the ongoing PFJ.

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Table 4. 13: Good Agronomic and Cultural Practices Undertaken

Variable	Frequency (%)	Std. Dev.
Planting in rows	67.72	0.4682094
Contour ploughing	25.94	0.259366
Crop rotation	60.81	0.4888863
Production under irrigation	2.88	0.1675676
Land fallowing	14.99	0.3574455
Planting trees around farm	14.70	0.3545914
Burning before planting	48.41	0.5004704
Burning postharvest residue	28.82	0.4535714
Manure application	19.02	0.393027
Ploughing in crop residue	48.13	0.5003705
Mulching	14.70	0.3545914
Intercropping with legumes	8.65	0.2814411

Source: Field survey, 2018

4.1.8 Extension Access, Visit Frequency, and Farmer Satisfaction with Extension Services

Various studies have found farmer contact with extension agents to positively influence farmer innovation (Katz & Baradun, 2002; World Bank, 2006; Belay, 2012), credit access (Martey *et al*., 2015), and farm efficiency (Seyoum *et al.*, 1998*;* Khan and Saeed, 2011). This study sought to analyse farmers' access to extension services during the production season as well as the frequency of visits, the information received from the AEAs, and their overall satisfaction with the services they received. Less than half (41.21%) of farmers had had some contact with an extension agent during the 2017 production season.

Table 4. 14: Percentage Distribution of Access to Extension Services by District

Extension Access	Karaga	Gushegu	Kumbungu	Savelugu-Nanton	West Gonja	Sawla-Tuna-Kalba
Yes	60.53	33.85	40.38	43.94	23.21	37.5
No	39.47	66.15	59.62	52.06	76.79	62.5
Total	100	100	100	100	100	100

Source: Field survey, 2018

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It can be surmised from the table that while Karaga and Savelugu-Nanton districts have access levels greater than the estimated average for the region, the same cannot be said of any of the remaining districts. The situation is especially dire for the West Gonja district, where only 23.21% of respondents reported having had access to extension services in the past growing season. The Extension Division of the local MoFA Directorate and other agriculture agencies need to step up efforts to increase farmer coverage.

The results further revealed an average of 2.5 visits during the production season for those farmers who had access to extension visits. This is more than twice the average number of visits reported by Wongnaa and Awunyo-Vitor (2017) for the Guinea Savannah zone in their study on the scale efficiency of maize farmers in four agro-ecological zones of Ghana. Generally, this number is enough considering the ratio of extension agents to farmers in the country. Concerning the information received from the extension agents during their visits, the three most reported information were on agronomic farm practices (74.83%), fertilizer application (67.13%), and pest prevention (66.43%). The case of pest prevention was especially necessary during the 2017 planting season due to the outbreak of the Fall Army Worm (FAW) pandemic that decimated maize farms all over the country.

Table 4. 15: Extension Information and Number of Visits

Variable	**Frequency (%)**	**Std. Dev.**
Fertilizer application	67.13	0.4713813
Improved crop variety	49.65	0.5017452
Crop-livestock integration	20.98	0.4085899
Cultural practices	74.83	0.4355429
Information on pest/disease prevention	66.43	0.473882
Information on credit access	6.29	0.2437033
Information on market access	7.69	0.267406
Information on machinery services	9.09	0.2884903
Other information	2.80	0.1654723

Source: Field survey, 2018

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On the usefulness of the information received from the AEAs on their visits, 97.90% of farmers reported that the information was either very useful or useful; only 2.10% reported that they did not find the information useful for their production activities.

Because agricultural extension is a service provided to customers (farmers), it must meet the stated needs of the customer, and be packaged and presented in a manner that satisfies the farmer. In this light, the study sought to understand the level of satisfaction of farmers who had had contact with an AEA and the reasons for dissatisfaction, if any. The results point to a general satisfaction with the quantity, quality, and timelines of extension services received as reported by 78.32% of farmers.

From the interviews with the farmers, the main bone of contention of the 21.68% of dissatisfied farmers with the services received from AEAs concerned the timeliness of information as most disgruntled farmers reported that information on how to combat the aforementioned FAW came a little too late. Some also claimed the methods proffered by the agents was ineffective in eradicating the menace. Other issues reported included inadequate information on where farmers could access the subsidized fertilizer provided by government for the Planting for Food and Jobs programme.

4.2 Sources and Magnitudes of Agricultural Financing in Maize Production

To understand farmers' innovations in financing their farming activities, it was necessary to first identify the common methods and means by which farmers sourced funds to invest in their maize production and the amounts raised from each of these sources. Using a review of the literature on farm financing in SSA and Asia, as well as key informant

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interviews with model farmers in the study area, the study identified sixteen (16) sources of finance in maize production prior to the main data collection. These sources were presented to farmers during the survey process for verification. The study found that the most popular sources of financing among maize farmers are their personal savings and ploughing back profits from the previous crop season. The highest percentage of farmers (62.82%) finance their maize production from their personal savings, followed by ploughing back profits from the previous season (59.37%) and using income from sale of other crops (52.16%). The latter source of farm financing is especially popular among maize farmers who produce for purely subsistence purposes, i.e., produce from the maize farm is reserved for household consumption with crops such as soybean, groundnut, and/or cassava grown largely for commercial reasons to raise income for financing the production of maize in the next season, among other needs.

Besides these three dominant sources, income from livestock sale and off-farm economic activities are the next most popular sources of finance among maize farmers in the Northern region. As one farmer in the Kumbungu District asserted, it is easier to plan for purchasing agro-inputs such as fertilizer and herbicides if one raises livestock as part of their farming;

"all I have to do is to sell one goat and I can afford to buy fertilizer for 1 acre of maize farm, that is why I do not joke with my goats" – Respondent Number 217, Cheyohi.

With 29.11% of farmers admitting that they use income from their off-farm enterprises to finance their maize farming, it is easy to establish the importance for production of having diverse sources of income.

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As stated earlier, crop farming in rural Ghana shifts more towards a socio-cultural activity and so does its financing. Thus, it is unsurprising to find that farmers depend on their relatives for loans to invest in some farm venture or the other. In fact, seeking and using informal loans are not limited to blood relations only but also friends, money lenders, and local Savings and Loans Associations. We found that 14.12% of farmers used loans from their friends for farm financing, 9.15% used loans from family members, 12.10% used loans from moneylenders, and 14.41% used loans from their local Savings and Loans Associations.

The most popular sources of farm finance, according to the scope of coverage in the literature, fall into a class of external loans sourced from formal institutions such as banks, microfinance institutions, non-governmental organisations (NGOs), input credit through arrangements such as contract farming and government agricultural sector support policies such as the Fertilizer Subsidy Programme and the recent Planting for Food and Jobs (PFJs) Programme. This popularity in the literature does not translate to popularity among farmers as evidenced by the relatively low responses in the affirmative to whether or not these sources are pursued by farmers.

Only 1.73% of respondents reported that they took loans from banks while a paltry 0.29% used loans from NGOs to finance their maize farming in the production season in context. Another 1.73% had access to input credit as a means of farm financing and used same in the past season.

Of course, not all external financing sources are loan-based and these are actively used by maize farmers as well. Another evidence of the importance of a strong societal support structure to the Ghanaian rural farmer is the finding that 10.66% and 5.19% of respondents

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respectively used remittances (gifts) from family members and friends for financing their maize farming. Other external non-loan sources of finance used by farmers include grants from NGOs (3.17%) and income from lottery (0.58%).

The average amounts used for each finance source is reported in Table 4.8 with Personal Savings posting the highest mean amount of GH₵ 759.24 with more than 10% usage. The next highest amount is reported for Loans from Friends with GH₵ 389.51 and GH₵ 375.50 for Ploughing Back Profits.

The sources of finance were grouped into three classes as internally-generated fund financing – if a respondent uses personal savings, income from sale of other crops, or reinvest profits; external non-loan financing – this encompasses gifts from family or friends, production grant, income from off-farm activities, lottery, or sold livestock; and external loan financing – if respondent used loans from friends or family, input credit, loans from moneylenders, VSLA, Banks, and NGOs; to aid the description.

Table 4. 16: Sources and Magnitudes of Agricultural Financing in Maize Production

Source	Use Percent	Mean (GH₵)	Std. Dev.	Min	Max
Gifts from Family Members	10.66	181.4545	161.9432	2	600
Gifts from Friends	5.19	146	114.3805	2	440
Loans from Family Members	9.15	396.6667	399.9746	20	1800
Loans from Friends	14.12	389.5106	438.2783	1	2000
Personal Savings	62.82	759.24	854.2224	1	5000
Ploughing back Profit	59.37	375.5	399.4516	50	2500
Income from Sale of others crops	52.16	279.4737	327.3488	30	3000
Income from Off-Farm Activities	29.11	360.8333	370.6627	40	2000
Income from Livestock Sale	25.94	279.3721	281.2998	15	1500
Income from Lottery	0.58	800	-	800	800
Input Credit	1.73	210	212.132	60	360
Grants from NGO	3.17	134	65.42171	50	200
Loans from Money Lenders	12.10	215.6667	185.3469	2	1000
VSLA Loan	14.41	400	374.1657	100	1000
Loans from Banks	1.73	275	154.1104	100	500
Loans from NGOs	0.29	100	-	100	100

Source: Field survey, 2018

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To assess respondents' choice among the individual financing sources and the level of overlap in use, a pairing of the sources against each other was conducted. For categorical variables, a factor analysis would have been preferable for this exercise. However, the dummy nature of the variables made this impossible to pursue. The results indicate that the combinations of personal savings and ploughing back profits (36.60%), personal savings and income from sale of other crops (36.02%), and ploughing back profits and income from sale of other crops (34.58%) recorded the highest representations and percentages. Thus, combinations among the internally-generated fund financing sources are the most popular among respondents.

Among the sources classified under external non-loan financing, income from off-farm economic activities was the most utilized financing source, recording 19.60%, 17.29%, and 15.85% respectively in its combinations with personal savings, and ploughing back profits and income from sale of other crops. Income from livestock sale and ploughing back profits also shows some interesting results with 17.58% of respondents using this combination.

Loans from VSLA, from friends, and from moneylenders also recorded some relatively high figures when paired against the three sources under internally generated financing. The details are outlined in Table 4.17.

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. 17: Cross Tabulations of Sources of Financing in Maize Production

	PerSav	Profit	Cropsale	OfFarm	LiveSale	FamGif	FamLoan	FrnGif	FrnLoan	Lotto	InpCred	Grant	Lendloan	VSLA Loan	Bank Loan	NGO
›ack	127															
e	125	120														
ı	68	60	55													
	46	61	52	31												
	30	20	21	15	13											
ι	16	17	17	8	9	3										
	12	13	12	7	8	6	1									
	27	27	27	14	13	3	3	4								
	2	1	1	1	1	1	1	0	1							
	3	3	2	2	2	0	2	0	0	0						
	4	4	3	2	3	2	0	0	2	0	0					
n	20	19	17	15	8	3	4	1	6	0	0	5				
ı	22	32	17	13	20	2	6	3	4	0	1	6	6			
n	5	2	2	4	1	1	1	0	0	0	1	2	0	1		
	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	

Persav = Personal savings; Profit = Ploughing back profit from maize farming; Cropsale= Income from sale of other crops; OfFarm= ‘rom off-farm employment; Livesale= Sale of livestock; Famgif= Gifts from family members; Famloan= Loan from family member; Gifts from friends; Frnloan= Loans from friends; Lotto=Income from Lotto; Inpcred=Input Credit; Grant= Grants from NGOs; ı=Loans from Moneylenders; Vslaloan= Loans from VSL Associations; Bankloan= Loans from banks; NGO= Loans from NGOs

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4.3 Innovative Financing in Maize Farming

The present study defined innovative agricultural financing as measures and methods initiated and pursued by rural farm households aimed at generating revenue for farm investment when the traditional ways are not enough. This revenue is then invested in improving their access to and control over farm resources such as land, labour, capital inputs, and market channels. This definition implies that this form of financing is different from those identified in Section 4.2 (those are classified as traditional forms of farm financing). In this study, a financing method is considered innovative when the decision to use it stems from the farmer's felt need and consciousness and would ordinarily not have been pursued by the farmer if s/he had access to credit or adequate financing from other sources. Specifically, the survey asked farmers the following questions to determine their use or nonuse of innovative financing;

1. Did you join any credit and loans group ***specifically*** to acquire credit for maize production?
   Yes [ ] No [ ]
2. Did you take a "by-day" job ***specifically*** to raise money for maize production?
   Yes [ ] No [ ]

Thus, innovative financing is a coping/risk-mitigating technique that the farmer uses in the face of lack of access to formal finance. In sum, innovative financing methods are external to farmers' household incomes and presents an opportunity for a maize farmer to increase the amounts of funds available for meeting the farmer's needs. Though external to the farm household, the decision to access innovative financing is not externally-driven; it is neither advertised nor presented to the farmer by an agency or institution in the same way that loans from financial institutions or NGOs are.

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Considering the methods of agricultural financing that this study identified, two (2) methods stand out in that they meet all the criteria for innovative financing. These are joining a savings and loans group with the sole aim of accessing credit for maize farming when the need arises and taking menial (by-day) jobs in order to raise funds for maize farming.

The former method is similar to (and yet different from) the traditional financing method of taking VSLA loans; in both cases, the farmers access loans from this venture (the difference lies in the initial motivation for joining the group and the intention behind taking a loan from the VSLA group – joining a VSLA in order to save parts of one's income or taking a loan from the VSLA to meet household needs like food, shelter, or healthcare is different from taking a loan in order to rent a tractor for land preparation). Similarly, while it is not uncommon to find farmers who engage in other economic activities (usually off-farm), taking menial jobs to raise funds for farm investment differs in that these jobs may also be on-farm (taking a "caretaker" job on southern cocoa farms during the northern off season). A farmer who uses either or both of these methods is said to be using innovative financing in maize farming. The distribution is as follows;

Table 4. 18 Distribution of Use of Innovative Financing in Maize Farming

	Innovative Financing in Maize Farming		
District of survey	Non-users (%)	Users (%)	Total (%)
Karaga	51 (67.11)	25 (32.89)	76 (100)
Gushegu	42 (64.62)	23 (35.38)	65 (100)
Kumbungu	31 (59.62)	21 (40.38)	52 (100)
Savelugu-Nanton	23 (34.85)	43 (65.15)	66 (100)
West Gonja	47 (83.93)	9 (16.07)	56 (100)
Sawla-Tuna-Kalba	16 (50.00)	16 (50.00)	32 (100)
Total	**210** (60.52)	**137** (39.48)	**347** (100)

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A cursory assessment of Table 4.18 reveals Savelugu-Nanton as the district with the highest population of users of innovative financing with over 65% of its sampled respondents. Sawla-Tuna-Kalba and Kumbungu districts are the second (2nd) and third (3rd) respectively in terms of population of users. The West Gonja district has the least percentage of its respondents using innovative agricultural financing.

There is a temptation to link the extent of users in a district to the distribution of sex of respondents from the various districts. This temptation is grounded in the fact that most VSLA groups in the Northern region are set up as a means to increase women's access to savings and loans. A comparison of Tables 4.2 and 4.18 gives some credence to this theory. However, the district with the least female representation (Kumbungu) is the third in terms of users of innovative financing. One could conclude that male farmers in Kumbungu tend to take menial jobs to raise funds for maize farm financing instead.

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4.4 Determinants of Innovative Financing

As indicated in Chapter 3, the Probit model component of the Greene (2010) was used to examine the factors that influence farmers' decision to use innovative agricultural financing. Table 4.19 presents the results of the estimation for both the unmatched and matched samples. The unmatched model uses all 347 respondents originally sampled for this study whiles the matched model uses the sub-sample of 309 respondents generated from the PSM procedure.

The model diagnostics are presented in the final row of Table 4.19. The Wald chi-square in the probit model is asymptotically equivalent to the F-test in linear regression model. It

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can be used to check if a relationship exists between the dependent variable and independent variables – it tests that at least one of the predictors' regression coefficients is not equal to zero in the model.

The Wald-chi-square values of 99.68*** for unmatched and 58.52*** for the matched model (*** represents statistical significance at 1% level) show that use of innovative financing is determined by at least one of the variables included in the model. Thus, the null hypothesis that $Z_1 = Z_2 = ... = Z_{22} = 0$ is rejected. The pseudo-R^2 values of 0.2727 and 0.1783 mean the selected sociodemographic and economic variables contribute to explaining about 27% and 18% of variations in the use of innovative financing in the unmatched and matched models respectively. Though these value are low, they reflect a characteristic of binary dependent models (these models are infamous for their tendency to report low R^2 values). In order to accurately measure the goodness-of-fit of the estimated model, we use the Count R^2 instead. The result of the Count R^2 estimation is presented in Table 4.20.

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Table 4.19: Determinants of Innovative Financing Use – Unmatched and Matched Models

	Unmatched Sample			Matched Sample		
Variable	**Coeff.**	**Robust S. E.**	**Marginal Effects**	**Coeff.**	**Robust S. E.**	**Marginal Effects**
Access to Formal Credit	0.9231***	0.2993	0.3445***	0.7723**	0.3392	0.2990**
Farming as Main Occupation	-0.2826	0.1892	-0.1055	-0.2879	0.3046	-0.1088
Extension Access	0.2795	0.2070	-0.1043	-0.2319	0.1922	-0.0831
FBO Membership	-0.4447**	0.0364	-0.1660**	-0.4534**	0.2098	-0.1576**
Assets owned	0.0283	0.0093	0.0106	0.0209	0.0373	0.0076
Household Size	-0.0202**	0.1907	-0.0076**	-0.0164*	0.0098	-0.0069*
Educational Status	-0.1090	0.1907	-0.0403	-0.0756	0.1887	-0.0272
Maize as main crop	0.3925*	0.2010	0.1465**	0.3444*	0.2043	0.1196*
Social Capital	0.3463***	0.1110	0.1292***	0.3248**	0.1190	0.1177**
Household Position	-0.4024**	0.1671	-0.1502**	-0.3380**	0.1736	-0.1231**
Level of Crop Diversification	-0.3842***	0.1045	-0.1434***	-0.3347***	0.1097	-0.1213***
Personal Tragedy	0.5247**	0.2055	0.1958**	0.4395**	0.2155	0.1658**
Manure Use	0.9662***	0.2195	0.3606***	0.8367***	0.2387	0.3200***
Karaga District	-1.0166***	0.2679	-0.3794***	-0.9597***	0.2746	-0.2936***
Gushegu District	-1.1549***	0.2883	-0.4310***	-1.0791***	0.3004	-0.3116***
Kumbungu District	-1.0863***	0.3035	-0.4054***	-0.9718***	0.3112	-0.2847***
West Gonja District	-1.9829***	0.3690	-0.7401***	-1.8176***	0.3812	-0.4116***
Sawla-Tuna-Kalba District	-0.9049**	0.3279	-0.3377**	-0.7777**	0.3363	-0.2308***
Only Commercial	-0.2648	0.3103	-0.0988	-0.2416	0.2862	-0.0834
Largely Subsistence	-0.1934	0.2830	-0.0722	-0.1637	0.1890	-0.0588
Largely Commercial	0.1794	0.1860	0.0670	0.1357	0.4361	-0.0504
Both Equally	0.6139**	0.4065	0.2291**	0.5228	0.3309	0.2015
Constant	1.14868***	0.4621		1.3126**	0.4754	
	N=347 Wald chi^2(22)=99.68*** Pseudo R^2=0.2727 Log-Pseudo= -169.307			***N***=309 Wald chi^2(22)=58.82*** Pseudo R^2=0.1783 Log-Pseudo= -166.272		

***, **, and * indicates significance at 1%, 5%, and 10% levels respectively.

Table 4.20: Classification Table for Correct Predictions by the Model

	Unmatched Model			Matched Model		
		True			True	
Classified	**D**	**~D**	**Total**	**D**	**~D**	**Total**
+	94	35	129	66	30	96
-	43	175	218	46	167	213
Total	137	210	347	112	197	309

The estimation of the Count R^2 yielded values of 77.52% and 75.40%; these show the true predictive power of the models in explaining variations in farmer's decision to use innovative financing. These estimations are about 50 percentage points higher than the result from the Pseudo-R^2 and also presents a truer picture of the goodness-of-fit of the model.

With regard to the independent variables that determine innovative financing use, the matched model had one less significant variable than the unmatched model with majority of the significant variables found to negatively influence the dependent variable. For the two categorical variables in the estimations, the researcher set for the Location variable, the Savelugu-Nanton district as the benchmark while the category for farmers who produce for subsistence purposes only is set as the benchmark for the Market Participation variable.

Both the coefficients of the variables and the marginal effects of the statistically significant variables are also reported in Table 4.19. The marginal effects report the extent of change in the probability of a respondent using innovative financing with a unit change in the independent variable.

From the results, a farmer with access to formal credit, a high level of integration into society, and who uses farmyard manure as a soil fertility-enhancing measure is more likely to use innovative financing than their radial opposite counterparts. The coefficients are statistically significant at 1% and 5% levels. Also, farmers who had experienced a personal tragedy prior to or in the early parts of the season and those for whom maize is a main crop of cultivation were more likely to use innovative financing than those who did not. Another

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positive determinant of innovative financing use is the extent of a farmer's market participation. It was found that farmers who produced for subsistence and commercial purposes equally were more likely to access innovative financing than subsistence only farmers although the significance of this variable was limited to the unmatched sample.

The results also show that farmers engaged in the production of other food crops than maize, who have larger household sizes, and who were members of FBOs were less likely to use innovative financing than those who had the opposites of these characteristics.

Based on the reported marginal effects, a farmer with access to formal credit is about 30% more likely to use innovative financing than those without access. Farmers who apply for credit make explicit their keen interest in investing in their maize farms. When the formal sources fail to provide adequate amounts, they tend to use innovative financing sources to complement the funds they receive from the formal institutions.

Social capital represents the number of social groups that a farmer belongs to. In line with the *a priori* expectation, the result shows that farmers with greater integration into society are more likely to use innovative financing than those with a limited social circle.

The reported marginal effect of 0.1196 means that with an additional group in which a farmer is involved, the likelihood of using innovative financing increases by about 12 percentage points, *ceteris paribus*.

It is an open secret that application of organic manure to maize fields helps in increasing yields and enhancing the structure of the soil. Despite this knowledge, there exist a fair number of farmers who still do not use this seemingly beneficial technology. From the field observations, the reason advanced by a number of farmers for abstaining from or "dis-

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adopting" of manure on their farms is its unavailability and the high cost of acquiring it from the sources where they are available. Thus, farmers who are determined to apply organic manure on their fields must have them available from their own livestock or raise the capital required to purchase it from elsewhere. This capital requirement is expected to boost a farmer's inventiveness and cause them to be more likely to use innovative financing than those who do not apply manure. The marginal effect of 0.3200 says that a farmer who applies manure is about 32% more probable to use innovative financing than those who do not apply manure.

A farmer who had experienced a personal tragedy before the start of the season or during the season prior to harvesting may suddenly be in need of some funds to cater for this unforeseen need and may as a result use whatever funds available to meet this sudden need. Therefore, to invest in farms after existing funds have been used for other purposes, the farmer finds the need to use an innovative financing method. The results indicate that a farmer who has experienced personal tragedy is about 17% more likely to use innovative financing for maize production than those who have not.

The probability of a farmer using innovative financing is higher for farmers whose major/first crop of interest is maize. Such farmers are about 12% more likely to seek extra financial sources than those mainly engaged in other crops. Farmers for whom maize is the main crop of cultivation tend to give a lot more attention to the production process and make most of the investments required to attain good yields (examples include purchasing and applying the right quantities of improved seeds and fertilizer in a timely manner). These activities require significant amounts of funds that may not always be available to farmers; necessitating the use of innovative financing methods to raise this extra capital.

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In assessing the effect of a farmer's maize market participation level on the likelihood of using innovative financing, farmers who do not participate in the maize market (farmers that produce solely to feed their families) was set as the benchmark for comparisons. The results indicate that there is no significant difference in the probability of using innovative financing for the base category and all other categories describing a particular level of market participation. However, farmers whose aim of production is to produce enough to feed their families and the market equally were found to be about 23% more likely to use innovative agricultural financing than those who produce solely for subsistence purposes in the unmatched model. This statistical significance is lost after correcting for biases from observed characteristics.

For the factors that reduce a farmer's probability of using innovative financing, the results show that members of FBOs are less likely to use innovative financing than non-members. This result is in line with the *a priori* expectation. One key vision of modern FBOs is to mobilise access to certain services that may not otherwise be available to member farmers.

An example of such services is access to credit. Since FBOs apply for credit as a group, they serve as collaterals (sureties) for each other and are therefore able to get access to the amounts of credit they require (Martey *et al*., 2015). This phenomenon may explain the inverse relationship between FBO membership and use of innovative financing.

The result also reveals that farmers with larger households are less likely to use innovative financing than those with smaller households. This may be attributed to the substitution of family labour for hired labour and the need to increase production. Maize production at medium to small scale requires a lot of physical labour due to use of manual implements and the limited level of mechanization in production. This labour requirement presents a

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significant cost burden for farmers and may influence their use of innovative financing methods positively. However, for large farm households, the presence of able-bodied members signifies a source of cheap labour and could offset the cost of hiring labour. In the absence of the need to raise funds to hire labourers for farm operations, farmers' perception of the expected utility of using innovative financing diminishes. The result shows that an additional employable family labour reduces the probability of using innovative financing by 0.69%.

Another household-related characteristic that reduces the tendency of a farmer to use innovative financing is the farmer's position in the household. The result indicates that breadwinner farmers are about 12% less likely to use innovative financing. This may be as a result of household head's innate disposition to have more control over the financing options of the household than other members. Since other household members are usually more resource constrained than the household head, they have greater expected utility from diversifying their income streams.

A similar interpretation can be ascribed to the finding that farmers engaged in diversified crop production are about 12% less likely than specialist maize farmers – the higher level of diversification connotes more income streams and less likelihood of being constrained financially.

With regard to the effect of a farmer's location on his/her probability to use innovative financing, the Savelugu-Nanton district was set as the benchmark because it is the district with the modal population of users. The model therefore helps to establish the veracity of this finding by testing for the difference in probabilities of using innovative financing. As expected, farmers in all other districts were found to have lower probabilities of being

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assigned the treatment than those in the base district. The magnitudes of the marginal effects from this estimation follow the same pattern as the percentage of users in the various districts with farmers in the West Gonja district (with a little over 16% of users) found to be about 41% less likely than farmers in the Savelugu-Nanton district.

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4.5 Observed Bias Correction Using the Propensity Score Matching (PSM) Technique

An emerging common practice in most impact evaluation studies (Bravo-Ureta *et al*., 2012, Martey *et al*., 2015, Anang *et al*., 2016, & Lawin and Tamini, 2018) is to use the result from the probit model to estimate propensity scores to match maize farmers with similar characteristics. The propensity score is the predicted probability that a farmer uses innovative financing. In line with this approach, this study uses the propensity score matching to deal with observed heterogeneity in the sample of maize farmers.

In the matching, the 1-to-5 nearest neighbour method was used while imposing a common support condition (Caliendo & Kopeinig., 2008). The essence of the multiple Control observations matching to one Treated respondent is to ensure that all aspects of a user's characteristics are properly represented in the control sample. This enhances the robustness of the matching procedure. The procedure produced a subsample of 309 farmers comprising 112 users and 197 nonusers of innovative financing.

In Figure A1 in the Appendix, a plot of the treated and untreated units after the matching is presented. The figure shows the propensity scores on the x-axis with the matched sample of users and nonusers presented above and below the horizontal line.

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The matching procedure serves two purposes; it helps to reduce the biases in the covariates for users and non-users of innovative financing while also providing a statistical basis for estimating the average effect of using innovative financing on the cost of production of maize farmers.

The difference in the cost of production for users and nonusers of innovative financing is presented in Table 4.21. Given similar production inputs and a predetermined level of output, it is expected that maize farmers would achieve this output level at the most minimum possible cost. Thus, farmers with lower costs are more efficient. In order to attribute this cost efficiency to the use of innovative financing, the present study estimates the average treatment effect on the treated (the cost outcome for users had they not used innovative financing). This is technically referred to as the counterfactual.

The result shows that the average cost of production of the technically efficient output level for users and nonusers of innovative financing is GHȻ 1,439.13 and GHȻ 1,986.40 respectively. This produces a difference of GHȻ 547.27 which is the savings accruing to innovative financing users. This figure is clearly significant in magnitude and is statistically significant at 10%.

Table 4. 21: Average Treatment Effect on the Treated after PSM

Effect of Innovative Financing Use on Farmers' Cost of Production					
Sample	**Users**	**Nonusers**	**Difference**	**S. E.**	**T-stat**
Unmatched	1545.63	1988.57	-442.94	209.5483	2.11
ATT	1439.13	1986.40	**-547.27**	332.4331	1.65

Source: Author's Computation (1 USD=GHȻ 4.9)

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To check the robustness of the Propensity Score Matching, a balancing test of the matched sample was performed (Table A1 in Appendix). This tests the variables from the Probit estimation for the presence of biases and corrects these by reducing the biases.

An examination of Table A1 reveals that prior to matching, some biases existed in some of the variables used in estimating the likelihood of using Innovative Financing among farmers (this can be confirmed by assessing the p-values of the variables in the unmatched category). Eleven (11) of the twenty-two (22) variables used in the estimation were found to be problematic – these include Access to Formal Credit, Maize as Main Crop, and Social Capital which were found to bias estimations positively, as well as Assets Owned, Household Position, and Level of Crop Diversification which possessed negative biases.

The Nearest Neighbour Matching used in the PSM procedure helped in reducing (or in some cases, completely eliminating) the level of biases in these variables. The levels of bias reduction (in percentages) are reported in the 6th column of Table A1.

The Balancing Test is important in that it presents evidence of biases pre-matching and the levels of these biases after matching. A t-test of the significance of the reduced biases is presented in the last column of the table.

The absence of a statistically significant difference in the means of variables after matching shows that the matching procedure is valid and robust – any estimation using this subsample will be void of biases from observed characteristics (Leuven and Sianesi, 2003).

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4.6 Results of the Stochastic Frontier Analysis

4.6.1 Results of Hypothesis Tests

Before proceeding to discuss the results of the Stochastic Frontier Model (SFM), three (3) hypothesis tests to establish the correctness of the estimation process are conducted – the appropriateness of the functional form, the existence of inefficiencies, and whether or not there are inefficiency effects in the model. These tests were carried out individually using the Generalised Likelihood Ratio tests on the null hypothesis. The results of these tests are summarized in Table 4.22.

Table 4. 22: Results of Hypothesis Tests

Test Type (Null Hypothesis)	χ^2 **Statistic**	**P-value**	**Conclusion and Decision**
Functional Form Test ($H_0 : \beta_{ij} = \beta_{ji} = 0$)	9.27	0.1591	Reject H_0: Cobb-Douglas is appropriate because P-value is not significant
No Inefficiency Test ($H_0 : \sigma_0 ... = \sigma_{22} = 0$)	470.85	0.000	Reject H_0: Inefficiency is present
No Inefficiency Effect ($H_0 : \sigma_0 ... = \sigma_{22} = 0$)	71.73	0.000	Reject H_0: Inefficiency effects are not stochastic.

The null hypothesis of the Translog being more appropriate is rejected with the results suggesting that the Cobb-Douglas functional form is more appropriate for modeling farmers' economic efficiency resulting from use of innovative financing. Also, the null hypothesis of no inefficiency and inefficiency effects are both rejected at 1% significance level. This implies that there are observed deviations from the cost frontier and these deviations have a nontrivial effect on the efficiency outcomes of farmers. With these established, we proceed to examine the effect of innovative financing use on farmers' economic efficiency.

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4.6.2 Innovative Financing and other Determinants of Maize Technical Efficiency (TE)

Table 4.23 presents the Maximum Likelihood Estimates (MLE) of the Stochastic Frontier Model (SFM) for the unmatched models and estimations for users and nonusers using the matched sample. Based on the outcome of the likelihood ratio test, this study uses the Cobb-Douglas (CD) functional form. Being self-dual, the CD functional form allows for an examination of both technical and economic efficiencies.

The estimation uses input values corrected at their geometric means and so the first order parameter coefficients are interpretable as elasticities (that is the relative change in maize output as a result of a marginal change in the input level used). Dummies for the sampled districts are included in this model to correct for any effect farmers' location may have on farm productivity and efficiency.

The estimated coefficients of all conventional inputs have the expected positive signs which means they shift the frontier outwards and contribute to determining technical efficiency. The constants in both the deterministic and inefficiency models are statistically significant in both the pooled unmatched and matched models. This implies a good model fitness – the Wald chi^2 value is highly significant. The Lambda values in both models are different from zero; confirming the suspicion of inefficiency effects on farmers' productivity. The estimated gammas measure the effect of technical inefficiency on the variations of observed outputs. Thus, 64.19% and 18.18% of variations in observed maize output for the unmatched and matched samples respectively are as a result of technical inefficiency.

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Another estimate presented in Table 4.23 of interest is the Returns to Scale Parameter which depicts the reaction of maize output to a marginal (or 1 percent) change in all input levels. This means for the unmatched model, a percentage increase in farm size, and the quantities of labour and fertilizer will result in a 0.882% increase in maize output while a similar change will result in a 0.9025% increase for the matched sample. Thus, the returns to scale parameter for sampled maize farmers in both pooled models depict decreasing returns to scale.

In the inefficiency model, the coefficient of innovative financing in both models has a negative sign. This confirms that use of innovative financing reduces farmers' level of production inefficiency. Indeed, this finding is confirmed in the disaggregated estimation of technical efficiency using both the unmatched and matched samples. In both samples, the estimated mean technical efficiency is higher for users than nonusers.

The gap in mean technical efficiency is wider in the matched sample estimations implying that observed biases influenced the estimation outcome in the unmatched samples. With this in mind, this study focuses its attention on the estimations from the sample selection corrected models. Estimations in these models were conducted using the matched samples – this was in a bid to take care of both observed and unobserved biases. The results from these estimations are presented in Table 4.24.

From the result, area cultivated of maize has the largest coefficient and so is the most important determinant of farmers' output. The coefficient of 0.6419 implies that an increase of maize cultivated area by 1 percent leads to an increase of 0.64% in maize output, *ceteris paribus* in the pooled matched model. In the Greene (2010) model for users and nonusers, the effect of area cultivated on maize output is higher for both categories than in

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the pooled matched model. An increase in maize area by 1% leads to 0.70% increase in maize output compared to 0.66% for users of innovative financing. It can be inferred that nonusers are more dependent on increases in area cultivated for increase in output than users. This finding corroborates that Bravo-Ureta *et al*. (2012) who reported higher partial elasticity of output as a result of agricultural area for non-beneficiaries of an agricultural intervention than beneficiaries. The marginal productivity of quantity of fertilizer used is higher for users in the sample selection model than for nonusers. Both elasticities are significant at 1% level and indicate that gains in maize output can be realized by applying greater quantities of fertilizer, *ceteris paribus*. In all the models, the coefficients of quantity of labour are not statistically significant. As discussed earlier, the study area boasts an embarrassment of wealth in human resource and this may lead to over-allocation of labour on maize farms which ultimately lead to its inconsequential effect on maize output levels.

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. 23: MLE of the SPF Model – Unmatched and Matched Samples

	Conventional SPF Models									
			Unmatched Models				Matched Models			
	Pooled		Users		Nonusers		Users		Nonusers	
s	**Coeff.**	**S. E.**	**Coeff.**	**S. E.**	**Coeff.**	**S. E.**	**Coeff**	**S.E**	**Coeff**	**S.E**
on Function										
:	0.6177***	0.0689	0.5591***	0.0969	0.6898***	0.0875	0.6834***	0.1007	0.7048***	0.0868
of Labour	0.0605	0.0414	0.0252	0.0515	0.0671	0.0549	0.1299	0.0512	0.0607	0.0527
of Fertilizer	0.2036***	0.0507	0.1462**	0.0662	0.2094***	0.0698	0.0459**	0.0470	0.1898**	0.0687
Dummies										
;a District	0.2198*	0.1075	0.4143**	0.1646	0.0927	0.1668	0.2683**	0.1319	0.0774	0.1641
:gu District	-.0408	0.1089	-0.1527	0.1431	-0.1922	0.1777	-0.0592	0.1236	-0.1496	0.1758
ɔungu District	0.1093	0.1149	0.2004	0.2019	-0.0795	0.1506	0.4372*	0.2291	-0.0807	0.1487
Gonja District	0.3666***	0.1034	0.6632***	0.1792	0.1942	0.1524	0.8084***	0.1395	0.1955	0.1591
District	-0.5401***	0.1675	-0.1888	0.2046	-0.8458***	0.1860	-0.0586	0.1821	-0.8289***	0.1892
	0.5209***	0.0790	0.5141***	0.1188	0.1755*	0.1027	0.4550***	0.0886	0.0091	0.1242
ıcy Model										
novative Financing	-0.5980**	0.2712	-	-	-	-	-	-	-	-
.d Size	0.0087	0.0108	-0.0194	0.0228	0.0471*	0.0280	-1.0349	3.1778	1.2014**	0.5845
ı Access	0.1458	0.2517	-0.2109	0.3775	-0.9977	0.7005	7.1092**	3.4247	-0.6304	0.7734
nbership	-0.6253**	0.2754	-0.0845	0.4849	-0.7619	0.9406	-17.291**	6.9302	-0.5135	0.6463
Education	-0.1092	0.2357	0.0173	0.3498	-0.7341	0.4555	-3.8099**	1.6106	-2.7431	1.5288
ɔerience	0.0011	0.1824	-0.0595	0.2303	1.1037	1.2319	27.6011***	4.3423	2.6344*	1.7490
:upation	0.6411**	0.3257	0.1336	0.3747			9.6367**	4.7085	1.4606*	0.8699
Jse	-0.2820	0.3043	-0.1061	0.4408	0.8494	0.9417	9.9322	5.9908	-2.6551**	1.3209
ı Formal Credit	-0.0918	0.2649	0.3475	0.3517	-0.3189	0.8249	-11.0398**	3.9984	-6.0236	4.8330
ersification	-0.1881	0.1517	-0.2201	0.1749	-0.1985	1.6046	3.3010	2.2149	-0.1120	0.4999
echanised Services	-0.0277	0.3328	-0.3743	0.2118	1.6002*	0.8482	-24.2239**	11.6413	2.1530	1.3213
?articipation										
Commercial	0.2759	0.3441	0.0499	0.5162	1.0461	1.2005	-19.9998**	9.2105	1.4073	1.3870
Largely Subsistence	-0.4005	0.2638	-0.9142**	0.4234	-3.3948	3.1179	-32.0559**	13.7202	0.5070	1.0831
Largely Commercial	-2.0058**	0.9999	-2.8871**	1.4486	-0.0907	0.7971	-0.8085	14.1023	-3.9804	7.5887
Both Equally	0.2647	0.4426	-0.0372	0.5394	0.5081	0.3398	-78.2916***	21.1362	0.0227	0.9606
Constant	1.3969	1.5928	1.0860	0.7851	-4.4739**	1.9691	4.4213**	2.0727	-6.334**	2.9480
Vsigma										
Constant	-1.8894***	0.1710	-2.2946***	0.3775	-2.0642***	0.3369	-2.6759***	0.2896	-1.5167***	0.1263
Minimum (%)	**8.33**		**12.26**		**5.59**		**13.88**		**7.40**	

n (%)	**93.57**	**92.42**	**96.30**	**100.00**	**99.98**
)	**66.69**	**66.28**	**65.93**	**92.66**	**82.61**
	0.5689	0.1626	0.6556	0.1367	0.3580
	0.4249	0.3498	0.3851	0.4373	0.4684
ɔ Scale (RTS)	0.8818	0.7305	0.9663	0.8592	0.9553
	1.3389	0.4648	1.7024	0.3126	0.7643
	0.6419	0.1777	0.7435	0.0890	0.3687
ihood	-302.7367	-103.9733	-143.3284	-76.5656	-191.3767
ions	347	137	210	112	197

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Table 4. 24: Pooled Matched Model and Sample Selection Corrected SPF

	Matched Model		**Sample Selection SPF**			
	Pooled		*Users*		*Nonusers*	
Variables	**Coeff.**	**S.E.**	**Coeff**	**S.E**	**Coeff**	**S.E**
Production Function						
Farm size	0.6419***	0.0712	0.6582***	0.0688	0.7013***	0.0614
Quantity of Labour	0.0643	0.0407	0.0332	0.0430	0.0392	0.0409
Quantity of Fertilizer	0.1963***	0.0502	0.2472***	0.0328	0.2279***	0.0362
Location Dummies						
Karaga District	0.1861*	0.1057	-1.004***	0.27224	-0.4634*	0.2602
Gushegu District	0.0179	0.1103	-1.148***	0.29002	-0.5610**	0.2753
Kumbungu District	0.1263	0.1194	-1.068***	0.30503	-0.8941***	0.2949
West Gonja District	0.4000***	0.1109	-1.9247***	0.34079	-1.423***	0.2966
STK District	-0.4878***	0.1686	-0.8713***	0.32425	-0.5084	0.3175
Constant	0.5085***	0.0719	0.6283***	0.0968	0.7094***	0.0677
Inefficiency Model						
Use of Innovative Financing	-0.6390**	0.2703	-		-	
Household Size	0.0070	0.0122	0.0005	0.0004	0.0013***	0.0005
Extension Access	0.0652	0.2607	-.0044***	0.0008	-0.0069	0.0101
FBO Membership	-0.4882*	0.2750	0.0166*	0.0086	0.0135	0.0109
Years of Education	-0.1469	0.2392	0.0069	0.0079	0.0157	0.0100
Farm Experience	0.0860	0.1948	-0.0077*	0.0046	0.0133**	0.0058
Main Occupation	0.5609*	0.3295	0.0173	0.0131	0.0304*	0.0166
Manure Use	-0.1754	0.3451	0.0371***	0.0090	0.0363***	0.0114
Access to Formal Credit	-0.1198	0.2883	-0.0049	0.0138	0.0035	0.0174
Crop Diversification	-0.4254***	0.1261	-0.0071*	0.0042	-0.0115**	0.0053
Use of Mechanised Services	-0.2210	0.1116	0.0119**	0.0048	0.0179***	0.0060
Market Participation						
Only Commercial	0.1819	0.3486	-0.6080*	0.3259	-0.7797**	0.3368
Largely Subsistence	-0.5582**	0.2756	-0.8793**	0.4031	-0.8589**	0.4001
Largely Commercial	-1.9704	1.2014	-0.8029**	0.3285	-0.8751***	0.3344
Both Equally	-0.4642	0.5272	-0.4277	0.5586	0.0189	0.5496
Constant	2.7210*	1.5263	0.74664***	0.0200	0.6969***	0.0253
Vsigma						
Constant	0.3737***	0.0334				
Sigma (u)	0.2404		0.8159***	0.1160	0.9256***	0.0680
Sigma (v)	0.5100		0.4795***	0.0615	0.3915***	0.0481
Rho (w, v)	-		0.6466***	0.0594	0.2325**	0.0809
Minimum	**7.41**		**0.1169**		**0.0942**	
Maximum	**93.06**		**0.8680**		**0.8635**	
Mean	**65.48**		**0.7609**		**0.7184**	
Returns to Scale (RTS)	0.9025		0.6914		0.9684	
Lambda	0.4714		1.7016		2.3637	
Gamma	0.1818		0.7434		0.8482	
Log-likelihood	-263.0947		-520.422		-544.189	
Observations	309		112		197	

With the finding that maize farmers in the Savelugu-Nanton District are more likely to use innovative financing than farmers in other locations, the study sets it as the base category

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for all further estimations. The results from the pooled matched model indicate that farmers in the Karaga and West Gonja Districts realise more maize output while farmers in the Sawla-Tuna-Kalba District achieve less output in comparison to farmers in the base district. There is no statistical difference in the yields of maize farmers in the Gushegu and Kumbungu Districts and that of farmers in the Savelugu-Nanton District.

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After subjecting the matched sample to correction for selectivity bias and disaggregating the outcomes, the coefficients for the location variables take on a more homogenous direction for both users and nonusers. For both categories, the result suggest that farmers in the Savelugu-Nanton district achieve higher maize output than farmers in other locations. This is further testament to the dominance of innovative financing use in determining the efficiency outcomes of farmers in the Northern region. However, for nonusers in the Sawla-Tuna-Kalba district, there is no statistical difference in maize output compared to the base location.

Regarding the inefficiency models, use of innovative financing is found to significantly reduce farmers' technical inefficiency in the matched model with the effect being more pronounced in than in the unmatched model. Membership of FBOs and cultivating more than one crop are the other determinants of technical inefficiency in the pooled matched model – both variables have an inverse relationship with technical inefficiency.

In the corrected models, extension access, farm experience, and greater diversification in crop production were all found to reduce technical inefficiency for user of innovative financing. With the exception of crop diversification, these effects do not carry over into

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the model for nonusers with farm experience actually having a detrimental effect on technical efficiency for nonusers. Contrary to the *a priori* expectation, use of mechanized services led to greater technical inefficiency for both users and nonusers. Seyoum *et al*. (1998) reported a similar finding for maize farmers in eastern Ethiopia. In that study, the cause of inefficiency from tractor use was attributed to its unavailability in a timeous manner which set back land preparation for smallholder farmers. They therefore recommended that maize farmers substitute bullock ploughing for tractor use where tractor service was not readily available. This study finds that a similar situation exists for maize farmers in Ghana's Northern region and so adopting a similar measure may result in efficiency gains for underserved farmers. Another contrary finding is the negative effect of manure use on farm efficiency.

As postulated earlier, a farmer's level of market participation may influence the level of "attention" given to the production process and the consequent efficiency performance of the farm. The result reveals that in both models for users and nonusers, farmers who sell a greater quantity of their farm produce tend to reduce their level of inefficiency compared to farmers who produce solely for household consumption. Conversely, the result indicate that there is no statistical difference in the efficiency of farmers who attempt to produce for household consumption and the market in equal measure and purely subsistent farmers. This finding may be an attestation of the importance of specialization to increasing efficiency in production.

The estimated Lambda for both groups is different from zero and evince the presence of inefficiency effect in the frontier estimation. The gamma values show that this effect is more pronounced in the model for nonusers. The returns to scale parameters indicate that

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both categories are operating under decreasing returns although nonusers are closer to optimal returns.

This sample selection estimation procedure became necessary because of the possibility of self-selection into innovative financing use and the outcome justifies the decision to err on the side of caution. The necessary parameter for detecting selection bias; Rho, is significant in the models for both users and nonusers. This implies that certain unobserved variables influence both the decision to use innovative financing and the stochastic error in the production frontier model. The presence of selectivity bias therefore influenced the outcome of technical efficiency of farmers in the previous estimations.

An analysis of the summary statistics of the efficiency parameters show that users consistently have higher technical efficiency levels than non-users. However, the high estimated means reported in the matched model (without selection) are drastically reduced. Users of innovative financing can increase their output by about 24% while nonusers have greater room for improvement with their mean efficiency level of 72%. This confirms beyond statistical doubt that innovative financing use yields positive economic benefits for users.

Table 4. 25: Technical Efficiency across Models

Index	**Unmatched**	**Matched**	**Sample Selection Model**	
TE			**Users**	**Nonusers**
Minimum	0.0833	0.0741	0.1169	0.0942
Mean	0.6669	0.6548	0.7609	0.7184
Maximum	0.9357	0.9306	0.8680	0.8635

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4.8 Stochastic Cost Frontier Model and Economic Efficiency in Maize Production

The Maximum Likelihood Estimates (MLE) for the parameters in the stochastic cost frontier model (defined by equation 3.12) are presented in Tables 4.26 and 4.27. This analysis was also conducted using mean-corrected values of the input variables. The coefficients of the logarithms of these inputs can thus be interpreted as elasticities at the means of input values. The $\hat{\lambda}$ values of 0.4987 and 0.3978, for the Unmatched and Matched samples respectively, are significantly different from zero; the null hypothesis of absent of inefficiency effects is rejected at 5% significance level in both models. From these, the estimated $\hat{\gamma}$ values of 0.1992 and 0.1366 indicate about 20% and 14% of variations in the cost of maize production can be attributed to cost inefficiencies for farmers in the Unmatched and Matched samples respectively.

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. 26: MLE of the SCF Model – Unmatched and Matched Samples

	Conventional SCF Models									
			Unmatched Models				Matched Models			
	Pooled		Users		Nonusers		Users		Nonusers	
s	**Coeff.**	**S. E.**	**Coeff.**	**S. E.**	**Coeff.**	**S. E.**	**Coeff**	S.E	Coeff	S.E
ıction										
ː	0.4714***	0.0551	0.5263***	0.0606	0.4920***	0.0927	0.5157***	0.0887	0.5064***	0.0765
ʟabour	0.3662***	0.0468	0.1569**	0.0784	0.4510***	0.0745	0.1712**	0.0731	0.4710***	0.0809
ertilizer	0.0551***	0.0079	-0.0286***	0.0096	0.0761***	0.0249	0.0385***	0.0117	0.0805***	0.0241
put	0.2354***	0.0400	-0.1363***	0.0607	0.2209***	0.0776	0.1638**	0.0753	0.2020***	0.0644
	-0.1692***	0.0418	0.2838***	0.0527	-0.1879*	0.2933	-0.2923***	0.0717	-0.2072**	0.1120
ıcy Model										
novative Financing	-1.3516**	0.5215	-	-	-	-	-	-	-	-
d Size	0.0497**	0.0206	0.0455	0.0289	0.0471*	0.0280	0.0219	0.0246	0.0476	0.0319
ı Access	-1.0181*	0.5665	-0.1152	0.5332	-0.9977	0.7005	-0.1038	0.4549	-1.2018	0.7293
nbership	-0.5134	0.5689	0.9119	0.8904	-0.7619	0.9406	0.8925	0.6410	-0.4980	0.8611
perience	-0.7094**	0.2599	0.0295	0.2790	-0.7341	0.4555	-0.1137	0.4488	-0.6390	0.4031
as Main Occupation	1.7648**	0.7045	1.4651	0.9194	1.1037	1.2319	2.3353**	0.8901	0.8188	1.1484
Participation										
Commercial	0.2321	0.7517	-1.2697	1.0958	0.8494	0.9417	-1.4440*	0.9414	0.7394	0.9110
ly Subsistence	-0.0344	0.5177	0.5040	0.4761	-0.3189	0.8249	0.3433	0.6487	-0.5611	0.8571
ly Commercial	0.7063	1.0170	-1.6959	1.6616	-0.1985	1.6046	-2.7602	6.1220	-0.2313	1.9010
Equally	1.3510*	0.7396	-0.9755	1.2183	1.6002*	0.8482	-1.6228	1.7821	1.5338*	0.8364
echanised Services	0.5359*	0.2740	0.2466	0.3302	0.5875	0.4937	0.5977*	0.3338	0.6116	0.5215
Jse	0.9661	0.5873	-2.2587***	0.5682	1.0461	1.2005	-2.4984***	0.4634	1.2534	1.0371
Formal Credit	1.2663*	0.7641	0.8623	1.0098	-3.3948	3.1179	0.8735	1.1386	-3.3626	2.8487
Main Crop	-0.4875	0.5214	-2.0238	0.6093	-0.0907	0.7971	-2.1688**	0.8967	-0.1842	0.9345
pital	0.5219**	0.2417	0.9617***	0.2075	0.5081	0.3398	1.2298***	0.3371	0.4777	0.3192
	-4.9917***	0.9774	-6.9190	1.4319	-4.4739**	1.9691	-7.5424***	1.6850	-4.3103	1.9837
Dummies										
Karaga District	1.3296***	0.3522	1.5845***	0.0535	1.0687**	0.4496	1.4689**	0.5298	0.9864**	0.4524
Gushegu District	0.1720	0.3196	0.0582	0.5865	0.3806	0.5172	0.6155	0.5283	0.5071	0.5914
Kumbungu District	0.6768**	0.3235	0.1811	3.4744	0.3036	0.4605	1.8622**	0.7264	0.1992	0.4742
West Gonja District	0.3738	0.3780	1.9827*	1.1029	-0.0135	0.5512	1.7750*	0.9528	0.0209	0.6607
Sawla-Tuna-Kalba District	-0.0945	0.3751	1.2306	0.8281	-0.5947	0.5059	0.9576	0.6679	-0.5590	0.5040
Constant	-2.3075***	0.2020	-3.1004***	0.4488	-2.0642***	0.3369	-3.3653***	0.3645	-2.0409***	0.3536
Minimum	13.48		21.21		13.76		35.91		14.09	

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n	98.18	98.74	98.56	98.40	98.54
	85.49	84.37	84.07	86.28	82.16
	0.1876	0.2073	0.2079	0.2150	0.2197
	0.4141	0.3339	0.4334	0.2866	0.4405
^{2}(4)	603.61***	195.07***	486.90***	121.34***	393.14***
ihood	-211.9967	47.9807	-143.3284	-35.8976	-138.9666
)	-	-	-		
ions	347	137	210	112	197

*, and * represent significance at 1%, 5%, and 10% respectively*

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Table 4. 27: Pooled Matched Model and Sample Selection Corrected SCF Models

	Matched Models		**Sample Selection SCF – Matched**			
	Pooled		**Users**		**Nonusers**	
Variables	**Coeff.**	**S. E.**	**Coeff.**	**S. E.**	**Coeff.**	**S. E.**
Cost Function						
Farm size	0.4545***	0.0634	0.38850***	0.1150	0.42677***	0.1006
Price of Labour	0.3805***	0.0547	0.17911*	0.1084	0.15474	0.0932
Price of Fertilizer	0.0590***	0.0087	0.06853***	0.0137	0.06695***	0.0115
Total output	0.2438***	0.0480	0.24727***	0.0595	0.22637***	0.0549
Constant	-0.1719**	0.0637	-0.11692	0.3051	-0.18014	0.2815
Inefficiency Model						
Usigma						
Use of Innovative Financing	-1.4301*	0.8258	-	-	-	-
Household Size	0.0519**	0.6685	0.0008	0.0083	0.0471*	0.0280
Extension Access	-0.9089	0.0590	-1.211**	0.4541	-0.8709*	0.5023
FBO Membership	-0.3720	0.7472	-0.1208	0.1190	0.0014	0.0535
Farm Experience	-0.6931**	0.3132	-2.0372**	0.9963	-0.1485	0.3352
Farming as Main Occupation	2.0372**	0.9962	-0.0970	0.1345	-0.0999	1.0902
Market Participation						
Only Commercial	-0.0302	0.7844	-1.2697	1.0958	0.8494	0.9417
Largely Subsistence	-0.4984	0.6457	0.5040	0.4761	-0.3189	0.8249
Largely Commercial	0.5559	1.7667	-1.6959	1.6616	-0.1985	1.6046
Both Equally	0.7845	0.8929	-0.9755	1.2183	1.6002*	0.8482
Use of Mechanised Services	0.5505	0.4282	0.2466	0.3302	0.5875	0.4937
Manure Use	1.2189*	0.6726	-2.2587***	0.5682	1.0461	1.2005
Access to Formal Credit	0.1934	2.4577	0.8623	1.0098	-3.3948	3.1179
Maize as Main Crop	-0.6096	0.6317	-2.0238	0.6093	-0.0907	0.7971
Social Capital	0.3952	0.2832	-0.9617***	0.2075	0.5081	0.3398
Constant	-5.0078***	1.2813	-6.9190	1.4319	-4.4739**	1.9691
Vsigma						
Location Dummies						
Karaga District	1.3047***	0.3904	1.5845***	0.0535	1.0687**	0.4496
Gushegu District	0.2462	0.3963	0.0582	0.5865	0.3806	0.5172
Kumbungu District	0.6546*	0.3430	0.1811	3.4744	0.3036	0.4605
West Gonja District	0.4852	0.4640	1.9827*	1.1029	-0.0135	0.5512
Sawla-Tuna-Kalba District	-0.0708	0.3588	1.2306	0.8281	-0.5947	0.5059
Constant	-2.3075***	0.2525	-3.1004***	0.4488	-2.0642***	0.3369
Minimum	**13.22**		**39.42**		**25.46**	
Maximum	**98.49**		**93.46**		**92.01**	
Mean	**85.68**		**75.72**		**66.07**	
$\sigma_{(u)}$	0.1796		0.3790**		0.3430*	
$\sigma_{(v)}$	0.4241		0.3274***		0.3219***	
Wald-chi^2(4)	535.09***		195.07***		486.90***	
Log-likelihood	-194.0096		-120.65		-143.3284	
Rho (w, v)	-		**-0.7857****		**-0.8888*****	
Observations	309		112		197	

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The estimated coefficients from the cost function in Tables 4.26 and 4.27 show the relative change in farmers' cost of production resulting from a percentage change in the input used. All estimated coefficients have the expected positive signs which means increasing the quantities used of each increases the cost of maize production. The negative sign of the estimated intercepts may be a confirmation of the underlying assumption that maize farmers in the Northern region of Ghana are cost minimizers.

The results above are along the lines of findings from the TE estimates from Section 4.6 above. Use of innovative financing significantly increases cost efficiency and estimation with the matched sample yields reduced mean economic efficiency outcomes. This means there are biases from observed characteristics which influence the estimated outcomes. This provides a basis subject the matched sample to further correction for unobserved biases using the selectivity framework for SFM.

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4.9 Results of the Stochastic Cost Frontier Model Correcting for Self-Selection

As indicated in Chapter 3, the stochastic frontier (SF) cost model correcting for selectivity bias comprises two stages; a Probit model (Equation 3.18 *pp.83*) which selects the users of the treatment and a subsequent maximum simulated likelihood stochastic frontier estimation using the selected sample from the initial estimation (Equation 3.19 *pp.83*). The SFM with selection is estimated for users and nonusers using the matched sample. The selection Probit model is similar to the result in Table 4.19 and is not repeated here.

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The outcome of the SFM with selection procedure shows that the suspicion of selectivity bias in the data is justified in that the indicator variable for selection bias (Rho) is statistically significant in both models. This justifies the use of a sample selection framework to estimate separate stochastic cost frontier models for users and nonusers.

The confirmation of selection bias indicates that the estimates from the conventional cost functions yield biased frontier estimates which affect the estimated cost efficiency scores. To the best of this researcher's knowledge, the only other study that estimated cost efficiency using a sample selection framework is that of Rahman *et al.* (2012) who also found selection bias among rice farmers in Thailand.

In the selection bias corrected models, all estimated parameters present positive partial cost elasticities although their statistical significance and magnitudes differ across models. In both models, the area of maize cultivated makes the greatest contribution to production cost followed by the level of output. A percentage increase in farm size leads to 0.43% increase in cost of production for Nonusers and 0.39% increase for Users.

In the model for Nonusers, cost of labour is not a significant determinant of cost efficiency while labour is significant at 10% level in the Users model. The mixed outcome for labour is consistent with the findings of Gonzalez-Flores *et al.* (2014) that labour is available in surplus in developing country agricultural settings and this distorts the labour market for smallholders. Thus, the significance of labour cost for users proffers their relatively more active participation in the labour market.

In the inefficiency model, manure use, higher social integration, extension access, and farm experience were all found to reduce farmers' cost inefficiency in the users model.

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Extension access was found to also reduce cost inefficiency in the model for nonusers. Larger family size and equal focus on subsistent and commercial production were found to significantly increase cost inefficiency for farmers who do not use innovative financing. With regards to the effect of a farmer's location on their cost efficiency, the estimated parameters in both models for users and nonusers are consistent in concluding that farmers in the base category have better cost efficiency. These parameters are statistically significant for farmers in the Karaga and West Gonja districts in the users model while the nonusers model affirm this finding for farmers in the Karaga district only. In both models, the intercept for the "noise" component of the stochastic error term is highly significant. Economic efficiency scores estimated in the unmatched model presents a rather low mean of 66% although the reported minimum of 25.46% is the highest estimated for any variant of this model in this study. The estimated cost efficiency for users ranges between 0.3942 (minimum) and 0.9346 (maximum) with a mean of 0.7572.

The estimated Lambda values in both models are significantly different from zero based on the significance of the standard errors of the decomposed error terms. This means there is an inefficiency effect in both models; deviations from the cost frontier are not solely as a result of "noise". The variable measuring selection bias in both models are statistically significant at 1% (for nonusers) and 5% level for the Users model. There is a correlation between the stochastic error term in the frontier model and the residual in the selection equation and caused an overestimation of farmers' economic efficiencies in the conventional SF models.

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In summary, estimation of a conventional cost frontier for users and nonusers of innovative financing using the unmatched sample yields bloated economic efficiency scores which can be reduced by correcting for observed biases in a PSM procedure. The sample selection framework decreases this overestimation even further.

The estimated mean scores imply that on the average, users and nonusers can reduce their cost of production by about 24% and 34% respectively at the current output level and production technology by making smarter financial decisions on input use.

Table 4. 28: Economic Efficiency across Model

Index	Unmatched	Matched	Sample Selection Model	
EE			**Users**	**Nonusers**
Minimum	13.48	13.22	0.3942	0.2546
Mean	98.18	98.49	0.9346	0.9201
Maximum	85.49	85.68	0.7572	0.6607

4.10 Allocative Efficiency in Maize Production in the Northern region

As stated earlier, economic efficiency is composed of technical efficiency and allocative efficiency. This study has already estimated technical efficiency and economic efficiency of maize farmers in the Northern region of Ghana. Allocative efficiency reflects a farmer's ability to optimally use the technically efficient inputs, given their respective prices and the prevailing technology.

With the estimated technical and economic efficiency levels for maize production, the study calculated allocative efficiency levels for farmers residually using the formula outlined in Equation 3.15. Mean Allocative Efficiency (AE) for the pooled model implies farmers can increase their optimality of input use by about 21% at the current market prices of the inputs and the production technology.

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The matched model presents a statistically similar outcome; the mean and minimum reduce by less than 1% while the maximum however experiences an increase over the estimate in the pooled model. Once again, the matching procedure is shown to reduce the measured mean efficiency which means the observed biases consistently lead to overestimation of efficiency scores.

With the estimated TE and EE from the selection correcting stochastic frontier models for users and nonusers, this study calculated AE for maize farmers with correction for selection bias. This calculation was done separately for users and nonusers of innovative financing in order to estimate the true effect of this choice. The mean allocative efficiency for users is 86.37% with minimum and maximum values of 14.72% and 100.00%. For nonusers, the mean value is 80.74% which means non-user farmers can increase their input use optimality by about 19%.

Considering the estimated means for technical, allocative, and economic efficiency of maize farmers, there is a significant distance between the frontier and the estimated mean for all categories of farmers. Thus, maize production in the Northern region is fraught with significant inefficiencies in input allocation and use given current technology levels and prices of inputs.

Table 4. 29: Summary of TE, AE, and EE for Users and Nonusers of Innovative Financing

Efficiency Index	TE		AE		EE	
	Users	Nonusers	Users	Nonusers	Users	Nonusers
Minimum	0.1169	0.0942	0.1472	12.26	0.3942	0.2546
Maximum	0.8680	0.8635	1.0000	92.42	0.9346	0.9201
Mean	0.7609	0.7184	0.8637	0.8074	0.7572	0.6607

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CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.0 Outline

This Chapter presents a summary of the key findings from this study in Section 5.1. Based on these findings, the researcher presents some conclusions in Section 5.2 and proffer some recommendations for planning financing options for credit-constrained maize farmers in the Northern region. Section 5.4 presents a scope for future research into innovative financing use in Ghanaian agriculture.

5.1 Summary of Key Findings

This study sought to bridge the research gap between the two broad fields of agricultural financing and efficiency and productivity analysis. The study approached this task by showing the link between timely access to farm financing resources and yield improvements. Past studies have proposed provision of credit to farmers as a means of increasing their adoption of yield-enhancing technologies and improving the food security situation of the country. However, many empirical studies show that credit access among smallholder farmers is seriously limited – this necessitates a paradigm shift in the research focus.

The main objective of this study then was to examine the effect of innovative financing use on the economic efficiency of maize farmers. Characterizing the sources of farm finance that can be broadly labeled as traditional or innovative, measuring the magnitudes of funds generated through these sources, and identifying the characteristics that increase a farmer's propensity to use innovative financing were all identified as essential steps in achieving

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the study's broad objective. Through the same estimation procedure implemented for assessing the effect of innovative financing use on farmers' economic efficiency, the present study was able to identify other factors that influence efficiency in maize production.

After the rigorous processes employed in analyzing the cross-sectional data collected on 347 maize farmers in the Northern region, the study found farmer's own savings, ploughing back profits from the previous season, and taking loans from relatives among others to be the traditional methods of farm financing. When faced with farm liquidity constraints, about 40% of farmers reported taking "by-day" jobs and/or joining VSLA groups specifically to meet their farm financing needs. These two methods were thus identified as farmer innovations in farm financing.

Farmers' own savings (62.82%), ploughing back profits (59.37%), and using income from sale of other crops (52.16%) were the most popular sources of financing maize production among farmers in the study area. With regards to the amounts generated from these sources, farmers reported an average of GH₵ 759.24 from own savings while farmers reinvest an average of GH₵375.5 of their profits in production. About GH₵279.47 of proceeds from other crops than maize was allocated to investment in maize production.

Farmers whose primary crop is maize were found to be more likely to use innovative financing. Also, access to formal credit, greater social integration and organic manure use were some other factors that increase farmer's likelihood of using innovative financing. Conversely, membership of FBOs, larger family size, and greater diversification in crops produced negatively influenced farmers' likelihood of using innovative financing.

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With regards to the effect of innovative financing use on farmers' economic efficiency, the study revealed that users of innovative financing had higher (75.72%) efficiency than nonusers (66.07%). Socioeconomic factors like Manure use, Agricultural Extension Agent (AEA) contact, farm experience, and higher market participation levels were found to increase farmers' economic efficiency.

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5.2 Conclusions

The above key findings reveal that traditional methods of farm financing like dependence of own savings and reinvesting farm profits and proceeds still dominate in maize production in the Northern region. Relatively modest amounts of funds are raised through these methods for farm investment. Where funds from these sources are inadequate to meet farmers' investment needs, some intelligent farmers join VSLA groups specifically for the credit option it presents and/or take menial jobs before and during the production season to raise emergency funds for farm investment.

Farmers who primarily farm maize, have access to some form of credit, and are members of several social groups are more likely to use these innovative financing methods. However, farmers who are members of FBOs, have larger family sizes, and are engaged in production of multiple crops are less likely to take "by-day" jobs or join VSLA groups in order to raise income for their farm financing needs.

Interestingly, users of innovative financing make smarter farm expenditure decisions and are, as a result, more cost efficient than nonusers. However, there is still a significant level of cost inefficiency in maize production in the Northern region.

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Farmers with access to support services like AEA contact and tractor services are more cost efficient. Farm experience and use of organic manure are some other determinants of economic efficiency.

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5.3 Recommendations

In line with the finding that majority of maize farmers in the Northern region depend on own financing methods, the study recommends that farmers be encouraged to continue and develop the existing culture of saving. The formal financial sector can influence this process through the provision of incentives like qualification for loan advances and personal and farm insurance cover. Since a large portion of farmers' income is from sale of farm produce, greater efforts should be made to empower farmers to reap more rewards from market participation.

The activities of VSLAs should be given more attention since they have the potential to serve as a conduit for mitigating risks involved in formal credit provision and can link farmers directly to inputs; reducing the need for cash loans. In its current state, VSLAs tend to target only female farmers. However, maize production in the Study Area is male-dominated and this creates the need to get more males to participate in these Associations. Since large portions of the household income is generated and controlled by the male head, inclusion of males in the VSLAs can increase the Association's capital stock and boost its attractiveness to input suppliers.

A significant proportion of users of innovative financing are farmers who generate funds by taking off-farm jobs. This study recommends that government at the local levels

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increase their efforts of creating (sustainable) employment opportunities that absorb farmers in the off-season so that participating farmers can make some savings towards farm investment in the upcoming season. These off-season jobs can be in diverse areas of the economy (for example agro-processing, services, and manufacturing) with capital sourced from the government's 1-District 1-Factory Project to boost the local economies.

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5.4 Suggestions for Future Research

This survey has attempted to break new grounds in farm financing research by shifting the focus to farmers' own attempts at meeting their financial needs. While the methods identified are widespread in the Northern region, they are by no means ecumenical either in the study area or in the nation as a whole. The study therefore urges other researchers to investigate other efforts of note in other locations using the working definition advanced in this study. An assessment of the impacts of these efforts in meeting farmers' financial needs will contribute to generating a comprehensive understanding of shortfalls and prospective areas for development of informed agricultural policies.

The findings from this study reveal that treatment effect studies on farm productivity and efficiency using the stochastic frontier model is fraught with diverse forms of biases. It is therefore recommended that future studies adapt the Greene (2010) method to correct these biases to enhance the reliability of research findings.

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APPENDIX A

Tables and Figures

Table A 1: Balancing Test of Matched Sample

Variable	Unmatched Matched	Mean T	Mean C	%bias	% |bias| reduction	t-test t	t-test p> |t|
Access to Formal Credit	U	0.1241	0.0571	23.4		2.21	0.028
	M	0.0804	0.0804	0.0	100.0	0.00	1.000
Farming as Main Occupation	U	0.8978	0.0762	-9.1		-0.84	0.401
	M	0.9018	0.1161	3.1	65.7	0.22	0.827
Extension Access	U	0.3796	0.4333	-10.9		-0.99	0.321
	M	0.375	0.4107	-7.3	33.6	-0.55	0.586
FBO Membership	U	0.3358	0.3524	-3.5		-0.32	0.751
	M	0.2946	0.3393	-9.4	-168.7	-0.72	0.475
Assets owned	U	6.613	7.1762	-23.3		-2.09	0.038
	M	6.6518	6.9107	-10.7	54.0	-0.87	0.386
Household Size	U	14.234	15.924	-18.2		-1.58	0.114
	M	14.688	14.348	3.6	79.9	0.28	0.776
Maize as main crop	U	0.8175	0.6905	29.7		2.66	0.008
	M	0.7946	0.8304	-8.4	71.9	-0.68	0.496
Social Capital	U	1.0876	0.8524	29.8		2.72	0.007
	M	1.0179	1.1429	-15.8	46.9	-1.24	0.215
Household Position	U	0.4307	0.6143	-37.3		-3.40	0.001
	M	0.4911	0.4821	1.8	95.1	0.13	0.894
Level of Crop Diversification	U	2.2409	2.5	-30.7		-2.75	0.006
	M	2.2857	2.375	-10.6	65.5	-0.86	0.393
Personal Tragedy	U	0.2628	0.1857	18.5		1.71	0.089
	M	0.2321	0.25	-4.3	76.8	-0.31	0.756
Manure Use	U	0.3218	0.1286	47.3		4.46	0.000
	M	0.25	0.2589	-2.2	95.4	-0.15	0.879
Only Commercial	U	0.0803	0.1095	-10.0		-0.89	0.372
	M	0.0804	0.0446	12.2	-22.2	1.10	0.272
Largely Subsistence	U	0.3358	0.4429	-22.0		-2.00	0.047
	M	0.3571	0.375	-3.7	83.3	-0.28	0.783
Largely Commercial	U	0.0292	0.0333	-2.4		-0.21	0.830
	M	0.0268	0.0357	-5.1	-115.9	-0.38	0.703
Both Equally	U	0.1241	0.0619	21.5		2.02	0.044
	M	0.9821	0.0982	0.0	100.0	0.00	1.000
Karaga District	U	0.1825	0.2429	-14.8		-1.33	0.185
	M	0.1696	0.1696	0.0	100.0	-0.00	1.000
Gushegu District	U	0.1679	0.2	-8.3		-0.75	0.455
	M	0.1607	0.2143	13.8	-66.8	-1.02	0.307
Kumbungu District	U	0.1533	0.1476	1.6		0.14	0.855
	M	0.1786	0.1071	19.9	-1160.7	1.53	0.128
West Gonja District	U	0.0657	0.2238	-46.0		-3.99	0.000
	M	0.0804	0.1071	-7.8	83.1	-0.69	0.494
STK District	U	0.1168	0.0762	13.7		1.28	0.202
	M	0.125	0.1160	3.0	78.0	0.20	0.838

Legend: M = matched sample; U = unmatched sample; T= Treated; C=Control

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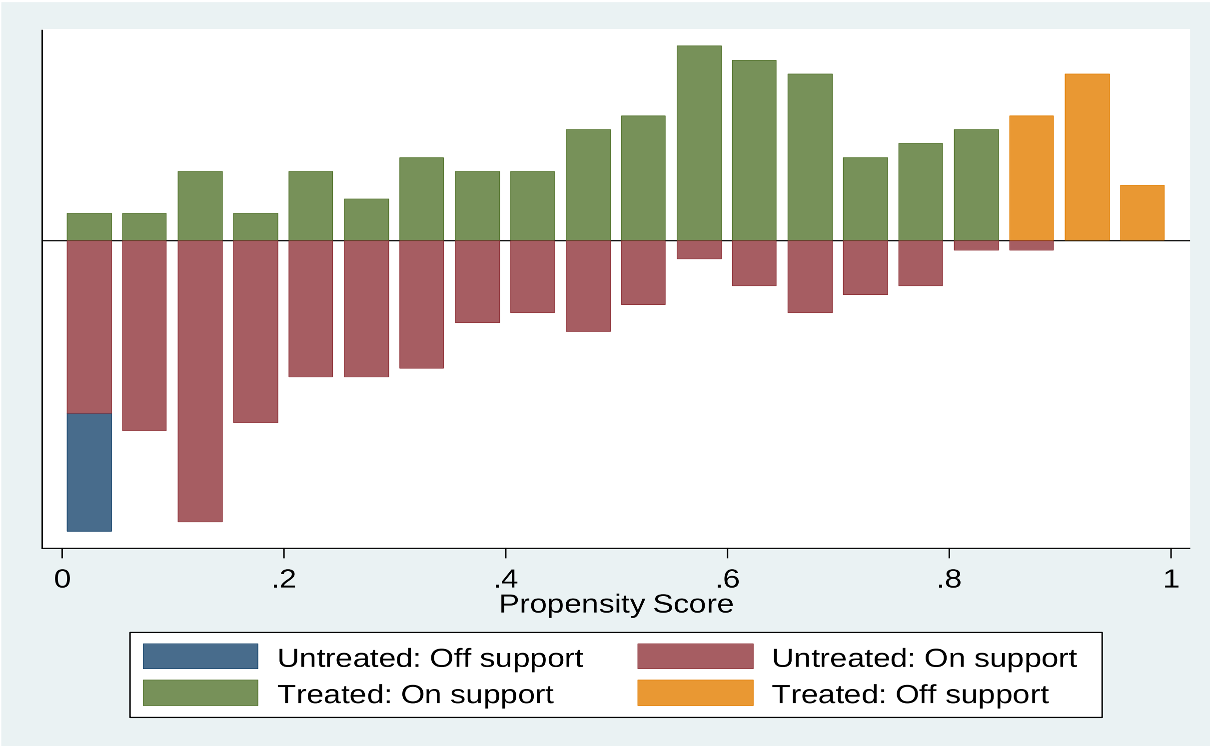

Figure A 1: Graph of the Common Support Region for Users and Nonusers after Matching

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APPENDIX B

SURVEY QUESTIONNAIRE

A survey to investigate Farmer Innovation in Agricultural Financing and Economic Efficiency of Maize Farmers in the Northern Region of Ghana

Dear Respondent, as part of my M.Phil. research at the University for Development Studies Nyankpala Campus, I am undertaking a survey to assess the innovative measures undertaken by maize farmers in Northern region to finance their production activities and to evaluate the Economic Efficiency of these Maize Farmers. I would be grateful for your participation in the completion of this questionnaire. Please answer as frankly as possible; I assure you that any information obtained in connection with this study that can be identified with you will remain strictly confidential.

Date of Survey	
Enumerator's name	
Respondent's name	
Respondents phone number	
District of survey	
Name of community	
GPS Coordinates	

Section A: Socio-Demographic Information

3. Sex of respondent	[ ] Male [ ] Female
4. Age of respondent	
5. Are you the household head	[ ] Yes [ ] No
6. If No, how old is the household head?	
7. Relationship with the HHH	[ ] Spouse [ ] In-Law [ ] Child [ ] Other___________________
8. Marital Status	[ ] Single [ ] Married [ ] Divorced [ ] Widowed
9. Highest Educational level of Respondent	None [ ] Primary [ ] JHS [ ] S. H. S [ ] Diploma [ ] 1st Degree [ ] 2nd Degree [ ] 3rd Degree [ ] Non-Formal [ ] Others ____________
10. Number of completed years of education	____________
11. Religion	[ ] Islam [ ] Christian [ ] Traditional[ ] Other
12. Household size	____________Total _________ Male ____________Female
13. Number of children	___________Total _________ Male _________ Female
14. Residency status	[ ] Native [ ] Migrant
15. If Migrant, for how long?	

16. Please indicate whether or not you own of the following assets and the quantities owned of same:

Asset	Response (1=Yes, 0=No)	Quantity Owned	Asset	Response (1=Yes, 0=No)	Quantity Owned
Bicycle			Radio		
Motorbike			Mobile Phone		
Car			Boats/Canoe/OtherFishing Vessel		
Tricycle			Knapsack sprayer		

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House			Hoe		
Tractor			Cutlass		
Land			Donkey Cart		
Television set			Sewing Machine		
Bullock Plough					

SECTION B: FARM AND PRODUCTION INFORMATION

17. Is farming your major occupation? Yes [ ] No [ ]
18. If No, what is your major occupation? ____________________
19. How many years have you been farming; generally? __________Maize? __________
20. Which of the following is your major crop?

Maize [ ] Yam [ ] Millet/Sorghum [ ]
Rice [ ] Cowpea [ ] Other, specify ____________________
Soybean [ ] Groundnut [ ]

21. What is your main aim for maize production? Only Subsistence [ ] Only commercial
22. [ ] largely subsistence [ ] largely commercial [ ] Both equally [ ]
23. What is the total size of maize farm cultivated last season? __________ acres.
24. Please provide the details of your maize and other crops plots in the Table below:

Plot No.	Crop planted	Area planted	Tenure Status 1=Own 2 = rented 3=communal	Farm System 1= Monocrop 2= Mixed crop	Average distance from house to plot (km)	Means of transport to plot
1	Maize					
2						
3						
4						
5						

25. What variety of maize did you plant in last season?

a. Bihilifa [ ] e. Omankwa [ ] i. PANA/Hybrid [ ]
b. Sanzal-Sima [ ] f. Aburohemaa [ ] j. Enii/Pibi [ ]
c. Ewul-Buyo [ ] g. Sika Aburo [ ] k. Other, specify______________
d. Wandata [ ] h. Obaatanpa [ ] l. Don't know [ ]

26. How did you acquire your seeds (*multiple responses allowed*)?

Purchase [ ] Gift/Borrowed [ ]
Supplied by Research Unit/NGO [ ] Others [ ]
Stored from previous harvest [ ]

27. Please indicate whether you undertook any of the following practices in the last 2 seasons on any of your maize farms?

Production/Cultural Practice	**Response (Y/N)**	**Production/Cultural Practice**	**Response (Y/N)**
Row planting		Bush burning before cultivation	
Contour Ploughing		Burning crop residue after harvest	
Crop Rotation		Applying organic manure	
Irrigated Production		Ploughing in crop residue	
Fallowing		Mulching/composting	
Planting trees		Intercropping with legumes	

28. Did you have access to agricultural extension services last season? Yes [ ] No [ ]
29. If yes, how many times were you visited during the season? ____________________
30. What information/advice did you receive from your AEA?

i. Fertilizer application [ ] vi. Information on credit access [ ]
ii. Improved crop variety [ ] vii. Information on market access [ ]
iii. Crop-livestock integration [ ] viii. Information on machinery services [ ]
iv. Cultural practices [ ] ix. Other, specify ____________________

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v. Information on Pest/Disease Prevention [ ]
vi. Brief Details? ____________________ ____________________

31. How useful was this information to you? (1) Very Useful [ ] (2) Useful [ ] (3) Not Useful [ ]
32. How long have you known your extension agent? __________ years.
33. Are you satisfied with the quality, quantity, and timelines of extension services? (1) Yes [ ] (2) No [ ]
34. Did you have access to agricultural mechanisation services? Yes [ ] No [ ]
35. If yes, which of the following tractor services did you utilise? (1) Ploughing [ ] (2) Threshing [ ] (3) Carrying farm produce home from farm [ ] (4) Other, specify_____________
36. Are you a member of any Farmer Based Organisation? [ ] Yes [ ] No
37. If yes, what role do you play in the Organisation? ____________________
38. If yes, did you receive any of the following assistance from the farmer based organization? Tick the appropriate box.

Assistance	**Do you have access to?**		**Have you used this?**	
	YES = 1	**NO = 0**	**YES = 1**	**NO = 0**
Technical training				
Access to Inputs				
Credit in kind				
Credit in cash				
Machinery services				
Storage				
Transportation of inputs and produce				
Market Access				

39. Other than the FBO, have you had any training or been to a training workshop on crop production? Yes [ ] No [ ]
40. Source of the training___________________________
41. Was the training beneficial? [ ] Yes [ ] No
42. Please provide the following information on your group membership:

Group Type	Membership? **TICK**	Years of Membership	Position Held 1= Leader 2=Member
Women's/Men's Group			
Religious Group			
Community group			
Financial/Credit Unions			
Political Group			
Other groups, specify ………………………			

43. Did you receive labour support on your maize farm from any of these groups/use group labour last season? Yes [ ] No [ ]
44. How much did you pay for this service? ____________________
45. Please indicate details of labour use in maize production in the last season

ACTIVITIES	**LABOUR TYPE: H=HIRED, F=FAMILY LABOUR, B=Friend, G=Group**								
	Labour Type	**No. of days**	**No. of people per day**			**No. of Hours of Work**	**Total man days**	**Unit cost GH₵**	**Total amount GH₵**
			M	**F**	**Total**				
Planting									
Spraying									
Weeding									
Harvesting									
Threshing									

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Carrying produce home									

46. Please provide information on income from maize and other crops production in the last season:

Crop	Qty. harvested (bags)	Qty. sold (bags)	Price per bag (GH₵)	Qty. Consumed (bags)	Qty. Stored (bags)	Reason for Storage 1= Future sale 2= Future consumption
1. Maize						
2.						
3.						
4.						

47. What is the quantity and per unit price of the following inputs for maize production in the last season?

Variable	Maize (all plots)	
	Quantity	Unit Price
Land (*cost of use for one season*)		
Inorganic Fertiliser (No. of 50kg bags)		
Manure		
Seeds		
Herbicides		
Insecticides		
Ploughing Cost		
Threshing Cost		
Produce Transport Cost		

48. Please give a brief description of how you apply your inorganic fertilizer

____

49. Where do you sell your produce? A. Farmgate [ ] B. Local Market [ ] C. District Market [ ] D. Other, specify ___________________

50. Whom do you sell your maize to? [ ] individuals[ ] retailers [ ] aggregators [ ] processors[ ] others, specify ___________________

51. Please provide information on the following shocks and how they may have affected your production in the last season:

Shock	Response (**Y/N**)	**Effect on Maize Production (1=None, 2=Moderate, 3=Severe, 4=Very Severe)**
Death of family member		
Pest/Disease Infestation		
Flood in maize farm		
Drought in last season		
Bush fire in any maize plot		

SECTION C: AGRICULTURAL FINANCING INFORMATION

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Please indicate whether you used any of the following agricultural financing sources in your production activities;

Source of finance	Did you use source? 1. Yes 2. No	Amount Used/Received(GH₵)	Interest rate (where applicable)	Other Conditions
Personal savings				
Gifts/remittances from family members				
Gifts/remittances from friends				
Loans from family members				
Loans from friends				
Loans from money lender(s)				
Ploughing back profit from farming				
Income from sale of other crops				
Income from off-farm activities				
Income from lottery				
Input credit				
Loans from banks				
Grants from NGO				
Loans from Microfinance Institutions (MFIs)				
Income from livestock sale				
Others (specify)				
1.				
2.				

52. Did you apply for agricultural credit in the last season? Yes [ ] No [ ]
53. Were you granted the loan or credit? Yes [ ] No [ ]
54. If you were granted credit or loan, did you get the full amount you applied for? Yes [ ] No [ ]
55. If No, how much did you apply for __________ and how much did you receive __________?
56. Why do you think you did not receive the full amount?

____

57. If you did not apply for loan/credit, why? A. Not interested [ ] B. Not available locally [ ] C. Inadequate collateral [ ] D. High interest rate [ ] E. Unfavourable repayment plan/schedule [ ] F. Others (specify) _____________________

58. Do you engage in contract farming? Yes [ ] No [ ]

59. If yes, what type of contracting? A. input credit contract [ ] B. product market contract [ ] C. Other [ ]

60. Which organization or individual provides the contract? __________________________

61. Please give a brief description of the terms of the contract

____

62. If you don't engage in contract farming at the moment, are you willing to engage in future? Yes [ ] No [ ]

63. i. Is your maize farm insured? Yes [ ] No [ ]
ii. If No, are you willing to insure your farm? Yes [ ] No [ ]
iii. If you are willing to insure your farm, how much premium per month are you willing to pay?
____

64. Did you receive any grants for maize production in the last season? Yes [ ] No [ ]
ii. How much did you receive? _____________________

65. Did you join any credit and loans group specifically to acquire credit for maize production? Yes [ ] No [ ]

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66. Did you take a "by-day" job specifically to raise money for maize production? Yes [ ] No [ ]

SECTION D: HOUSEHOLD INCOME

67. Do you rear any livestock? Yes [ ] No [ ]
68. What is your reason for rearing livestock? 1= prestige/pride [ ] 2= commercial/business/profit motive [ ] 3= security/insurance [ ] 4= bride price [ ] 5= Household consumption [ ] 6= other [ ] specify____________________
69. Do you generate income from the sale of farm manure? Yes [ ] No [ ]
70. How much did you earn from manure sale in the past 12 months? ____________________
71. Do you use maize farm residue to feed your livestock? Yes [ ] No [ ]
72. Please provide information on income from livestock production in the past 12 months

Livestock Type	Current stock	Number sold in the Last 12 months	Total Income from Livestock Sale	Reason for keeping Particular Livestock
1.Cattle				
2.Sheep				
3. Goat				
4.Chicken				
5.Guinea Fowl				
6.				
7.				

73. Do you engage in any other economic activity? Yes [ ] No [ ]
74. If yes, please specify ____
75. How much do you earn from this activity per month? ____________________

SECTION E: CHALLENGES IN AGRICULTURAL FINANCING

In accessing funds for agricultural production, which of the following sources of finance do you face challenges in and how severe is the challenge?

Source of finance	Ever Used? (Y/N)	Faced Challenge? (Y/N)	Brief Description of Constraint	Very severe (1)	Severe (2)	Not severe (3)
Personal savings						
Gifts/remittances from family members						
Gifts/remittances from friends						
Loans from family members						
Loans from friends						
Loans from money lender(s)						
Ploughing back profit						
Income from sale of other crops						
Income from off-farm activities						
Income from lottery						
Contract farming						
Input credit						
Loans from banks						
Grants from NGO						

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Loans from Microfinance Institutions						
Income from livestock sale						
Others (specify)						
1.						

76. Any other information?

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