ESSAYS ON FINANCE, PRODUCTIVITY, MARKET PARTICIPATION AND WELFARE: THE CASE OF SMALLHOLDER AGRICULTURAL FARMERS IN GHANA

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Declaration

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R.E. Nordjo December 2018

Dedication

I dedicate this thesis to my wife, Mrs Irene Enyonam Nordjo, and my princess, Heidi Selasie Nordjo. I appreciate your support.

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Abstract

Access to finance plays a significant role in transforming or modernising the agricultural sector from subsistence to commercial farming; however, access to finance remains a challenge to smallholder farmers, especially for those in developing countries. Although the literature points to some directions on the transmission of finance into the productivity and welfare of smallholder farmers, very few rigorous studies have been conducted to investigate the impact of access to finance on smallholder agricultural productivity and household welfare, particularly in Sub-Saharan Africa. This study, therefore, tested for the finance-productivity and finance-welfare links in Ghana using rigorous evaluation techniques that address the problems of endogeneity and selection bias. Additionally, the study examined the determinants of smallholder market access and market participation as well as the impact of integrated soil fertility management (ISFM) on productivity. Data for the study was obtained through a field survey on the Agricultural Value Chain Facility (AVCF) project implemented in the Northern Region of Ghana. The outcomes of the study are presented in four essays.

In the first essay, we estimate the effect of access to finance on the productivity of smallholder maize farmers in the Northern Region of Ghana. We applied instrumental variable (IV) estimation techniques to control for selection and endogeneity bias. Our results indicate that access to finance increases maize productivity. The second essay estimates the effect of access to finance on smallholder farmers' welfare. We compared the average difference in welfare between farmers with access to finance and non-equivalent control groups. By adopting propensity score matching (PSM) and propensity score weighting (PSW) to control for selection bias, the results of the econometric estimation indicate that access to finance has a positive and significant effect on the welfare of smallholder farmers. Financial sector policies must be focused not only on rural finance in general but must also be geared towards unlocking the challenges of agricultural financing at all levels. To this end, developing a comprehensive agricultural value-chain finance policy will play a cardinal role towards improving access to finance and improving the welfare of smallholder farmers. Agricultural policies must have significant financing subcomponents aimed at financing the agricultural value chain.

In the third essay we assess the market access and market participation amongst smallholder farmers. Using the double-hurdle model, we found that there are significant differences in the effect of market factors (transactions and transportation costs) and production factors on market participation and the intensity of participation. These differences also exist across crop types. Policies and strategies for increasing market access and market participation must not be the same for all smallholder farmers. The fourth and final essay estimates the impact of the Integrated Soil Fertility Management (ISFM) training program under the Danish International Development Assistance (DANIDA) Agricultural Value Chain Facility (AVCF) project on the productivity of smallholder farmers. We used a survey data of beneficiary and non-beneficiary non-equivalent control groups to compare the mean productivity. The propensity score matching (PSM) method was deployed to estimate the impact of the ISFM program. The results indicate a statistically significant increase in the farm-level productivity of the crops. In view of this, a policy direction towards increasing agricultural productivity of smallholder farmers must take into consideration the ISFM practices.

This study makes unique contributions to the literature in several ways. First, we show that finance in the form of production credit is crucial for smallholder farmers. For these farmers a critical challenge to productivity is the ability to access short to medium-term credit on a regular basis to finance the cost of inputs, market access issues and other operational costs. Access to finance helps to mitigate against the shocks and risks (real and perceived) associated with smallholder farming and which make commercial banks shy away from lending in this area. Second, we present evidence on the effect of finance on the welfare of smallholder farmer households, using the case of Ghana. Although the literature on finance and welfare specifies a production channel via which finance affects welfare, it fails to show how this occurs with empirical evidence. Therefore, to better understand the link between finance and welfare, it is important to empirically test this amongst smallholder finance. Third, we present new dimensions to the literature and show, in particular, that there is substantial separability between the decision to access the market and that of market participation by smallholder farmers. The decision to market access and market participation are therefore mostly two different issues for smallholder farmers and factors that affect these decisions can affect them separately and in different directions. Finally, this thesis presents further evidence on the productivity impact of soil fertility and crop management by assessing the impact of a relatively new practice, namely Integrated Soil Fertility Management (ISFM). This evidence strengthens the case for an integrated approach to crop management within ecological contexts.

Key words:

agriculture, smallholder farmer, finance, market participation, welfare and Ghana

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List of acronyms and abbreviations

2SLS	Two-Stage Least Squares
AAGDS	Accelerated Agricultural Growth and Development Strategy
ADB	Agricultural Development Bank
ADC	Agricultural Development Corporation
ADP	Agricultural Diversification Project
ADRA	Adventist Development and Relief Agency
AGRA	Alliance for Green Revolution in Africa
AgSAC	Agricultural Sector Adjustment Credit
AgSAP	Agricultural Sector Adjustment Program
AgSSIP	Agricultural Services Sub-Sector Investment Program
AMSEC	Agricultural Mechanization Service Centre
ASAC	Agricultural Sector Adjustment Credit
ASIP	Agricultural Sector Investment Project
ASRP	Agricultural Services Rehabilitation Project
ATE	Average Treatment Effect
ATET	Average Treatment on the Treated
AU	African Union
AVCF	Agricultural Value Chain Facility
AVCMP	Agricultural Value Chain Mentorship Program
CAADP	Comprehensive African Agricultural Development
CAPI	Computer-Assisted Personal-Interview
CRP	Cocoa Rehabilitation Project
DANIDA	Danish International Development Assistance
DHM	Double Hurdle Model
DMB	Deposit Money Banks
ERP	Economic Recovery Program
FA	Factor Analysis
FAO	Food and Agriculture Organization
FASDEP	Food and Agricultural Sector Development Policy
FFS	Farmer Field School
FINSAP	Financial Sector Reform Program

FINSSIP	Financial Sector Strategic Plan
GAABIC	Ghana Agricultural Association's Business Information Centre
GCAP	Ghana Commercial Agricultural Project
GDP	Gross Domestic Product
GFDC	Ghana Food Distribution Corporation
GLSS	Ghana Living Standard Survey
GMB	Grains Marketing Board
GPRS	Growth and Poverty Reduction Strategy
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
HCI	Household Commercialization Index
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
IFDC	International Fertilizer Development Centre
IFPRI	International Food Policy Research Institute
INTAPIMP	Integrated Agricultural Productivity Improvement and Marketing Project
IPM	Integrated Pest Management
IPW	Inverse Probability Weighting
IPWRA	Inverse-Propensity Weight and Regression Adjustment
ISFM	Integrated Soil Fertility Management
IV	Instrumental Variable
MCA	Multiple Correspondence Analysis
METASIP	Medium-Term Agriculture Sector Investment Plan
MoFA	Ministry of Food and Agriculture
MTADP	Medium Term Agricultural Development Programme
NAEP	National Agricultural Extension Project
NAFCO	National Food Buffer Stock Company
NDPC	National Development Planning Commission
NEPAD	New Partnership for Africa's Development
NGOs	Non-Governmental Organizations
NNM	Nearest-Neighbour Matching
OFY	Operation Feed Yourself

OFYI	Operation Feed Your Industries
OLS	Ordinary Least Squares
PCA	Principal Component Analysis
PHC	Population and Housing Census
PSM	Propensity Score Matching
PSW	Propensity Score Weighting
RA	Regression Adjustment
RAFiP	Rural and Agricultural Finance Programme
RCBs	Rural Community Banks
RFP	Rural Financial Project
RFSP	Rural Financial Services Project
ROSCA	Rotating Savings and Credit Associations
SAP	Structural Adjustment Program
SARI	Savanna Agricultural Research Institute
SRID	Statistical, Research and Information Directorate
SSA	Sub-Saharan Africa
TFFDC	Task Force Food Distribution Corporation
WFP	World Food Program
WLS	Weighted Least Squares

CHAPTER 1
INTRODUCTION

1.1. BACKGROUND OF THE STUDY

The growth and development of the agricultural sector is sensitive to the growth of an economy and improving welfare (Cheong, Jansen & Peters, 2013). Raising production and productivity among farmers creates the path for diversification of agricultural products into agro-processing and commercialization, resulting in structural transformation of an economy (Salami, Kamara &Brixiova, 2010). Similarly, enhancing agricultural productivity spurs employment creation, boosts income generation from farm activities, and creates self-sufficiency of farm households, thus improving food security (Cheong & Jansen, 2013; FAO/IFAD/WFP, 2015). Clearly, these developments trigger the need for developing economies to devise strategies for the growth and transformation of the agricultural sector that is characterized by smallholder farmers whose average farm size is less than two hectares (ha) (Mutamba, 2011).

Ghana offers a unique case in Africa worth studying. Agriculture's contribution to the economy of Ghana stands at 20.2 per cent of gross domestic product (GDP), with an annual growth rate of 2.5 per cent in 2015 (MoFA – SRID, 2016). An estimated 44.7 per cent of the country's labour force is engaged in agricultural activities, which also include forestry and fisheries (Ibid). Ghana's main agricultural produce can be broadly categorised in three parts, namely: industrial crops;[1] starchy staples, cereals and legumes;[2] and fruits and vegetables[3]. The sector is dominated by smallholder farmers with an average farm land size of about two hectares using rudimentary or traditional technology as part of their farming system (MoFA – SRID, 2011).

A primary reason why Ghana's case is unique for study is the country's multiplicity of policies and steps towards improving the agricultural sector, especially smallholder farmers in rural areas, and for improving welfare. As early as 1919, the Ten-Year Development Plan during the pre-independence era earmarked agriculture as a major activity that needed to be developed. Subsequently, other policies such as the first Five-Year Development Plan 1951–1956 concentrated on large-scale farming to commercialize agriculture with the aim of increasing productivity. The second Five-Year Development

[1] cocoa, oil palm, coconut, coffee, cotton, kola, rubber
[2] cassava, cocoyam, yam, maize, rice, millet, sorghum, plantain
[3] pineapple, citrus, banana, cashew, pawpaw, mangoes, tomato, pepper, okro, egg plant, onion, asian vegetables

Plan 1959–1964 further increased the role of agricultural development corporations in large-scale farming and popularized the concept of state farms in the bid to grow the agricultural sector and increase productivity substantially. During this period, extension services were also a key component of agricultural policies and were championed by the United Ghana Farmers Co-operatives Council. However, despite the implementation of these policies, agricultural performance and growth in Ghana was unimpressive and largely irregular as the average growth rates for the sector in 1975 – 1979 and 1980 – 1984 were recorded at negative 0.88 per cent and negative 0.63 per cent respectively. During the 1970s to 1980s, the policy strategies had shifted from large-scale agriculture to small-scale farming pioneered by the "Operation Feed Yourself" policy. Although agricultural growth responded to these policies, the irregularity and unimpressive growth and productivity witnessed in the 1960s were still present. This lacklustre performance and the initiation of a comprehensive Economic Recovery Programme (ERP) and its associated Structural Adjustment Programmes (SAP) implemented from the early 1980s under the World Bank program paved the way for further agricultural sector policies from the 1990s.

Policies like the Medium-Term Agricultural Development Programme (MTADP) from 1991–2000, the Accelerated Agricultural Development Strategy (AAGDS) and the Food and Agricultural Sector Development Policy (FASDEP) I & II have been implemented to deal with the perennial and almost intractable problem of agricultural productivity and subsequently farmers' welfare. The country also adopted the Comprehensive African Agricultural Development Programme (CAADP), which aimed at increasing agricultural productivity to an average of six per cent annual growth (Dzanku &Aidam, 2013; Asante &Awo, 2017). These multiple policy initiatives and attempts once again did not yield the desired outcomes. Agricultural growth and productivity are still unimpressive. For instance, the average agricultural growth rate of 3.2 per cent from 2011–2015 was far below the expected growth rate of six per cent, while the average yield for all major crops is also far below the potential yield (MoFA-SRID, 2016). Tables 1.1 and 1.2 below highlight some facts and figures on the growth rates of main cereal crops as well as their output per farm size (productivity).

Table 1.1: Annual Growth Rates (%) of Cereal Crops in Ghana, 2000–2015

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Maize	-4.09	-7.38	49.26	-7.96	-10.16	1.19	1.49	2.59	20.54	10.17	15.57	-10.03	15.79	-9.51	0.23	-4.35
Rice (Paddy)	20.15	10.42	1.85	-12.59	-1.08	-2.18	5.69	-25.88	62.92	29.65	25.60	-5.61	3.69	18.37	6.06	6.20
Millet	10.61	-20.67	18.39	10.47	-18.18	28.65	-10.81	-31.52	71.50	26.68	-10.79	-15.98	-2.34	-13.69	0.14	1.32
Sorghum	0.13	-0.03	13.00	6.64	-14.74	6.13	3.28	-50.86	113.82	5.92	0.68	-18.67	-2.47	-8.32	0.90	-11.81

Source: Ministry of Food and Agriculture (MoFA) – Statistical, Research and Information Directorate. (SRID) & Ghana Statistical Service (GSS)

Table 1.2: Annual Productivity (Metric Tonnes Per Hectare) of Cereal Crops in Ghana, 2000–2015

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Maize	1.46	1.31	1.49	1.63	1.58	1.58	1.50	1.54	1.74	1.70	1.89	1.65	1.87	1.72	1.73	1.92
Rice (Paddy)	2.16	2.03	2.28	2.08	2.03	1.97	2.00	1.70	2.27	2.41	3.03	2.35	2.54	2.64	2.69	2.75
Millet	0.81	0.70	0.80	0.85	0.79	1.00	0.83	0.69	1.06	1.31	1.24	1.03	1.04	0.97	0.96	0.97
Sorghum	0.97	0.85	0.94	0.97	0.96	1.00	0.98	0.74	1.20	1.31	1.40	1.18	1.21	1.14	1.14	1.00

Source: Ministry of Food and Agriculture (MoFA) – Statistical, Research and Information Directorate (SRID) & Ghana Statistical Service (GSS).

The growth rates for all crops over the period 2000–2015 were not stable. The data shows there was a high degree of volatility. The annual growth rates in the cereal crops indicate that except for maize, rice (paddy), millet and sorghum recorded high negative growth rates in 2007 of 25.88 per cent, 31.52 per cent and 50.86 per cent respectively. The three crops also recorded the highest growth rates in the following year (2008) of 62.92 per cent, 71.50 per cent and 113.82 per cent respectively. Maize recorded its highest negative growth rate of 10.03 per cent in 2011 and a high growth rate of 49.26 per cent in 2002. Generally, the data shows evidence of a high number of negative annual growth rates over the period.

Table 1.2 also shows that the productivity levels for all crops are not sustainable. For instance, the productivity level for maize was recorded at 1.31 metric tonnes (mt) per hectare (ha) in 2001 with the highest level of productivity of 1.92 mt/ha in 2015. Rice (paddy) and sorghum recorded 1.70 mt/ha and 0.74 mt/ha productivity levels in 2007 respectively while both crops also recorded a high productivity level of 3.03 mt/ha and 1.40 mt/ha in 2010 respectively. Millet recorded a low productivity level of 0.69 mt/ha in 2007 and a high productivity of 1.31 mt/ha in 2009. Generally, the data shows that rice recorded the highest productivity level over the period as compared to the remaining crops while millet recorded the lowest.

There is an absence of explicit financing policies in agriculture. In Ghana agricultural finance can be sourced mainly from formal and semi-formal financial institutions as well as informal sources. The formal institutions are commercial banks, normally within urban areas, and rural community banks in rural areas. The semi-formal financial sector consists of finance unions, savings and loans and non-governmental organisations (NGOs). The informal sources of agricultural finance include family, friends, traders, money lenders, and savings from farm and off-farm income (Kuwornu, Ohene-Ntow & Asuming-Brempong, 2012).

Apart from the absence of explicit finance strategies in agricultural policies in Ghana, very little exists in terms of market access and participation. As seen from Table 1.3, market traders and farm gate buyers are the two main channels through with agricultural produce are marketed in Ghana. The implication is that these two actors are key intermediaries between the farmer and retailers as well as consumers (Quartey, Udry, Al-Hassan & Seshie, 2012).

Table 1.3: Distribution of Marketing Channels

Main Outlet	Frequency	Percent
Pre-harvest contractor	146	1.52
Farm gate buyer	2,939	30.56
Market trader	5,548	57.7
Consumer	789	8.21
State trading organisation	24	0.25
Cooperative	5	0.05
Exporter	15	0.16
Other	150	1.56

Source: GLSS 5+ in Quartey et al. (2012).

Market prices provide very good signals for market access and market participation. In Ghana the nature of market access and participation not only varies with prices but is also directly related to geographical location. For instance, IFPRI (2007) shows that with respect to maize in Ghana the farm gate price is lower in rural areas (the major producing centres) than in the urban areas (the wholesale and retail centres). Even in the case of location, wholesale prices in semi-urban food production areas such as in Techiman market are lower than those of purely urban areas such as the capital Accra. These price changes are influenced by transaction costs such as handling and storage charges, transport costs and the profit margin of the seller. The marketed share of farm produce and the percentage of farmers who sell their produce tend to be the lowest in northern Ghana. Furthermore, there is little or no evidence on the impact of policy interventions on the productivity, market access and welfare levels of farmers.

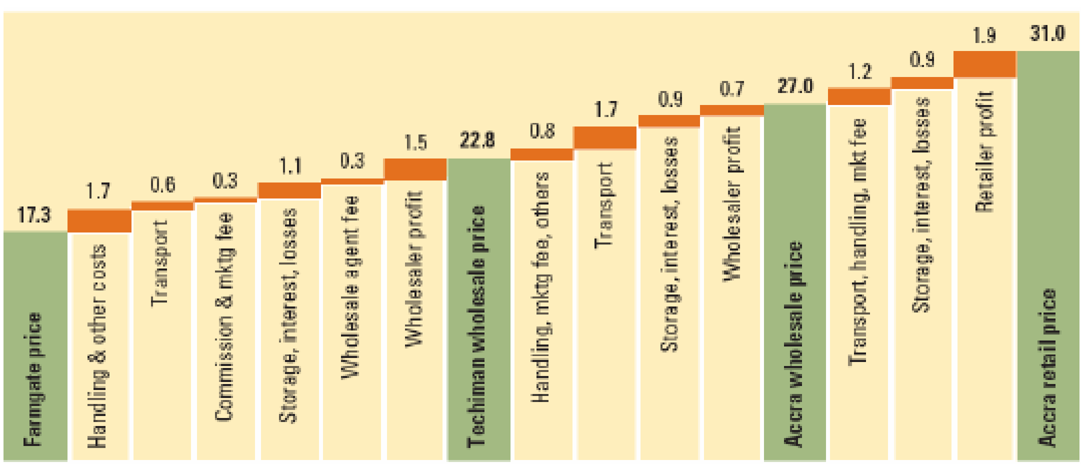
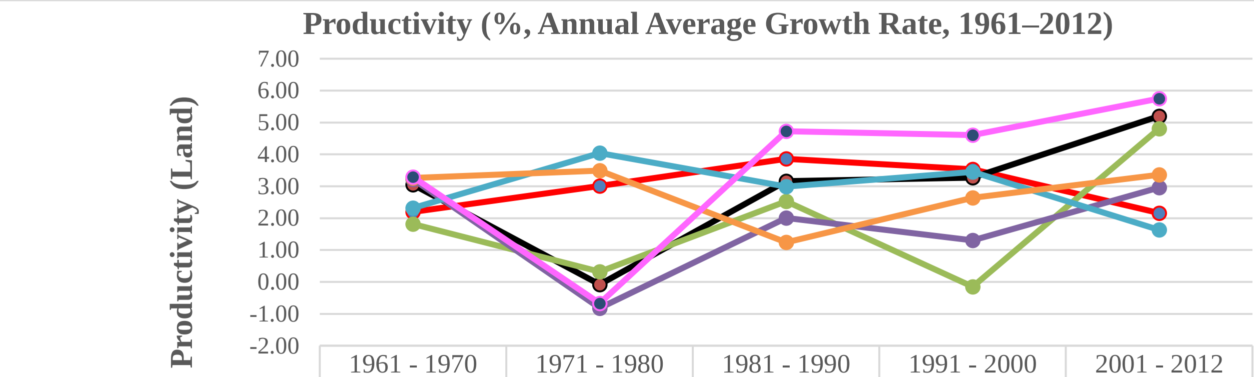


Figure 1.1: Typical Marketing Costs in the Ghanaian Maize Value Chain $ per 100 kilograms, 1998
Source: International Food Policy Research Institute (2007).

It is against this background that this study evaluated the productivity, market participation and welfare effects of agricultural policy interventions, using the case of the Danish International Development Agency (DANIDA) Agricultural Value Chain Facility (AVCF) project on Smallholder Farmers in the Northern Region of Ghana. Agricultural Value Chain Facility (AVCF) is aimed to provide mentorship services to smallholder farmers, including the promotion of business development services and technical services with the purpose of developing value chains for basic food crops with its focus in the northern parts of Ghana. The facility also includes a loan/guarantee scheme to facilitate term lending of commercial banks to actors within the agricultural value which includes small and medium enterprises (SMEs), commercial farmers and farmer-based organizations. The rational of AVCF is to develop linkages between and among commercial farmers and farmer-based organizations, business development and technical service providers as well as financial institutions to ensure operational sustainability of the value chain actors, increasing productivity, creating employment and enhancing welfare (DANIDA, 2009). The AVCF is one of those projects formulated in line with the Food and Agricultural Sector Development Policy (FASDEP II) of Ghana that focused on using the value-chain approach towards agricultural modernisation.

Trends of historical antecedents in the growth and development of agriculture in Sub-Saharan Africa indicate that the region lags Asia in terms of agricultural growth (Africa Progress Panel, 2010) and records low yield compared to other regions of the world such as Asia and Latin America and the Caribbean (World Bank, 2008; Oluoch-Kosura, 2013; De Cleene, 2014). The annual average agricultural growth rates in these regions show that Sub-Saharan Africa recorded an annual average agricultural growth rates of 2.7 percent ranging from 1971 – 1980, increasing to 3.1 per cent in 1991 – 2000 and 2.6 per cent in 2001 – 2010 showing a decline in average growth rate. Over the same periods, Asia recorded annual average growth rates of 4.1 per cent, 4 per cent and 3.5 per cent respectively. The trend shows a consistent decline in the annual average agricultural growth rates. Similarly, Latin America and the Caribbean region recorded annual average agricultural growth rates of 2.4 per cent, 3.1 per cent and 3.2 per cent respectively. The trend shows a marginal increase in the growth rates. A comparative analysis of the annual average agricultural growth rates of these three regions (Sub-Saharan Africa, Asia and Latin America and the Caribbean) reveals that the growth rates of Asia are higher as compared to the remaining two regions despite the marginal decline. Although the Sub-Saharan Africa region recorded a high growth rate as compared to Latin America and the Caribbean in 1991 – 2000, both regions recorded the same growth rate of 3.1 per cent indicating an increase over the previous period. However, the agricultural growth rate in the three regions in 2001 – 2010 shows that Sub-Saharan Africa records the least (Benin, Wood & Nin-Pratt, 2016).

Figure 1.2 below shows the trend in land productivity in Africa. It reveals that the growth rate in land productivity increased by 2.2 per cent for 1961 – 1970, which increased to 3.86 per cent for 1981 – 1990 and subsequently declined to 2.16 per cent for 2001 – 2012. Figure 1.2 clearly shows that the West African region recorded the highest productivity growth rate of 3.29 per cent for 1961 – 1970 as compared to Southern (3.26 per cent), Eastern (3.22 per cent), Northern (2.32 per cent) and Central (1.82 per cent). For 2001 – 2012, the Western region of Africa again recorded the highest productivity growth rate of 5.75 per cent as compared to Central (4.81 per cent), Southern (3.36 per cent), Eastern (2.96 per cent) and North (1.63 per cent). Generally, the trend in the annual average productivity growth rate reveals that the Western region of Africa has shown a more consistent increasing growth rate in land productivity despite the negative growth rate (-0.67 per cent) recorded for 1971 – 1980. The trend in Southern and Northern Africa has also been consistent except for 1981 – 1990 when Southern Africa recorded 1.24 per cent while Northern Africa recorded 1.63 per cent for 2001 – 2012 as their lowest growth rate. The annual average productivity growth rates for Eastern and Central Africa have been highly volatile and despite the negative growth rates recorded by these two regions, Eastern Africa (-0.82 per cent) for 1971 – 1980 and Central Africa (-0.15 per cent) for 1991 – 2000 respectively, Central Africa recorded higher growth rate of 4.81 per cent for 2001 – 2012.



	1961 - 1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - 2012
Africa	2.20	3.01	3.86	3.53	2.16
Sub-Saharan Africa	3.05	-0.08	3.16	3.27	5.20
Central	1.82	0.32	2.53	-0.15	4.81
Eastern	3.22	-0.82	2.01	1.30	2.96
Northern	2.32	4.04	2.99	3.45	1.63
Southern	3.26	3.49	1.24	2.64	3.36
Western	3.29	-0.67	4.73	4.60	5.75

Figure 1.2: Productivity (%, Annual Average Growth Rate, 1961–2012)
Source: Benin, et. al., 2016

Similarly, although the welfare of the people in Sub-Saharan Africa has improved because of the decline in the poverty rate from 58.44 per cent in 1993 to 41 per cent in 2013, yet the poverty levels in Sub-Saharan Africa are still alarming as the population with low welfare remain higher than other regions in the world. As at 2013, South Asia recorded poverty rate of 15.1 per cent, Latin America and the Caribbean is 5.4 per cent, East Asia and Pacific records poverty level of 3.54 per cent, Europe and Central Asia records 2.15 per cent while the rate of poverty in the Middle East and North Africa is 1.75 per cent (Roser and Ortiz-Ospina, 2018).

Indeed, about 80 per cent of the population experiencing low welfare are living in rural areas with 64 per cent engaged in agriculture as their main economic activity (World Bank, 2016). The irony of the challenges confronting agricultural development in Africa is that despite the efforts made to improve the physical environment and biological conditions over the years as well as the formulation of policies to drive agricultural mechanisation, agricultural productivity has not risen substantially. The literature on agricultural productivity highlights some critical factors, such as market access and market participation, soil management and recently the impact of finance on the productivity and welfare of smallholder farmers.

On finance-productivity link, theoretically, Carter (1989) identified three channels through which access to finance might have a positive effect on shifting the production function. First, by having access to finance, a smallholder farmer can purchase and apply fertiliser on the farm, leading to an increase in farm input and productivity evidenced by a shift of the profit function. The second channel through which access to finance impacts on productivity is the purchase of technology. The use and application of technology is expected to enhance efficiency in the process of production, thereby increasing the production surface. Through access to finance, a farmer can acquire high-yielding seeds. The third channel identified is that finance creates the opportunity for the use of intensive fixed inputs of land, family labour and technical skills that are geared towards farming. With the help of finance, the skilled farmer increases return on productivity and income. In brief, access to finance is expected to increase profit from fixed outputs, market conditions and individual skills.

According to Chambers and Lopez (1984) and Udry (2010), a farmer who is financially constrained is limited in terms of investment opportunities, resulting in low performance or agricultural output. By improving access to finance, smallholder farmers can invest in their production needs, specifically the financing of farm inputs such as high-yielding seeds, fertiliser, pesticides and farm equipment. Access to finance stimulates the adoption of advanced technology for farming. The outcome is a move away from traditional methods of farming to the investment in more efficient and advanced methods of farming (Beets, 1990). This access to finance is also helpful in dealing with the sunk and operational costs in market access and enables smallholder farmers to participate in the market and generate income to further improve household welfare (Rugube & Machethe, 2011). In a nutshell, access to finance contributes to increasing agricultural productivity, enables market access, and lifts the agricultural household to higher welfare levels.

Zeller, Diagne and Mataya (1997) spelt out pathways through which access to finance affects poverty reduction or improving welfare. First, access to finance helps to finance inputs, meet transaction costs and procure equipment for income generation. Where this takes place, the welfare of smallholder farmer households improves. Second, access to finance influences the capacity of households to bear risks. This implies that, with access to finance, smallholder farmers can identify investment opportunities and take the risk of investing in those ventures with the aim of generating revenue or income and stabilising or sustaining the consumption of food and other goods considered to be essential to the household.

Notwithstanding the facts highlighted above, it is also argued that access to finance may have a null effect on smallholder households' welfare (Karlan & Zinman, 2009).

Smallholder farmers are however challenged with accessing finance (Meyer, 2014; Rahman & Smolak, 2014). These challenges are mainly due to information asymmetry resulting in high transaction and information costs (Mukonyora & Bugo, 2013; Rahman & Smolak, 2014). These information problems are accentuated by unfavourable climatic conditions that affect production, unstable prices of farm produce, low income and low asset stock. The persistence of these challenges has resulted in a highly segmented financial market that provides very little access to agricultural firms in Africa, especially for smallholder farmers.

With respect to market access and market participation, the literature is not very clear about transaction costs as the most significant factor (De Janvry, Fafchamps & Sadoulet, 1991; Boughton, Mather, Barrett, Benfica & Abdula, 2007; Barrett, 2008), and marketing related factors include transport costs, storage, searching for and processing of information, negotiating contracts, monitoring agents and contract enforcement (Jaleta, Gebremedhin & Hoekstra, 2009). In the case of soil management, the principles of integrated soil fertility management (ISFM) have emerged as the innovative and effective channel for enhancing agricultural productivity, yet not many studies have examined the impact thereof.

1.2. THE RESEARCH PROBLEM

From a theoretical viewpoint, some key factors in enhancing smallholder agricultural productivity are soil management, markets and finance (Beets, 1990). However, as pointed out, a major absence in most policies has been that of finance. It plays a key role in increasing agricultural productivity (Morduch, 1995; Robinson, 2001). Finance enables smallholder farmers to finance their production-related activities, including the purchase of farm inputs, seeds and fertilizer as well as financing of other services such as ploughing (Meyer, 2014).

The empirical literature on the effect of access to finance on smallholder farm productivity has shown mixed results. On the one hand, the results of some of these studies have shown that access to finance has a positive and statistically significant impact on productivity (Iqbal, Ahmad & Abbas, 2003; Ayaz & Hussain, 2011; Akram, Hussain, Ahmad & Hussain, 2013; Rahman, Hussain & Taqi, 2014). On the other hand, studies by Zuberi (1989) and Hussain (2012) documented no effect of access to finance on agricultural productivity. Quartey et al. (2012) also argued that, unless the uncertainties in production are managed or insured, access to finance will not yield its intended purpose of shifting the production frontier outwards. Interestingly, finance is supposed to help mitigate these uncertainties and risks and subsequently boost productivity. These mixed findings pose a challenge to the theory and a subsequent gap in the literature. This challenge and gap are certainly what has been picked up in the policy frameworks on agricultural productivity and development. Therefore, the gap in the literature presents a gap in policy design and implementation and creates a dire need for investigation.

This thesis addresses this gap by assessing the impact of finance on the productivity of smallholder farmers in the Northern Region of Ghana under the DANIDA's AVCF project. This gap is addressed in the first empirical paper. Finance, for this project was in the form of production credit which is a short to medium term working capital for smallholder farmers to procure farm inputs such as fertilizers, agro-chemicals and certified seeds. Finance (production credit) is sourced from micro-finance institutions like Sinapi Aba Savings and Loans and the Centre for Agricultural and Rural Development (CARD) a financial non-governmental organization (FNGOs).

Access to finance should enhance not only the productivity of farmers but also improve the welfare of smallholder farm households (Coleman, 2002; Saboor, Hussain & Muni, 2009; Beaman, Karlan, Thuysbaert & Udry, 2014). With access to finance, smallholder farmers can widen their economic opportunities, increase their assets and reduce their rate of vulnerability (Karlan & Morduch, 2009). However, there seems to be an alternative view on the significance of access to finance on welfare. Chowdhury (2009) argued that access to finance is not enough to improve the welfare of smallholder agricultural farmers; instead, there is the need to also provide other supports such as training and market information to improve welfare. Mahajan (2005) also indicated that finance is necessary but not sufficient to improve welfare.

Like the case of finance and productivity, empirical studies have shown contradictory outcomes on the relationship between access to finance by smallholder farmers and welfare. For instance, studies by Pitt and Khandker (1998); Quach (2005) and Woutersen and Khander (2013) showed that access to finance has a positive and significant effect on welfare. However, Diagne and Zeller (2001) in their study also did not find any significant effect of the availability of finance. This again poses a significant challenge and presents a gap in the literature. This gap is examined in the second empirical paper on the impact of finance on the welfare of smallholder farmers in the Northern Region of Ghana under the DANIDA's AVCF project on welfare.

The extant literature shows that market participation (sale of farm outputs) are driven by factors that are mainly related to market (transaction and transportation costs) and production-related cost. Some of these factors include productive resource endowment (assets), infrastructure such as roads, energy and communication, and agro-climatic endowments (Barrett, 2008; Jouanjean, 2013; Mather, Boughton & Jayne, 2013). However, the literature is also unclear on how these factors affect the market access and market participation of smallholder farmers. For instance, Karaan (2009) argues that most of these factors, especially the transaction costs, affect large-scale farmers and not smallholder farmers. Livingston, Schonberger and Delaney (2014) further show that for smallholder farmers in Sub-Saharan Africa, transaction costs are the most critical factors regarding market access and market participation. These factors could also be sensitive to the crop type and maturity span but are again less explored in the literature. This lack of clarity raises deep and broad questions for contexts like Africa where most of the farming is smallholder based and further justifies the need to investigate the determinants of market access and participation. Furthermore, the decision to access the market and participation can be two different decisions for a smallholder farmer. Therefore, factors affecting market access and market participation could do so differently. This is a further area in the literature that is less explored. In addition to these gaps that are worth exploring, studies on market participation in Africa are very scanty and rare. We address this gap in the third empirical paper on factors affecting market access and market participation in the third empirical paper.

The literature on soil management to enhance agricultural productivity has been fragmented. Some recent developments, however, show that soil management can be effective under the integrated soil fertility management (ISFM) practices, a new and innovative farming system which is a pathway to increasing agricultural production and productivity (Vanlauwe et al., 2010a; Nezomba, Mtambanengwe, Chikowos & Mapfumo, 2015). ISFM is about gaining knowledge and adapting to best agronomic practices (timely land preparation and planting, proper fertilization and control of pests and weeds as well as better irrigation facilities) aimed at shifting from the traditional farming system to an improved system of farming. This requires proper study of the ecological factors as well as, the appropriate crop type to plant by taking into consideration the prevailing conditions of farming within a specific geographical location. The ISFM practices also entail effective farm management practices that are geared towards intensification of farm inputs with the ultimate objective of increasing productivity. However, knowledge, adaptation and the productivity impact of ISFM practices remain largely under-researched. The fourth empirical paper therefore assesses the impact of ISFM on the productivity of smallholder farmers. Agricultural productivity in Africa has been observed to be low compared to that of other developing economies around the globe (Benin et al., 2016).

Finally, most of the studies on the impact of finance on productivity, welfare and that of integrated soil fertility management on productivity have failed to use rigorous evaluation techniques to control for endogeneity and issues of selection bias which occur with interventions that are not randomized. For studies on market participation, the choice of factors influencing market access and market participation widely varies across the various studies and is also not classified under marketing channels such as transaction costs and/or production costs. Moreso, most of these studies only used predictive analysis techniques such as probit or logit models which fail to show that a farmer's decision to access the market and participate in the market are made jointly or are separable. This thesis, therefore, bridges the gap by using rigorous evaluation techniques to address the problem of endogeneity and selection bias and to ensure that the results of the estimations meet the test of both internal and external validity. For our study on market participation, we used rigorous econometric methods on the assumption that a farmer's decision to access the market and participate in the market is separable.

1.3. RESEARCH QUESTIONS

1. What is the impact of access to finance on agricultural productivity?
2. What is the impact of access to finance on the welfare of agricultural households?
3. What are the factors influencing smallholder market participation and its intensity?
4. What is the impact of integrated soil fertility management (ISFM) on agricultural productivity?

1.4. OBJECTIVES OF STUDY

The broad objective of the study was to evaluate the productivity impact of finance and soil management, the welfare impact of finance and the factors driving market access and the intensity of market participation of smallholder farmers in the Northern Region of Ghana using data from the DANIDA AVFC project. The broad objectives were the following:

1. To determine the impact of access to finance on agricultural productivity;
2. To determine the impact of access to finance on the welfare of smallholder farmers' households;
3. To determine the factors that influence smallholder farmer market access and market participation; and

4. To determine the impact of integrated soil fertility management (ISFM) on agricultural productivity.

1.5. RATIONALE FOR EACH STUDY

The first empirical essay explores the effect of finance on smallholder farm productivity. Theoretically, access to finance is expected to increase agricultural production and productivity through technical and allocative efficiency of the smallholder farmer. However, contrary arguments exist, resulting in mixed evidence, few of which feature the African context. However, we know that smallholder farmers, especially in Africa, are financially constrained. Ali, Deininger and Duponchel (2014) argued that there is a yield gap between farmers with access to finance as against those who are constrained financially. From a policy perspective, the stark absence of finance provides further justification to the conundrum in the literature. Therefore, there is a challenge and gap in the literature, which this study fills. Using field survey data on smallholder farmers in Northern Ghana, the study applied rigorous econometric methods to assess the impact of finance on productivity and offers further insights into the literature and context.

In the second empirical essay we estimate the impact of finance on household welfare of smallholder farmers. Access to finance serves as a catalyst for smallholder farmers to invest in production aimed at generating income, smoothens consumption and reduces risks (Ledgerwood & Gibson, 2013). Again, the lack of substantial empirical evidence creates a contention in the literature. In this study, we used farmers' household assets as proxy to welfare – a paradigm shift from the consumption approach – and applied propensity score matching (PSM) and propensity score weighting (PSW), which control for selection bias to assess the impact of finance on welfare of smallholder farmers.

The third empirical essay evaluates the determinants of market access and intensity of market participation of smallholder farmers. The rationale for this study is rooted in the lack of clarity in the literature on factors that determine market access and intensity of participation and contributes to an understanding of smallholder farmers' behaviour or decision on market participation and its intensity. It also highlights whether decisions to participate in the market and intensity of participation are linked and the factors influencing smallholder participation are separate.

The last empirical essay presents evidence on the productivity impact of relatively new soil fertility management practices as in the case of the integrated soil fertility management (ISFM). The paucity of studies in this area serves as a rationale for this study and the results contribute to deepening the knowledge depth in soil fertility management and its impact.

1.6. RESEARCH METHODOLOGY

This section presents the survey instruments, sample design and discussion on data analysis techniques used.

1.6.1. Survey Instruments

To achieve the set of objectives, detailed information was collected on key elements of socioeconomic characteristics of farmers by means of a questionnaire. The questionnaire also centered on farmer and farm plot characteristics. Data on production, farm size and markets among other characteristics of the survey were collected based on one-year (2014/15) farming season. The questionnaires were designed using the Ghana Statistical Service questionnaire on agricultural households as a guide. Data collection was carried out by thirty-eight personnel who were recruited from the University of Development Studies (UDS) and the Tamale Polytechnic. The data were captured using Computer-Assisted Personal-Interview (CAPI) software over a period of two months from July to August 2015.

The questionnaires were administered to two distinct groups, the beneficiary and non-beneficiary groups. Technically, both questionnaires were the same. The assumption here is that these groups of people are all farmers and as such have the same or similar vector of observable characteristics. The only difference is that one group (the beneficiaries) received the AVCF intervention while the other group (the non-beneficiaries) did not receive such intervention.

1.6.2. Sample Design

The sample design for the papers slightly varies. For instance, the focus of analysis for the papers on the impact of finance on productivity of smallholder agricultural farmers and the impact of finance on the welfare of smallholder farm households in Ghana are on farmer level whereas the analysis for the papers on market participation of smallholder farmers in Northern Ghana as well as the integrated soil fertility management (ISFM) and productivity of smallholder farmers are focused on farm level.

The Impact of Finance on Productivity of Smallholder Agricultural Farmers:

This study evaluates the impact of access to finance on the productivity of smallholder farmers. For the data, we applied a combination of convenient, stratified and proportional sampling techniques. The record consisted of 27,856 farmers across the Northern Region of Ghana who participated in the ACVF project. These farmers are into farming of selected staple crops, namely maize, rice, soyabean and groundnut. Following a four-stage approach, the population was classified into different subgroups or strata, then the final subjects were proportionately selected at random from the different population groups or strata. First, we selected seven communities from each of the 22 districts representing the Northern Region of Ghana. The choice of these seven communities was influenced by the number of beneficiary farmers within a community. This brought the total number of communities to 154.

The second stage was to randomly select a sample of 1,700 farmers from the 154 communities for data collection. After data editing and cleaning of outliers and various inconsistencies, we had 1,564 farmers. To achieve the objective for this study, we focused on maize farmers bringing the data to 1,152 farmers. The maize farmers were chosen because finance (production credit) was allocated to only them. At the third stage, we categorised the data into two separate groups, namely maize farmers with access to finance (treatment group) and maize farmers who are financially constrained (control group). The data indicated a total number of 154 farmers with access to finance and 998 farmers who are financially constrained. At the fourth stage, 398 maize farmers were sampled from the 998 farmers who were financially constrained for analysis.

To ensure robustness in the checking of results, the study used a second control group. The second group of farmers are the non-beneficiary group of AVCF. Data for the non-beneficiary group was also collected on farmers in selected communities within the Northern and Brong Ahafo (BA) regions, with a total number of 295 farmers and 200 farmers respectively. The selected areas for this group are within the same agro-ecological zone as the beneficiary group. They share similar agricultural practices as well as community and socioeconomic characteristics. The selection of the areas or communities of these farmers was influenced by the fact that they are remote from communities where Government provides agricultural extension services to farmers and by the fact that non-governmental organizations (NGOs) are not there to provide agricultural services. After data cleaning and editing, the total number of smallholder farmers who did not benefit from the AVCF project intervention was recorded at 466. Of this number of smallholder farmers, the data revealed 366 of them were maize farmers.

The Impact of Finance on the Welfare of Smallholder Farm Households in Ghana:

This study evaluates the impact of access to finance on the welfare of smallholder farmers' household. For the data, we applied a combination of convenient, stratified and proportional sampling techniques. The record consisted of 27,856 farmers across the Northern Region of Ghana who participated in the ACVF project. These farmers are into the farming of selected staple crops, namely maize, rice, soyabean and groundnut. Following a four-stage approach, the population was classified into different subgroups or strata, then the final subjects were proportionately selected at random from the different population groups or strata. First, we selected seven communities from each of the 22 districts representing the Northern Region of Ghana. The choice of these seven communities was influenced by the number of beneficiary farmers within a community. This brought the total number of communities to 154.

The second stage was to randomly select a sample of 1,700 farmers from the 154 communities for data collection. After data editing and cleaning of outliers and various inconsistencies, we had a number of 1,564 farmers who either owned a maize farm or groundnut farm or soyabean farm or rice farm only, or a farmer owning a combination of farms of different crops. At the third stage, we categorised the data into two separate groups, namely farmers with access to finance (treatment group) and farmers who are financially constrained (control group). The data indicated a total number of 176 farmers with access to finance and 1,388 farmers who are financially constrained. At the fourth stage, 208 farmers were sampled from the 1,388 farmers for purposes of matching and estimation.

To ensure robustness in the checking of results, the study used a second control group. The second group of farmers are the non-beneficiary group of AVCF. Data for the non-beneficiary group was also collected on farmers in selected communities within the Northern and Brong Ahafo (BA) regions, with a total number of 295 farmers and 200 farmers respectively. The selected areas for this group are within the same agro-ecological zone as the beneficiary group. They share similar agricultural practices as well as community and socioeconomic characteristics. The selection of the areas or communities of these farmers was influenced by the fact that they are remote from communities where Government provides agricultural extension services to farmers and by the fact that non-governmental organizations (NGOs) are not there to provide agricultural services. After data cleaning and editing, the total number of smallholder farmers who did not benefit from the AVCF project intervention was recorded at 466. Of this number of smallholder farmers, 233 farmers were sampled for estimation.

Market Participation of Smallholder Farmers in Northern Ghana:

This study examines the determinants of market access and market participation of smallholder farmers. The focus of analysis for this paper is on the farm level. The data for this study consisted of two groups of farmers (the AVCF group and the non-AVCF group). Both groups consisted of farmers who are farming in either one or a combination of the following crops: maize, rice, soyabean and groundnut. The total number of the beneficiaries of AVCF consists of 27,856 farmers across the Northern Region of Ghana.

To obtain the sampled data, we applied a combination of convenient, stratified and proportional sampling techniques. This was made possible following a two-stage approach: we first selected seven communities from each of the 22 districts representing 154 communities from the Northern Region of Ghana. In the second stage, we randomly selected 1,700 farmers from the 154 communities. After data cleaning and editing we had data on 1,608 farmers. The total number of plot farms owned by the 1,608 smallholder farmers was recorded at 2,724 plot farms covering all the four crops. Of the total number of 2,724 plot farms, 1,163 were for maize plot farms, 698 were for groundnut plot farm, 645 soyabean plot farms and 218 rice plot farms.

The data for the non-AVCF group was collected on farmers in selected communities of the Northern and Brong Ahafo (BA) regions with a total number of 295 farmers and 200 farmers respectively. The selected communities for this survey have in common the same agro-ecological zone and areas where agricultural practices and socioeconomic characteristics of the farmers are similar to the beneficiary group. After data cleaning and editing, the total number of smallholder farmers was recorded at 484. The total number of plot farms owned by the 484 smallholder farmers stood at 701 plot farms covering all the four crops. The data reveals 369 maize plot farms only, 261 groundnut plot farms only, 44 soyabean plot farms and 27 rice plot rice.

Integrated Soil Fertility Management (ISFM) and Productivity of Smallholder Farmers:

Two groups of farmers were sampled for identifying the impact of ISFM on farm-level productivity. The beneficiary group is the group that participated in the AVCF project and received the ISFM training and the non-beneficiary group is the group of farmers who did not participate in the AVCF project and so did not receive the ISFM training. Both groups consisted of farmers who were farming in either one or a combination of the following crops: maize, rice, soyabean and groundnut. This paper focuses on farm level analysis.

A three-stage sampling approach was used in the case of the beneficiary group. A combination of convenient, stratified and proportional sampling techniques was used. The rationale was to segment the entire population into different subgroups or strata, then randomly select the farmers proportionately from the different population groups or strata. In the first stage, we selected seven communities from each of the 22 districts used for this study in the Northern Region of Ghana. The selection of a community was influenced by the size of farmers who received ISFM training. That is, farmers were selected from communities with a large number of farmers who received ISFM training. The second stage was to randomly select a sample size of 1,700 farmers from a total number of 154 communities. After data editing and cleaning of outliers and various inconsistencies, we had 1,608 of farmers who either owned a maize farm or groundnut farm or soyabean farm or rice farm only, or farmers who owned a combination of farms of different crops. The data shows a total number of 2,724 farms covering all the four crops. Of the total number of 2,724 farms, 1,163 were for maize farm plots only and 698 were for groundnut farm plots. In the third stage, we sampled 292 maize farms and 209 groundnut farms from the 1,163 maize farms and 698 groundnut farms respectively. The choice of maize and groundnut for analysis is due to the fact that we did not have enough observations for soyabeans and rice for matching.

Data for the non-beneficiary group were also collected on farmers in selected communities within the Northern and Brong Ahafo (BA) regions with a total number of 295 farmers and 200 farmers respectively. The selected areas for this group are within the same agro-ecological zone as the beneficiary group. They share similar agricultural practices as well as community and socioeconomic characteristics. The selection of the areas or communities of these farmers is influenced by the fact that they are remote from communities where Government provides agricultural extension services to farmers and by the fact that NGOs are not there to provide agricultural services. After data cleaning and editing, the total number of smallholder farmers who did not benefit from the AVCF project intervention was recorded at 484. The total number of plot farms owned by the 484 smallholder farmers stands at 701 plot farms covering all the four crops. From the 701 plots farms, there are 369 maize plot farms and 261 groundnut plot farms only. The data was limited to maize plot farms and groundnut plot farms due to the limited observations for soyabeans and rice.

1.6.3. Data Analysis

For the study, various estimation methods were used in line with the above stated objectives and research questions. Research question 1 was estimated using the instrumental variable (IV), question 3 was estimated using the double hurdle model (DHM), while research questions 2 and 4 were estimated following propensity-score matching (PSM) techniques.

We also estimated the impact of access to finance on agricultural productivity of smallholder farmers. Access to finance (production credit) to the smallholder farmers was not carried out at random; thus, a problem of possible selection bias could arise. According to Heckman (1979), non-randomisation fuels the problem of selection bias caused by either an individual's self-selection or selection methods used by the project implementing agencies. The problem of selection bias may also emerge because of unobservable or missing characteristics. Under this prevailing circumstance, an ordinary least squares (OLS) estimator will not produce a result which is consistent due to bias in the selection of farmers with access to finance and also endogeneity of access to finance (Baum, 2006). To control for such biases and to produce an estimation that is consistent, we adopted the IV estimations technique. The IV with exclusion restrictions is preferred as it establishes causality and addresses selection bias (Cuddeback, Wilson, Orme & Combs-Orme, 2004; Bushway, Johnson & Slocum, 2007).

This study also adopted the DHM proposed by Cragg (1971) to access the determinants of smallholder farmers' market participation and intensity. The DHM is considered much more flexible than the Tobit model, which assumes the factors influencing market participation and intensity of participation are jointly made. Meanwhile, the application of the DHM assumes that the adoption decision and the intensity are separable. The factors influencing the decision to participate on the market are not the same factors influencing the extent of market participation (Mather et al., 2013).

According to Hacking (1988), Burtless (1995) and Loux (2015), randomisation (experimentation) is generally viewed as the most robust evaluation approach as it controls for selection bias. It is described as a highly reliable evaluation technique that helps to easily assign the difference in the average outcome to the treatment. However, the design of AVCF, which was the project of study, was not randomised. Meanwhile, the characteristics of the AVCF project offered the opportunity to use the propensity scores matching the PSM estimation model as the alternative approach for the estimations. The choice of the PSM estimation is to control for selection bias and endogeneity. According to Rosenbaum and Rubin

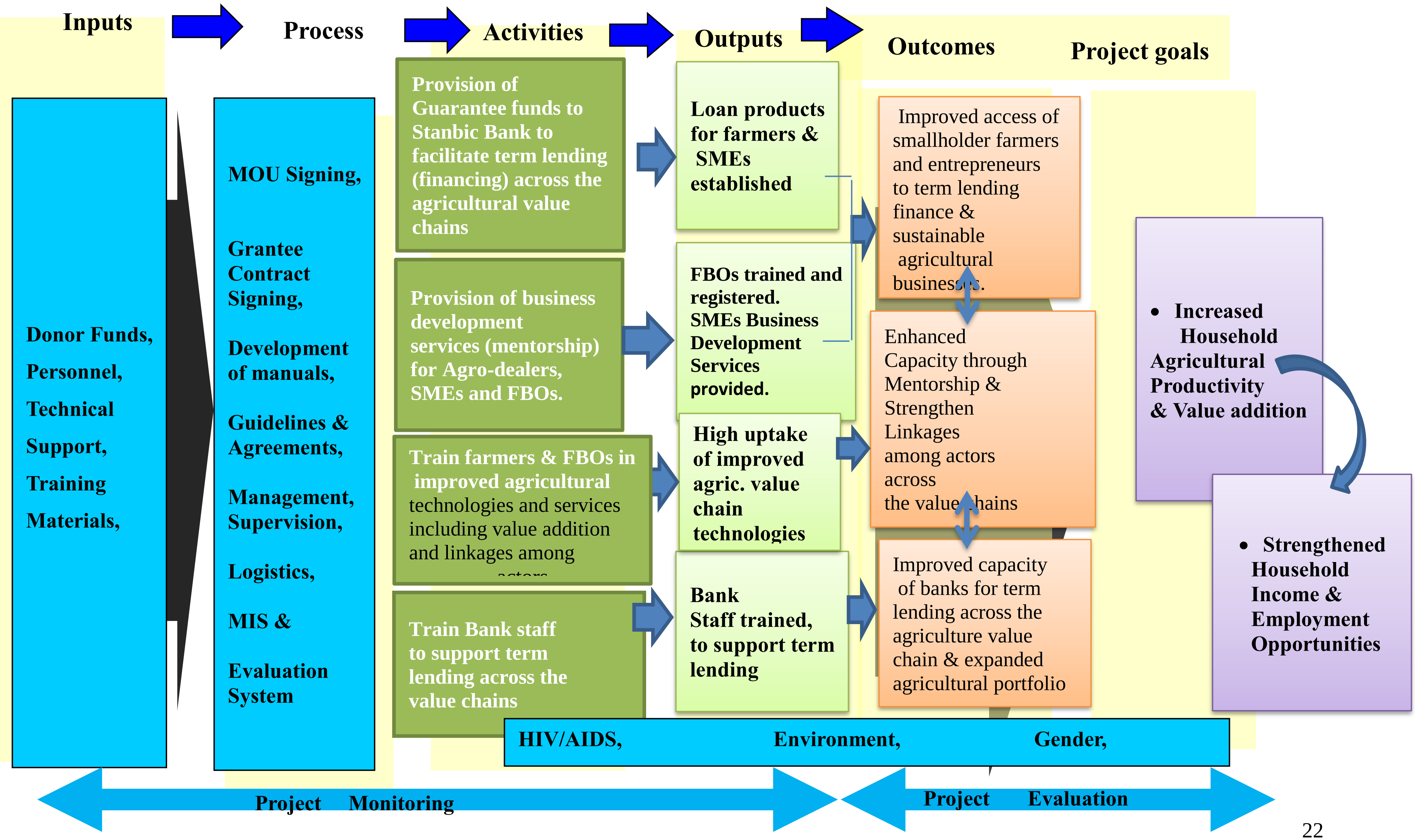
(1983), propensity score is "the conditional probability of assignment to a particular treatment given a vector of observed covariates". In other words, the propensity score is the probability of participating or receiving a treatment depending upon the pool of the observed characteristics. On that note, data was collected from both the beneficiary and the non-beneficiary and non-equivalent control groups who answered the same questionnaire for the purpose of estimating the average treatment effect. Similar studies by Jalan and Ravallion (2003) used PSM to estimate "the benefit incidence of an antipoverty program in Argentina" and while Wendimu, Henningsen and Gibbon (2016) also adopted the PSM model for the estimation of "the effects of compulsory participation in sugarcane outgrowers schemes in Ethiopia".

1.7. AN OVERVIEW OF THE DANISH INTERNATIONAL DEVELOPMENT AGENCY'S (DANIDA'S) AGRICULTURAL VALUE CHAIN FACILITY (AVCF)

The AVCF was a program which was funded by the Danish International Development Agency (DANIDA) and implemented under the guidance, management and coordination of the Alliance for Green Revolution in Africa (AGRA). The project was implemented over a five-year period from 2010 to 2015 with the goal to "increase income and employment in rural areas, particularly in breadbasket areas of Northern Ghana, through increased agricultural production, productivity and value addition" (DANIDA, 2009). The AVCF adopted a comprehensive and holistic value chain approach to address key challenges facing agricultural development in Ghana such as access to finance, increase productivity and increase the sale of farm products. In this vein, AVCF focused on "improving medium to long term access to finance combined with mentorship/technical assistance to key players in the value chains, including commercial farmers, seed producers, input suppliers and agro-dealers, agribusiness and agro-processors, marketers, farmer-based organizations and groups/associations of out-grower farmers" (Ibid). That is, the AVCF takes the form of interconnectivity of actors within the agricultural sector which in this case is, agro-dealers supplying farm inputs or service providers providing tractor services to smallholder farmers for production and then followed by distribution or marketing using various marketing outlets to the consumer. This creates the opportunity for finance and information to flow through the chain. Through this chain or interconnectivity, AVCF is expected to increase farm inputs through agro-dealers, increase productivity, increase market access and participation and also increase access to finance. Figure 1.3 below depicts the Danish International Development Assistance (DANIDA) Agricultural Value Chain Facility (AVCF) log framework.

Figure 1.3:

DANIDA's AVCF Project Logic Framework



The DANIDA AVCF Project had broad outcomes and goals of which included improvement of welfare and livelihood of farmers, increase in productivity and yield of smallholder farmers and enhancement of access to market participation. Three facilities were implemented to attain these goals: Facility A concentrated on the technical capacity of farmers, Facility B focused on the capacity of banks to lend to smallholder farmers and Facility C dealt with access to term credit (long-term assets finance) by smallholder famers. This study is a collection of essays on finance, productivity, market participation and welfare of smallholder agricultural farmers in Ghana following the DANIDA AVCF Project. It specifically concentrated on interventions under Facilities A and C of the DANIDA AVCF to ascertain their outcome on welfare, productivity and market participation of smallholder farmers.

AGRA's major focus is mentorship and advisory services which is "Facility A" with the objective of enhancing the technical and business skills of farmers and their organizations, as well as small and medium enterprises (SMEs) along the agricultural value chains. To achieve this objective, AGRA engaged a consortium of three institutions to implement the mentorship and advisory services under the project name the Agricultural Value Chain Mentorship Project (AVCMP). These institutions with their assigned mandates are as follows:

1. International Fertilizer Development Center (IFDC) - responsible for small and medium enterprise (SME) support component. The focus among others include training SMEs and business associations in business development and entrepreneurial skills and facilitating business partnerships (market linkages) between SMEs, agro-dealers and identified markets;
2. Savanna Agricultural Research Institute (SARI) - responsible for productivity support component. That is to improve improve technical and farm business management skills of Farmer Based Organizations (FBOs) and their member farmers to adopt the application of Integrated Soil Fertility Management (ISFM) technologies; and
3. Ghana Agricultural Associations Business Information Centre (GAABIC) - responsible for agro-dealer support component. The focus of this component is to facilitate access to finance to agro-dealers for farm inputs and support farmers to expand productivity, improve food security and increase agro-dealer market access.

The Adventist Development and Relief Agency (ADRA) was also engaged by AGRA to implement the mentorship and advisory services under the project name Integrated Agricultural Productivity Improvement and Marketing Project (INTAPIMP). ADRA carried out its mandates with the support of service providers (AGRA, 2014; AGRA/DANIDA, 2016). At the end of the AVCF project, 27,856 smallholder farmers of direct beneficiaries had received technical training in integrated soil fertility management (ISFM) (AGRA/DANIDA, 2016).

The AVCF project is one that seeks to bring together all actors within the agricultural value chain. It creates the opportunity to widen the scope of finance by addressing the financing needs of smallholder farmers and also ensuring efficiency through productivity enhancing interventions. Furthermore, the project improves repayment and contributes towards strengthening the network of the set of actors. The project also champions the course for smallholder farmers to focus on producing high value products for the markets and participate directly as sellers or indirectly through sales outlets. AVCF as a market-led approach contributes to minimizing transaction cost and minimizes the risks associated with credit allocation through an improved access to information. In the light of these, the AVCF model could be a significant tool for the development of the agricultural sector of most developing economies. The AVCF and its expected outcomes of improving economic performance of smallholder farmers, improving welfare through income generation and ensuring financial sustainability could be of great relevance to developing economies, development partners as well as development finance institutions. In short, the AVCF is an effective and coordinated model to implement.

1.8. CHAPTER ORGANISATION

This thesis is organised around the four main empirical essays and outcomes of the study in line with the objectives and research questions and is presented in seven chapters. The first chapter introduces the research by highlighting the research problem, the significance and objectives of the study. The second chapter presents an overview of agriculture in Ghana, reviews agricultural sector policies and trends in agricultural performance for major crops.

The first empirical essay is presented in Chapter 3, where we explore the effect of finance on smallholder farm productivity. The second empirical essay appears in Chapter 4, where we estimate the impact of finance on household welfare of smallholder farmers. Chapter 5 presents the third empirical paper, which evaluates the factors influencing smallholder farmers' market participation and its intensity. In Chapter 6, which contains the last empirical essay, we estimate the impact of integrated soil fertility management (ISFM) on productivity of smallholder farmers. Chapter 7 presents conclusions from the thesis, outlines the main contributions, and provides some policy recommendations.

CHAPTER 2
THE AGRICULTURAL SECTOR IN GHANA: POLICIES AND DEVELOPMENTS

2.1. INTRODUCTION

The agricultural sector in developing economies is dominated by the activities of smallholder farmers. According to Dalberg Global Development Advisors (2012) and Conway (2014), there are 450 million smallholder farmers around the globe but mostly in Africa, Asia and Latin America. It is estimated that about 87 per cent of these farmers use farms of less than two hectares (ha) in size. The average farm size for smallholder farmers in Sub-Saharan Africa (SSA) ranges from 1.6 ha to 2.4 ha, while East Asia and South Asia record an average farm size of one ha and 1.6 ha respectively (Livingston et al., 2014). Smallholder farmers are characterised by low welfare, a lack of resource endowment and assets, operate in the informal sector and are domiciled in rural areas (World Bank, 2008; Dercon, 2013).

Ghana’s agricultural sector has significantly contributed towards the growth and development of the economy. The sector over the years has employed on average 44.7 per cent of Ghana’s total labour force (GSS, 2014). The agricultural sector has contributed an average of 8.21 per cent from 2006 to 2014 to the GDP of Ghana while the average growth rate within the period was recorded at 4.14 per cent (Jayne et al., 2015). However, the trends show a reduction in the agricultural value addition in recent times. For instance, the value addition was recorded at 40.30 per cent in 2004 but reduced to 22.40 per cent in 2013 (MoFA-SRID, 2013).

Agriculture in Ghana is a predominantly rural economic activity and largely dominated by smallholder farmers, most (90 per cent) of them with a farm size of an average of less than two hectares (MoFA-SRID, 2011; MoFA-SRID, 2016). The system of farming practised is basically rain fed (Nyanteng & Dapaah, 1997; Diao, 2010), which has an effect on promoting higher agricultural productivity and improving growth. There are two rainy seasons in the Southern part of Ghana, from March to July and from September to October, while the Northern sector records only one rainy season from July to September. The attributes of the soil in Ghana are near depletion, which requires fertilisation in order to improve the soil fertility (Jayne et al., 2015; Omari, Sarkodee-Addo, Fujii, Oikawa & Bellingrath-Kimura, 2017). Approximately 95.1 per cent of the farming population are engaged in crop farming, which is characterised by traditional farming methods. This is mainly the use and application of rudimentary technology such as hoes and cutlasses; however, mechanised farming is also gradually taking place in some parts of the country (MoFA-FASDEP II, 2007). Most (51%) of these farmers are practising monocropping, while 44 per cent are also engaged in mixed cropping techniques (MoFA-SRID, 2013; MoFA-SRID, 2016).

The level of formal education among smallholder farmers in Ghana is relatively low. Available statistics show that 31.5 per cent of the agricultural households in Ghana have no formal education while 60.3 per cent have a minimum of basic education (Ghana Statistical Service, 2013). The farmers are also faced with multiple challenges that impact on the farming system and ultimately agricultural productivity. Some of these challenges are the lack of knowledge on best or improved agronomic practices and the timely application of these practices. Access to finance also remains one of the challenges that influence smallholder farmers' investment decisions in production. Because of the lack of storage facilities resulting in post-harvest losses, poor road networks, and the lack of access to information on market prices and the nature of the market, smallholder farmers' market access and the market participation remain low in Ghana (Jayne et al., 2015). The outcomes of these challenges are also expected to contribute to the poverty of smallholder farm households. The evidence available indicates that the rate of poverty in Ghana among farmers is 39.2 per cent while rural poverty is 37.9 per cent (Ghana Statistical Service, 2014).

The sub-sections below present the agricultural production and productivity in Ghana and highlight some stylised facts on the rainfall patterns and finally present facts and figures on the soil fertility status in Ghana.

2.2. AGRICULTURAL POLICIES AND STRATEGIES IN GHANA

The agricultural policies and strategies in Ghana have been designed following the role of agriculture towards the growth and development of the economy. Ghana's agricultural policies have focused mainly on increasing production, with the ultimate effect of creating employment, increasing income, and improving welfare and food security. This section highlights some of these policies and strategies.

The Agricultural Development Corporation (ADC) was first established by the Government of Ghana in 1951–1956 and sought to focus on agricultural modernisation and provision of extension services to farmers (Asuming-Brempong, 2003). Similarly, other policies prior to independence (before 1957) tilted in favour of the production of cash crops such as oil palm and cocoa mainly for the export market to generate foreign exchange and using Ghana for a source of raw materials (Seini, 2002). The independence era then ushered in both a capitalist approach and a labour-intensive approach towards the development of the economy of Ghana, including the agricultural sector. During this era, agricultural policies focused on employment creation and increasing food production for the growing urban population. The Government's strategy was among others to establish state-owned farms, indicating its involvement in farming. The policies failed to yield the expected results due to population growth (Ibid).

Ghana's agricultural policies in the 1970s and beyond centred on agricultural modernisation, which intended to transform the sector from subsistence to commercial farming. Two flagship programs known as Operation Feed Yourself (OFY) and Operation Feed Your Industries (OFYI) were introduced in 1972–1974 with the aim of increasing agricultural production (Nyanteng & Seini, 2000). To complete the production of agricultural products, the Ghana Food Distribution Corporation (GFDC) was established purposely to promote distribution and marketing of food and cash crops (Aryeetey & Nyanteng, 2006).

The introduction of the Economic Recovery Program (ERP) in 1983–1986 and Structural Adjustment Program (SAP) in 1987–1990 focused on stabilisation, diversification and structural transformation of the economy of Ghana (Nyanteng & Seini, 2000; Seini, 2002). These periods witnessed the demise of states as a result of the role of market liberalisation policies in agricultural production and marketing, paving the way for the emergence of active private sector participation. Some of the projects that were launched and implemented during these periods are the Cocoa Rehabilitation Project (CRP), the Rural Finance Project (RFP) and the Agricultural Services Rehabilitation Project (ASRP) (Asante & Awo, 2017).

With the Government's focus on agricultural modernisation, rural development and enhancing welfare, several policy initiatives were set out after the ERP/SAP era. The Medium-Term Agricultural Development Program (MTADP) was the first of its kind, which was implemented from 1991–2000 with the goal of increasing production at an expected growth rate of four per cent per annum. The strategies of this program among others include private-sector engagement in marketing of agricultural products for both inputs and output markets and the creation of an environment for a laissez-faire pricing system. Projects implemented under MTADP include Agricultural Sector Adjustment Credit (ASAC) (1992–1999), National Agricultural Extension Project (NAEP) (1992–2000) and the Agricultural Sector Investment Project (ASIP) (1994–2000), (Asuming-Brempong, 2003; Dzanku & Aidam, 2013; Asante & Awo, 2017). The AAGDS was also developed in 2000 to complement or as a follow-up to the implementation of MTADP. Key areas for the implementation of AAGDS include improving market access, access to technology, access to financial services, improved road infrastructure and development of human resource and institutional capacity (Ibid).

The FASDEP I was introduced and implemented from 2002–2007 as the main agricultural sector policy initiatives for the Government of Ghana. The implementation of FASDEP was shaped in line with the thematic areas of AAGDS. The agricultural policy document was implemented alongside the Ghana Poverty Reduction Strategy (2003–2005) (Dzanku & Aidam, 2013; Asante & Awo, 2017). As a follow-up to FASDEP I, FASDEP II was launched to provide a long-term agricultural policy guide covering the period from 2007–2015 (MoFA-METASIP, 2010; Asante & Awo, 2017). The policy document of FASDEP II focused on adopting an agricultural value-chain approach towards modernisation of the agricultural sector. By this, commercialisation was identified as the path to increasing production. The objectives of FASDEP II include food security and emergency preparedness, improved growth in incomes, sustainable management of land and environment, science and technology applied in food and agricultural development, improved institutional coordination, and increased competitiveness and enhanced integration into domestic and international markets. The development and implementation of this policy document was linked to the Growth and Poverty Reduction Strategy (GPRS) II and Comprehensive African Agricultural Development (CAADP), (MoFA-FASDEP II, 2007).

By midway through the implementation of FASDEP II, the Medium-Term Agriculture Sector Investment Plan (METASIP) (2011–2015) was developed as the framework that is focused on the creation of an investment environment for the implementation of agriculturally-led policies, programs and projects. This is to complement the implementation of FASDEP II towards achieving the agricultural growth rate of six per cent per annum as set under CAADP (MoFA-METASIP, 2010). CAADP is an integral part of the African Union's (AU's) New Partnership for Africa's Development (NEPAD). CAADP sets out clear policies for members of the AU towards agricultural development, of which Ghana is a part. The Regional Agricultural Policy for West Africa (ECOWAP) is another agricultural policy that influences agricultural policy formulations in Ghana (Asante & Awo, 2017).

Despite the implementation of the above-mentioned agricultural policies since the early 1950s, Ghana is still faced with the challenge of attaining a constant or sustainable agricultural growth rate of six per cent. This is due to multiple factors, including the absolute reliance on rainfall and the lack of or limited irrigation facilities as well as the poor state of the soil in terms of nutrients. The section below discusses the climate conditions in Ghana and the state of the soil.

2.3. THE CLIMATE OF GHANA

According to Asare and Amoatey (2001), climatic conditions in terms of weather or rainfall and soil influence the farming system a farmer practises and the crops to farm. This section presents Ghana's climate following the six agro-ecological zones, indicating variations in the climatic conditions. By this we refer to variations in rainfall patterns, temperature, and humidity. Figure 2.1 below vividly captures the agro-ecological map of Ghana.

Sudan and Guinea Savannah zones (Northern Sector) have a single rainy season, which is mainly from May/June to August/September, with an average rainfall of 594.6 mm during July/September. Meanwhile, the northern sector experiences its peak rainfall in August/September. Although each of the remaining four (4) zones, Coastal Savannah, Transitional, Deciduous and Rain Forest zones (Southern Sector), record two rainy seasons in a year, they are independent of the geographical area. For instance, the Coastal Savannah zone records its major rainy season between April and June and the minor rainy season between September and November. Similarly, the rainy pattern in the Transitional zone is from April to October with September to October recording the peak rainy season. Deciduous ecological zone experiences rainfall almost all year round with the peak rainfall in May/June, with the minor rainy season in September/November.

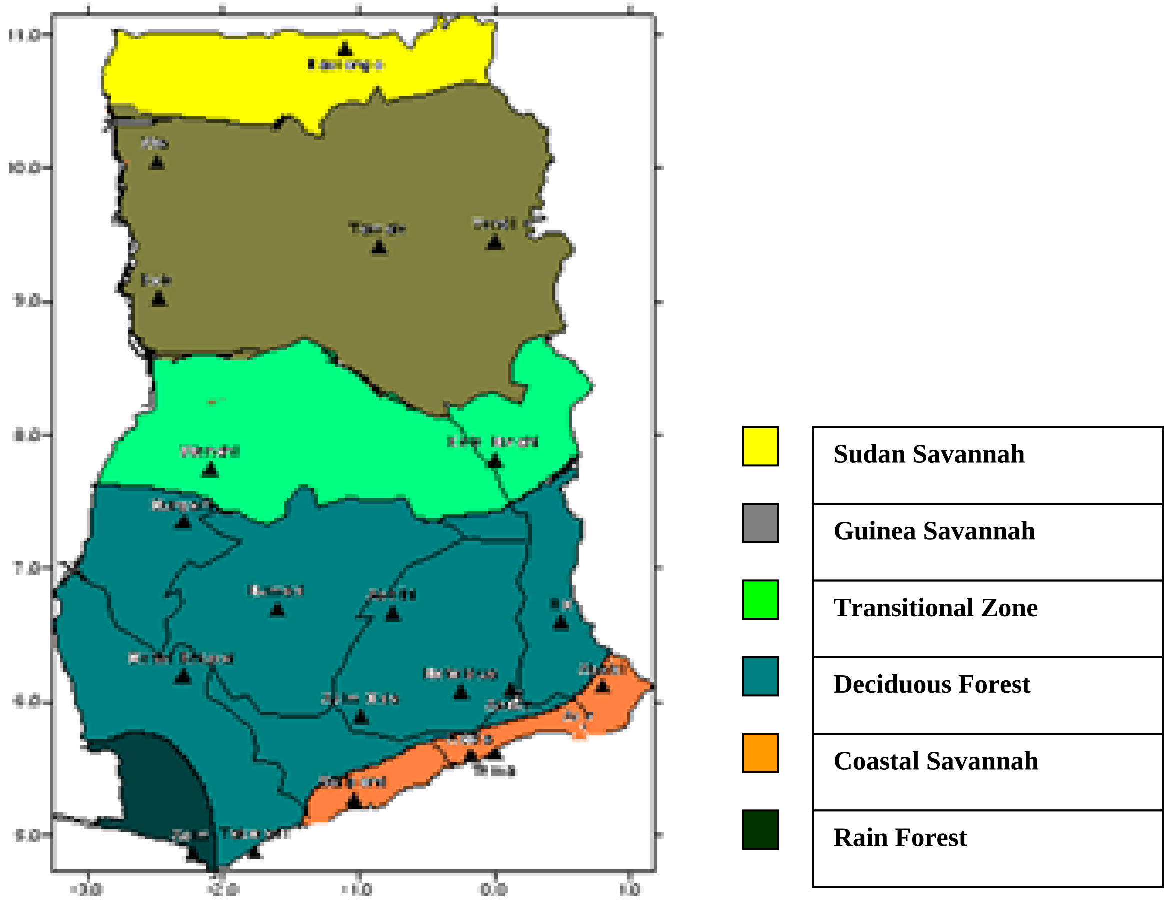


Figure 2.1: Agro-ecological Map of Ghana
Source: Ghana Meteorological Authority.

Table 2.1 below presents the average annual rainfall pattern recorded by each of the six agro-ecological zones from 2004–2014. The Rain Forest ecological zone records the highest level of rainfall. The rainfall pattern shows some seasonal variation, with the least average rainfall of 892.2 recorded in 2013. The average rainfall recorded for the Transitional and Deciduous Forest ecological zones is slightly similar but shows some seasonal variations with the rainfall pattern or trend. The data for Guinea Savannah zone presents relatively constant average rainfall records above the average for Sudan Savannah and Coastal Savannah. On the other hand, the data for Sudan Savannah presents a high level of fluctuations over the period. The Coastal Savannah zone, which is among the zones with two rainy seasons, seems to record the lowest rainfall among the zones. Its highest rainfall levels were recorded only in 2011 and 2014, higher than those of Sudan Savannah.

Table 2.1: Average Rainfall Patterns in Ghana: 2004–2014

	RAINFALL (MM)					
Year	Sudan Savannah	Guinea Savannah	Transitional	Deciduous	Coastal Savannah	Rain Forest
2004	918.1	1240.2	1388.4	1281.8	671.2	1724.4
2005	926.4	1181.3	1304.3	1056.1	863.5	1975.8
2006	1037.7	1004.3	1128.4	1262.7	762.3	1458.9
2007	1365.8	1037.9	1318.4	1328.5	958.3	2165.5
2008	988.9	1240.8	1497.0	1384.5	918.8	1715.9
2009	1109.2	1232.0	1375.0	1248.7	836.6	2095.8
2010	1128.6	1278.9	1355.0	1403.1	955.1	2391.1
2011	926.2	1109.8	1197.4	1299.4	959.2	2276.9
2012	1072.8	1136.7	1234.0	1284.6	685.0	1711.1
2013	865.4	1012.1	1329.5	1165.9	594.5	896.2
2014	716.6	950.8	1335.3	1379.0	1019.1	2564.7

Source: Ghana Meteorological Agency.

2.4. SOIL CHARACTERISTICS AND FERTILIZER USAGE IN GHANA

According to Quansah, Safo, Ampontuah and Amankwah (2000), the depletion of the nutrients of the soil in Ghana cuts across all the agro-ecological zones, with nitrogen (N) and phosphorous (P) being the most affected nutrients. According to Stoorvogel, Smaling and Jansen (1993), the rate of depletion of the soil nutrients in Ghana is increasing as nitrogen (N) loss is 30 kg per hectare her year ($ha^{-1}yr^{-1}$) recorded in 1982/84 and 35 kg $ha^{-1}yr^{-1}$ in 2000. Similarly, phosphorous (P) also recorded a loss of 3 kg $ha^{-1}yr^{-1}$ in 1982/84 and 4 kg $ha^{-1}yr^{-1}$ in 2000 while the rate of potassium (K) depletion was also recorded at 17 kg $ha^{-1}yr^{-1}$ for 1982-84 and 20 kg $ha^{-1}yr^{-1}$ in 2000. The low fertility is mainly characterised by low organic matter, unfavourable moisture, weathering, the acid content, as well as some basic intrusive rocks. Additionally, the health of the soil is negatively affected by erosion and the high level of iron concentration in some ecological zones. Notwithstanding the characteristics, the topography is also a contributing factor to the health of the soil (Obeng, 2000; Oppong-Anane, 2006). Table 2.2 below depicts the soil fertility status in relation to the agro-ecological zones.

Table 2.2: Soil Fertility Status in Ghana

Agro-Ecological Zones	Soil pH	Organic (C)	Total (N)	Available (P)– (mg/kg soil)	Available (K)
Sudan Savannah	6.4 - 6.7	0.48 - 0.98	0.06 - 0.14	0.06 - 1.80	36.96 - 44.51
Guinea Savannah	6.2 - 6.6	0.51 - 0.99	0.05 - 0.12	0.18 - 3.60	46.23 - 55.27
Transitional	5.1 - 6.4	0.59 - 0.99	0.04 - 0.16	0.30 - 4.68	58.29 - 72.53
Coastal Savannah	5.6 - 6.4	0.61 - 1.24	0.05 - 1.16	0.28 - 4.10	48.02 - 58.71
Rain Forest	3.8 - 5.5	1.52 - 4.24	0.12 - 0.38	0.12 - 5.42	63.57- 150.41
Deciduous	5.5 - 6.2	1.59 - 4.80	0.15 - 0.42	0.36 - 5.22	62.01 - 84.82

Source: Bationo, 2015 in Jayne et al. (2015).

According to Rasmussen and Collins (1991), the concentration of soil organic carbon (SOC) or organic carbon (organic C) is expected to range from a minimum of one per cent to five per cent maximum, depending on the texture of the soil. The data also shows a positive correlation between organic C and nitrogen (N).

Table 2.2 shows that Sudan Savannah, Guinea Savannah and Transitional zones are very low in organic carbon or matter (C) falling below the minimum threshold of one per cent. The Coastal Savannah zone recorded a minimum limit of 0.61 per cent and upper limit of 1.24 per cent, making the organic matter of the soil relatively better, with an improved nitrogen (N) compared with Sudan Savannah, Guinea Savannah and Transitional zones.

By juxtaposing the soil and rainfall conditions based on the agro-ecological zones, there is evidence to infer that farming in the Deciduous, Rain Forest, Transitional and Coastal Savannah zones is more likely to contribute towards increasing productivity. A study by Omari et al. (2017) revealed that the nutrients of the soil in the Deciduous zone are much higher compared to those of Guinea Savannah, suggesting that there is the need to increase fertilizer usage in Guinea Savannah zone. The outcome of this study simply implies that areas with lower soil nutrients demand high fertilization to improve productivity.

2.4.1. Importation of Fertilizer and Pesticides

According to Morris, Kelly, Kopicki and Byerlee (2007), the use and application of low quantities of fertilizer serve as a constraint to increasing agricultural production and productivity. Ghana is among countries in SSA with low usage of fertilizer of about ten kg per hectare which is far lesser than the fifty kg/ha target set in the Abuja Declaration for SSA (MoFA, 2012). Table 2.3 below presents an account of imports of fertilizer and agro-chemicals to Ghana from 1997–2015 and shows that the volume of fertilizer imports on average has been increasing with the highest import recorded in 2010, while imports for chemicals recorded the highest quantity imported in 2012 and 2013.

Table 2.3: Fertilizer and Agro-Chemical Imports from 1997–2015

Year	Fertilizer[4] (Mt)	Chemicals[5] (Mt)
1997	55,080	
1998	39,218	
1999	9,968	
2000	43,318	2,349
2001	9,262	2,507
2002	40,987	3,580
2003	88,052	10,133
2004	221,145	2,476
2005	72,810	13,048
2006	165,891	17,927
2007	163,565	21,609
2008	125,567	18,723
2009	308,893	12,038
2010	477,694	13,690
2011	310,408	2,283,210
2012	468,519	1,714,300
2013	455,142	10,861
2014	195,890	15,569
2015	322,885	299,032

Source: Ministry of Food and Agriculture (MoFA)–Statistical, Research and Information Directorate (SRID) & Ghana Statistical Service (GSS).

2.4.2. Link Between Fertilizer and Cereal Production in Ghana

The literature as discussed also points to the fact that improving soil fertility is a sine qua non for improving agricultural production and productivity. Thus, the application of fertilizer is significant for improving the health of the soil thereby contributing towards increasing production. Figure 2.2 below depicts the trends in fertilizer consumption and the production of cereals in Ghana. Clearly, the trend shows a positive relationship between fertilizer and cereal production from 1995 to 2004 despite the rate of volatility in fertilizer consumption and production. However, for the periods (2005, 2007 and 2010),

[4] Fertilizers include NPK, urea, muriate of potash, sulphate of ammonia, phosphate, nitrate, potassium and cocoa fertilizer, all measured in metric tonnes (mt)
[5] Chemicals include insecticide, fungicide, herbicide and rotenticide, all measured in metric tonnes (Mt)

the value of fertilizer consumption and production of cereals were slightly close. In deed, the data recorded some inverse relationship between fertilizer consumption and cereal production after 2010. The inverse relationship could be explained based on ecological factors in terms of weather pattern. That is, a favorable rainfall could also contribute to improving the health of the soil while low application of fertilizer could also lead to increasing productivity and vice versa. This shows that increasing fertilizer consumption is as equally important as recording a favorable rainfall pattern aimed at improving agricultural production and productivity.

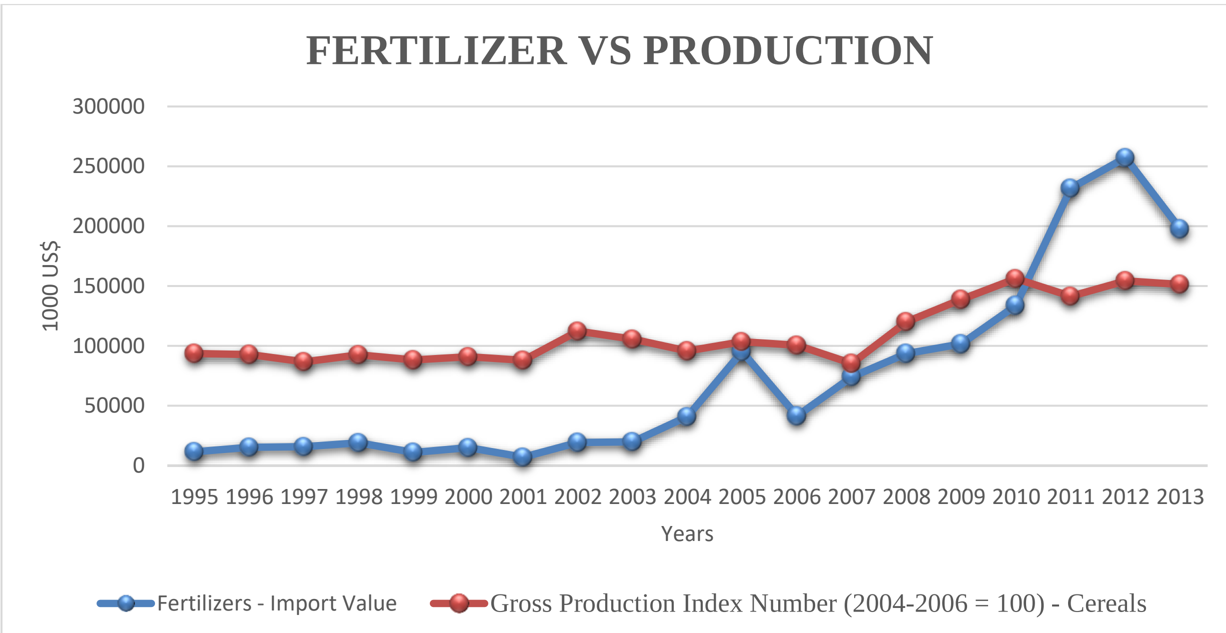


Figure 2.2: Relationship Between Fertlizer[6] and Cereal Production in Ghana
Source: FAOSTAT.

[6] Nitrogenous fertilizers, Phosphate fertilizers, Potash fertilizers, Fertilizers Manufactured, Organic – fertilizers, Natural Phosphates, Natural Sodium Nitrate and Natural Potassic Salts

2.5. THE FINANCIAL SYSTEM AND FINANCE FOR AGRICULTURE SECTOR IN GHANA

Ghana's financial system has transformed over time but more especially after the liberalisation of the financial sector in the 1980s. The two major reforms that took place after 1980 are the Financial Sector Reform Program (FINSAP), which was implemented in 1988–2000, and the Financial Sector Strategic

Plan (FINSSIP), also implemented from 2001–2008. Both programs aimed at deepening the financial sector and the development of the financial market, which became necessary due to the economic crisis in the economy (Brownbridge & Gockel, 1998:57). However, the implementation of these policies yielded a mixed outcome.

Ghana's financial system consists of 34 Deposit Money Banks (DMBs) and 68 NBFIs. The number of Rural and Community Banks (RCB) was 141, 417 forex bureau, 3 credit reference bureaux and 566 microfinance institutions (MFIs) (Bank of Ghana, 2017). Table 2.4 shows that, loans and advances from DMBs, NBFI and RCBs have shown a constant increase from 2012 to 2017. For instance, loans and advances from DMBs, NBFI and RCBs increased by 32.13 per cent, 70.7 percent and 10.53 per cent respectively from 2012 to 2013. Except for loans and advances from DMBs that increased by 43.84 per cent from 2013 to 2014, the percentage increase of loans and advances for NBFIs and RCBs declined to 15.95 per cent and 8.47 per cent respectively for the period from 2013 to 2014. However, from 2015 to 2017, the percentage change in loans and advances from RCBs have seen a consistent increase while that of DMBs and NBFIs was volatile but recorded 1.09 and 22.70 percentage change in the loans and advances made from 2016 to 2017. For MFIs, Table 2.4 shows loans and advances increased by 14.68 per cent from 2014 to 2015. However, this declined by 2.88 per cent from 2015 to 2016.

Table 2.4: Loans & Advances of Financial Institutions From 2012 - 2017 (GH¢M)

	2012	2013	2014	2015	2016	2017
DMB	11,686.90	15,442.30	22,212.70	27,094.72	31,229.18	31,568.71
NBFI	1,453.00	2,480.20	2,875.90	3,455.39	4,337.25	5,321.72
RCB	648.5	716.80	777.50	871.63	988.94	1,160.91
MFI			481.10	551.73	535.84	554.17

Source: Bank of Ghana Annual Reports

Although these financial institutions extend credit to the agricultural sector, there is no record of sectorial distribution of the loans and advances by the financial institutions except for that of DMBs. Credit allocation to the agricultural sector from the Deposit Money Banks (DMBs) recorded a steady decline from 12 per cent in 1997 to 9.60 per cent in 2001 down to 3.57 per cent in 2017. Table 2.5 below depicts sectorial distribution of finance by DMBs from 2002 to 2017. With focus on agriculture, the statistics show that the share of DMBs supply of finance to the agricultural sector has seen a marginal decrease over time from 2004 and 2017. Comparatively, the supply of finance to the agricultural sector records the lowest level of finance from the DMBs to other sectors such as services, domestic trade and manufacturing.

Table 2.5: Sectorial Distribution of Finance (Credit) by Deposit Money Banks 2002–2016 (%)

Years	Agric./Forestry & Fishing	Manufacturing	Services
2002	6.50	15.60	7.10
2003	0.40	17.60	15.20
2004	7.90	19.40	10.60
2005	6.40	20.40	13.60
2006	6.30	18.70	17.80
2007	4.46	12.88	22.37
2008	4.32	12.01	24.13
2009	4.77	11.71	21.11
2010	6.16	13.33	20.74
2011	5.77	9.00	26.96
2012	4.87	11.08	26.46
2013	4.09	8.87	26.35
2014	3.64	9.46	23.48
2015	3.84	8.41	21.89
2016	3.79	8.18	19.62

Source: Facts and Figures (2017); Ministry of Food and Agriculture – Statistics, Research and Information Directorate

It is important to state that, except for the financial institutions within the informal sector that are not regulated by the Bank of Ghana, the formal and semi-formal financial institutions are regulated by the Bank of Ghana under either the Banks and Specialized Deposit-Taking Institutions Act, 2016 (Act 930) or the Non-Bank Financial Institutions Act, 2008, (Act 774).

2.5.1. The Structure of the Microfinance Sector in Ghana

Microfinance is “the provision of a broad range of financial services such as deposits, productive loans, loans as livelihood support, payment services, money transfers, and insurance for the poor and low-income households and for their microenterprises through a wide variety of institutions”, (Shetty, 2012).

Ghana's microfinance sector is classified under three broad microfinance institutions (Ghana Microfinance Policy, 2006). These are:

- Formal suppliers of microfinance (i.e. rural and community banks, savings and loans companies, commercial banks);
- Semi-formal suppliers of microfinance (i.e. credit unions, financial non-governmental organizations [FNGOs], and cooperatives);
- Informal suppliers of microfinance (e.g. susu collectors and clubs, rotating and accumulating savings and credit associations [ROSCAs and ASCAs], traders, money lenders and other individuals).

The end users of these services are mainly micro, small and medium entrepreneurs who are also referred to as economically active entrepreneurs and this group include smallholder farmers, traders and some microenterprises. The stakeholder of microfinance in Ghana are multiple cutting across financial institutions, association of actors of microfinance, development partners and regulatory bodies. Figure 2.3 below presents the list of microfinance institutions and apex bodies within the microfinance sector:

Stakeholders of Microfinance in Ghana

1. **Microfinance Institutions, including:**
   - The Rural and Community Banks,
   - Savings and Loans Companies
   - Financial NGOs
   - Primary Societies of CUA
   - Susu Collectors Association of GCSCA
   - Development and Commercial banks with microfinance programs and linakges
   - Micro-insurance and micro-leasing services
2. **Microfinance Apex Bodies, namely:**
   - Association of Rural Banks (ARB)
   - ARB Apex Bank
   - Association of Financial NGOs (ASSFIN)
   - Ghana Cooperative Credit Unions Association (CUA)
   - Ghana Cooperative Susu Collectors Association (GCSCA)
3. **Supporting Institutions**
   - Microfinance and Small Loans Centre (MASLOC)
   - The Ghana Microfinance Institutions Network (GHAMFIN)
   - Development Partners and International Non-Governmental Organizations
   - Universities, Training and Research Institutions

Source: Ghana Microfinance Policy, 2006

The sector currently consists of 12 Financial Non-Government Organizations (FNGOs), 70 Money Lending Institutions and 484 Microfinance Companies. As shown in Table 2.4 above, MFIs have seen their loans and advances increase by 14.68 per cent from 2014 to 2015. However, this declined by 2.88 per cent from 2015 to 2016 (Bank of Ghana, 2017). According to Bank of Ghana regulations, the minimum capital requirement at entry for microfinance and money lenders is Two Million Ghana Cedis (GHS 2,000,000) and Three Hundred Thousand Ghana Cedis (GHS 300,000) for FNGOs (Bank of Ghana, 2015).

2.6. AGRICULTURAL PERFORMANCE

This section presents stylised facts on agricultural growth and productivity of selected crops in Ghana. The discussion ranges from agriculture's contribution to GDP, the national agricultural growth rates, trends in agricultural growth and productivity of major crops in Ghana, and a decomposition of growth and productivity of selected crops at regional levels.

2.6.1. Share of Agriculture in GDP and Agriculture Growth Rate in Ghana

Figure 2.2 shows a five-year average of the share of agriculture in GDP in percentage (%) and the average growth rate at 2006 constant prices in percentage (%). Figure 2.2 shows that the share of agricultural contribution to GDP has been constantly declining. The average share of agriculture in GDP recorded 40.02 per cent in 1976–1980, which decreased to 32.32 per cent in 1991–1995 with a further reduction to 22.48 per cent in 2011–2015. The decline in share of agriculture in GDP is explained by the structural transformation of the economy of Ghana as the service sector recorded the highest (54.6%) contribution to GDP in 2015. Figure 2.2 also shows that the average agricultural growth rate significantly declined from 3.55 per cent recorded in 1976–1980 to negative 0.93 per cent in 1981–1985. However, there has been a relatively constant increase in agricultural growth rates from 1.83 per cent recorded in 1986–1990 to 5.11 per cent in 2001–2005. This period was also followed by a decline in 2006–2010 and 2011–2015, recording a growth rate of 4.79 per cent and 3.25 per cent respectively. This shows that Ghana has not been able to achieve a six per cent growth rate target set under CAADP.

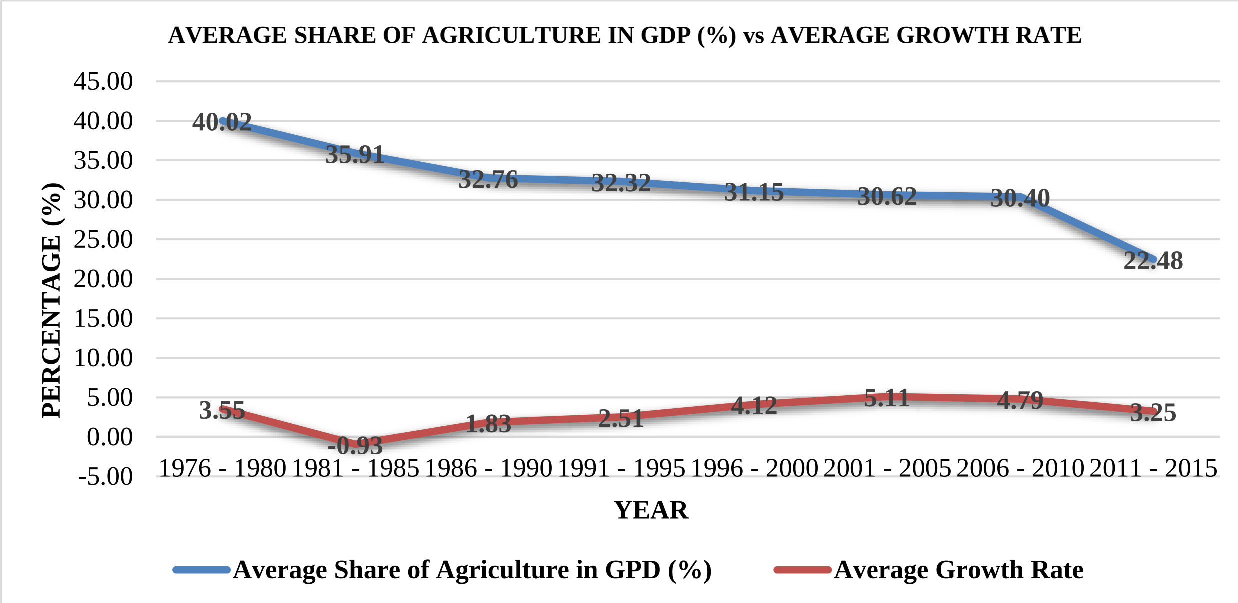


Figure 2.2: Average Share of Agriculture in GDP (%) vs Average Growth Rate
Source: Ministry of Food and Agriculture (MoFA) – Statistical, Research and Information Directorate (SRID) & Ghana Statistical Service (GSS).

The decline in the average share of the agriculture sector's contribution to gross domestic product (GDP) is influenced by the increasing service and industry sectors' contributions to the national GDP. From 1980 to 2015, agriculture sector's contribution to GDP has been decreasing at an average rate of negative 1.80 per cent. On the other hand, the service sector's contribution to GDP has been increasing at an average growth rate of 1 per cent while the industry sector's contribution to GDP also record an average growth rate of 2.05 per cent. However, the high average growth rate of the industry sector is due to the new oil and gas industry. Thus, from 2010 to 2015, the annual contribution of the industry sector to GDP increased on an average of 5.5 per cent.

The trend in average growth rate is influenced mainly by the agricultural sub-sector growth. These sub-sectors are the crop sector which includes cocoa, the livestock, forestry and logging and the fisheries sub-sectors which envelope the agricultural sector. A decline in the performance of either of these sub-sectors affects the overall agricultural growth rate. For instance, from 1981 – 1985 the crop and livestock sectors recorded high negative growth rates which account for the negative average growth rate for the period. The data also shows that, forestry and logging recorded high growth rates per year from 1996 – 2000 contributing to the average growth of 4.12 per cent recorded. However, from 2001 – 2005 except for the fisheries sub-sector that on average performed marginally low as compared to the other sectors, the annual growth rate for each of the sectors over the periods was relatively consistent. The decline in the average growth rate in the periods 2011 – 2015 could also be attributed to the negative growth rates recorded by the forestry and logging as well as the fisheries sub-sectors in 2011 and only the fisheries sub-sector in 2014. (Data for the analysis is shown in Chapter 6, Table 6.10).

2.6.2. Trends in National Agricultural Growth and Productivity of Major Crops in Ghana

The average annual trends in agricultural growth of major crops are presented in Table 2.6 below. The results show variations in the growth rates for the cereals. The result is quite revealing as it shows that, on average, all the cereal crops except maize recorded their highest average growth rates in 2008–2009, with rice recording the highest of 59.27 per cent growth while millet and sorghum recorded a growth of 58.02 per cent and 45.08 per cent respectively. Meanwhile, maize recorded its highest growth in 2002–2003 at the rate of 37.83 per cent. Among all the cereals, the growth rate for rice over the entire period reveals that on average the trend reflects an increase in rice production while the trend for maize reflects a constant growth rate. However, all cereals recorded a negative growth at various periods, with sorghum recording the highest negative growth of 20.69 per cent in 2006–2007. Millet and sorghum recorded the highest number of negative growth rates over the periods with the trend showing a negative growth for both crops. As shown in Table 2.7, the productivity levels for all the cereals show that rice recorded the highest level of productivity followed by maize, millet and sorghum. Although there are few reductions in the productivity rate for all the cereals, what is most revealing is that all the cereals experienced a low output per hectare in 2006–2007.

For the roots and tubers as well as plantain, as shown in Table 2.6, yam recorded the highest growth of 38.03 per cent in 1998–1999 and at the same time recorded the negative growth rate of 21.73 per cent in 1994–1995, compared to the rest. Similarly, the highest growth rate of 29.68 per cent was recorded for plantain in 1994–1995, with the least growth (1.04 per cent) also recorded in 2012–2013. The growth rate for cocoyam reflects a more decreasing trend while that of cassava reflects a more constant growth over the period, ranging between ten per cent and 20 per cent, despite the sharp decline in 2004–2005 and 2006–2007 respectively. Table 2.7 shows that cassava and yam recorded a relatively similar productivity level (output per hectare) of 11.79 and 11.58 per cent respectively. However, yam recorded a higher productivity of 14.33 per cent in 1998–1999 as compared to cassava, while both showed a more consistent productivity level till 2010–2011, when cassava recorded a progressively higher productivity level than yam. In general, cassava, yam and plantain have shown an increase in productivity levels over the periods despite the shortfalls, while the productivity level for cocoyam seems to be constant, ranging between six to eight metric tonnes per hectare.

The analysis of the growth rate of legumes reveals that, overall, these crops showed a downward growth rate despite the high growth rate of 61.11 per cent and 102.33 per cent recorded in 2002–2003 for groundnut and cowpea respectively and 120 per cent for soyabean recorded in 2004–2005. The average productivity for cowpea and groundnut ranged between 0.50–1.50 metric tonnes per hectare, while soyabean recorded a high productivity level of 1.91 metric tonnes per hectare in 2010–2011. Generally, the trend reflects a relative increase in productivity for all the legumes.

Table 2.6: National Average Growth Rates (%) of Major Crops in Ghana, 1994–2015

YEARS	1994 - 1995	1996 - 1997	1998 - 1999	2000 - 2001	2002 - 2003	2004 - 2005	2006 - 2007	2008 - 2009	2010 - 2011	2012 - 2013	2014 - 2015
CEREALS											
Maize	10.14	8.02	2.90	-5.80	37.83	-13.37	3.41	28.29	15.08	4.46	-6.84
Rice (Paddy)	27.88	12.12	18.02	7.13	0.16	-8.73	-9.00	59.27	37.83	9.94	18.55
Millet	16.65	-12.88	-6.35	-3.69	10.23	-1.80	-15.45	58.02	-8.26	-16.92	-6.60
Sorghum	17.25	1.90	-7.46	-11.87	16.74	-9.30	-20.69	45.08	-6.09	-16.15	-9.19
ROOTS & TUBERS & PLANTAIN											
Cassava	8.61	11.67	5.29	14.91	16.94	-3.30	2.85	18.76	17.65	10.06	10.48
Cocoyam	5.27	20.58	7.20	-0.97	11.33	-4.18	-4.01	-4.71	-16.85	-4.62	2.70
Yam	-21.73	22.40	38.03	6.90	15.56	-2.13	10.86	23.19	9.77	17.05	5.12
Plantain	29.68	17.16	5.58	1.19	17.76	14.08	17.03	12.50	3.73	1.04	7.59
LEGUMES											
Groundnuts	26.65	-11.67	17.49	48.49	61.11	1.05	1.50	16.23	4.27	-11.26	-4.53
Cowpea	80.90	9.07	25.01	-6.64	102.33	12.04	0.23	34.56	18.53	-7.11	-4.49
Soybean						120.01	38.71	80.21	64.93	-6.14	-2.26

Source: Ministry of Food and Agriculture (MoFA) – Statistical, Research and Information Directorate (SRID) & Ghana Statistical Service (GSS) (2011).

Table 2.7: National Annual Average Productivity (Metric Tonnes Per Hectare) of Major Crops in Ghana, 1994–2015

YEARS	1994 - 1995	1996 - 1997	1998 - 1999	2000 - 2001	2002 - 2003	2004 - 2005	2006 - 2007	2008 - 2009	2010 - 2011	2012 - 2013	2014 - 2015	**Potential (Mt/Ha)**
CEREALS												
Maize	1.49	1.53	1.48	1.38	1.55	1.58	1.52	1.72	1.76	1.80	1.82	**5.50**
Rice (Paddy)	2.04	1.86	2.06	2.09	2.18	2.00	1.86	2.35	2.66	2.59	2.72	**6.00**
Millet	1.01	0.94	0.90	0.76	0.83	0.90	0.77	1.19	1.13	1.00	0.96	**2.00**
Sorghum	1.06	1.08	1.01	0.91	0.96	0.98	0.89	1.26	1.29	1.18	1.07	**2.00**
ROOTS & TUBERS & PLANTAIN												
Cassava	11.79	12.07	11.70	12.31	12.47	12.59	12.48	13.67	15.72	17.51	18.69	**45.00**
Cocoyam	6.67	7.34	7.42	6.42	6.48	6.65	6.47	6.70	6.48	6.49	6.49	**20.00**
Yam	11.58	12.81	14.33	12.60	12.85	12.79	13.36	14.69	14.85	16.17	16.80	**52.00**
Plantain	7.87	8.09	7.92	7.66	8.16	9.18	10.15	10.84	10.77	10.68	10.82	**38.00**
LEGUMES												
Groundnuts	0.95	0.88	1.00	1.05	1.09	0.92	1.00	1.39	1.44	1.31	1.26	**3.50**
Cowpea	0.68	0.71	0.73	0.65	0.78	0.78	0.88	1.19	1.31	1.28	1.23	**2.50**
Soybean					1.16	0.91	1.05	1.35	1.91	1.71	1.64	**3.00**

Source: Ministry of Food and Agriculture (MoFA) – Statistical, Research and Information Directorate. (SRID) & Ghana Statistical Service (GSS) (2011).

A decomposition of growth in the production of maize across the ten regions of Ghana is presented in Table 2.8 below. Generally, Table 2.8 shows some variations in the growth rate of maize over the periods 1996–2015. We find that on average maize growth rates in Upper East Region have been high compared with the rest of the regions. Upper East Region recorded the highest average growth of 166.26 per cent in 2000–2001 and 280.94 per cent growth rate in 2008–2009. However, the region recorded its highest negative growth of 45.49 per cent in 1996–1997, and currently (2012–2013 and 2014–2015) recording a negative growth of 5.30 per cent and 7.22 per cent respectively.

Cumulatively, the trend in Northern and Upper West from 1996–2015 on average shows a steadily increasing growth rate in maize production despite the variations. Northern Region recorded its highest average growth rate of 60.78 per cent in 2008–2009 and highest negative average growth rate of 35.15 per cent in 2000–2001. Similarly, within the same agro-ecological zone with one rainfall season in a year, Upper West Region also recorded its highest average growth rate of 48.85 per cent in 2012–2013 and highest negative growth rate of 20.18 per cent in 1996–1997. In all, both regions also recorded a negative average growth rate in 2014–2015. These results could be explained by the unfavourable climatic conditions in terms of low rainfall and low soil fertility in the regions.

The growth trends in the other seven (7) regions show that Greater Accra recorded a high negative growth rate of 70.23 per cent in 1998–1999 and 51.04 in 2002–2003. Brong Ahafo and Central Regions recorded high average growth rates of 68.90 per cent and 89.73 per cent respectively in 2002–2003 while Central and Eastern Regions recorded very similar average growth rates of 33.05 per cent and 33.67 per cent respectively in 2008–2009. Volta Region recorded a 72.92 per cent average growth rate in 2008–2009. The data also shows that except for Ashanti and Volta Regions that recorded positive average growth rates in 2014–2015, the remaining five regions recorded a negative average growth rate. Meanwhile, cumulatively from 1996–2015, the trend shows a slight reduction in the average growth rates for Ashanti, Brong Ahafo, Central and Western, while the average growth rates for Eastern are more constant. Greater Accra and Volta Regions show relatively increasing average growth rates in maize production. Table 2.8 again shows that 44 per cent of the data points provided recorded a negative average growth rate while only 2008–2009 recorded a positive average growth rate in all the regions. It indicates though there is national production growth in maize from 1996–2015, where growth is more likely to be slow.

A regional decomposition of maize productivity (output per farm size) is presented in Table 2.9. From Table 2.9, the highest productivity was recorded at 2.47 metric tonnes per hectare in 2014–2015 from the Eastern Region, while Greater Accra recorded the lowest productivity rate of 0.68 metric tonnes per hectare in 2004–2005. This implies that from 1996–2015 the highest average productivity rate attained is far below the potential maize productivity rate of 5.50 metric tonnes per hectare, a clear indication of a significant gap.

Table 2.9 shows that the maize productivity rate in all regions ranges mainly between one and two metric tonnes per hectare. However, figures for 2010–2011, 2012–2013 and 2014–2015 reveal that Eastern Region recorded an average productivity of above two metric tonnes per hectare, while that of Brong Ahafo also recorded 2.05 and 2.10 productivity rates in 1996–1997 and 2012–2013 respectively. Similarly, Central Region also recorded 2.41 in 2002–2003 and 2.01 metric tonnes per hectare in 2008–2009. Greater Accra, Northern and Upper East were the regions that recorded average productivity rates of less than one metric ton per hectare at various periods.

The trend in annual average maize (and generally agricultural productivity) growth rate and its corresponding farm productivity level across the regions as shown in Tables 2.7 and 2.8 can best be explained on the premises of agro-ecological factors (the environment and climatic conditions), the farming system, the knowledge and farm management practices the farmer adopts as well as the market orientation of the farmer in the regions. It is equally important to state that Ghana has different agro-ecological zones spread across the different regions. These differences in zones affect farming practices, rainfall patterns, crop type production and general agricultural productivity and also contributes further to the differences across regions.

Table 2.8: Regional Distribution of Annual Average Maize Growth Rate (%) in Ghana, 1996–2015

YEARS	1996 - 1997	1998 - 1999	2000 - 2001	2002 - 2003	2004 - 2005	2006 - 2007	2008 - 2009	2010 - 2011	2012 - 2013	2014 - 2015
Ashanti	19.08	10.56	-4.02	28.05	-25.58	-3.26	10.81	15.54	-4.66	3.89
Brong Ahafo	27.67	6.16	3.24	68.90	13.26	16.50	13.95	11.30	9.70	-18.01
Central	6.59	2.17	24.51	89.73	-27.48	5.88	33.05	-12.86	-9.44	-2.14
Eastern	12.37	9.65	-20.97	30.18	-22.30	-2.46	33.67	27.47	8.15	-0.40
Greater Accra	41.75	-70.23	-1.87	-51.04	-22.69	1.93	23.73	32.44	14.27	-10.31
Northern	-21.65	-1.37	-35.15	16.77	-1.34	8.71	60.78	31.92	-3.86	-10.04
Upper East	-45.49	52.57	166.26	23.91	-24.80	-19.48	280.94	53.84	-5.30	-7.22
Upper West	-20.18	3.58	20.78	14.71	-12.21	-18.47	42.68	34.13	48.85	-13.48
Volta	10.27	-7.44	-12.64	-3.16	-17.17	-3.14	72.92	12.84	-11.77	15.70
Western	21.98	-8.00	12.66	15.65	-8.75	-5.71	5.36	-7.09	13.60	-9.92

Source: Ministry of Food and Agriculture (MoFA) – Statistical, Research and Information Directorate (SRID) & Ghana Statistical Service (GSS) (2011).

Table 2.9: Regional Distribution of Annual Average Maize Productivity Rate (Metric Tonnes Per Hectare) in Ghana, 1994–2015

YEARS	1994 - 1995	1996 – 1997	1998 - 1999	2000 - 2001	2002 - 2003	2004 - 2005	2006 - 2007	2008 - 2009	2010 - 2011	2012 - 2013	2014 - 2015
Ashanti	1.47	1.70	1.66	1.54	1.60	1.42	1.20	1.27	1.39	1.31	1.48
Brong Ahafo	1.66	2.05	1.89	1.72	1.67	1.84	1.91	1.88	1.94	2.10	1.85
Central	1.20	1.19	1.13	1.31	2.41	1.77	1.69	2.01	1.92	1.71	1.89
Eastern	1.91	1.83	1.80	1.50	1.64	1.68	1.62	1.88	2.14	2.28	2.47
Greater Accra	0.70	1.33	0.89	0.85	0.74	0.68	0.81	0.90	1.06	1.24	1.10
Northern	1.34	1.09	0.98	0.73	0.71	1.17	1.18	1.68	1.61	1.47	1.63
Upper East	0.98	0.75	0.84	1.53	1.66	1.19	0.74	1.63	1.69	1.43	1.39
Upper West	1.41	1.10	1.22	1.51	1.65	1.45	1.22	1.50	1.36	1.83	1.79
Volta	1.69	1.68	1.70	1.41	1.35	1.38	1.38	1.74	1.81	1.74	1.83
Western	1.34	1.39	1.37	1.41	1.40	1.47	1.43	1.43	1.44	1.55	1.29

Source: Ministry of Food and Agriculture (MoFA) – Statistical, Research and Information Dept (SRID) & Ghana Statistical Service (GSS) (2011).

Next, we present a decomposition of the average growth rate in production of cassava from 1996–2015 as shown in Table 2.10 below. No data is available for Upper East and Upper West regions, which could be due to the fact that cassava is not part of the crops that are mainly produced.

Looking at the trend in the growth of cassava production by the regions, we find that overall, Northern Region has relatively outperformed in the production of cassava compared to the remaining regions. The region recorded its highest average growth rate of 87.07 per cent in 2008–2009, 79.52 per cent in 2000–2001 and 74.18 per cent in 2002–2003. However, 2006–2007 showed a negative average growth rate of 11.84 per cent. Similarly, Central Region recorded the highest average growth rate of 95.25 per cent in 2000–2001. However, the trend from 1996–2015 shows a decline in the growth rate for Central Region. Greater Accra also recorded the highest average growth rate in 1996–1997 period of 49.46 per cent while the highest negative growth rate was also recorded in 1998–1999 of 57.08 per cent. However, the trend over the period 1996–2015 shows slow growth. Similarly, the general growth rate for Eastern and Ashanti Regions from 1996–2015 was slow. The highest average growth rates for these two regions were recorded in 2010–2011. The trend analysis for both Brong Ahafo and Western Regions shows a relatively constant growth rate from 1996–2015. However, Brong Ahafo Region recorded high average growth rates of 43.54 per cent and 31.46 per cent in 2000–2001 and 2002–2003 respectively while 1998–1999 and 2006–2007 periods recorded a negative growth rate. Volta Region recorded the highest number (4) of negative growth rates as compared to the remaining regions.

Analysis of regional decomposition of cassava productivity (output per farm size) is presented in Table 2.11, which shows that the level of productivity for all the regions ranges between five to 20 metric tonnes per hectare. However, there are few outliers, where Greater Accra Region recorded 4.15 metric tonnes per hectare in 1994–1995 while Eastern Region also recorded an average productivity of 20.11, 22.75 and 23.69 in 2010–2011, 2012–2013 and 2014–2015 respectively. Meanwhile, the figures show that the average productivity of cassava is far lower than the potential yield of 45 metric tonnes per hectare. Table 2.11 shows that Ashanti and Eastern Regions recorded the highest average productivity levels while Brong Ahafo, Central, Greater Accra and Northern Regions recorded progressively increasing productivity levels but with few fluctuations. The average productivity level for Western Region was relatively more constant over time while the average productivity level for Volta decreased from the 2000–2001 period to the 2006–2007 period but subsequently recorded an increase in average productivity from 2008–2009 period.

Table 2.10: Regional Distribution of Annual Average Cassava Growth Rate (%) in Ghana, 1996–2015

YEARS	1996 - 1997	1998 - 1999	2000 - 2001	2002 - 2003	2004 - 2005	2006 - 2007	2008 - 2009	2010 - 2011	2012 - 2013	2014 - 2015
Ashanti	13.04	6.99	-1.06	3.96	-10.58	-2.48	7.59	52.13	25.55	14.32
Brong Ahafo	15.92	-13.94	43.54	31.46	3.74	-0.38	4.93	10.11	17.35	15.54
Central	13.65	12.57	95.25	10.20	-9.34	11.31	27.37	-3.40	-9.00	10.63
Eastern	2.28	12.02	-11.78	14.86	6.01	12.48	14.62	24.78	13.78	6.46
Greater Accra	49.46	-57.08	5.54	-26.03	0.11	0.39	32.71	6.21	24.98	22.46
Northern	6.99	15.64	79.52	74.18	-8.07	-11.84	87.07	56.28	16.00	-0.70
Volta	20.09	17.33	-4.64	8.97	-14.77	-1.49	44.05	9.37	-19.14	7.80
Western	11.25	12.27	9.44	15.08	-5.62	-8.85	1.21	-0.37	18.84	20.62

Source: Ministry of Food and Agriculture (MoFA) – Statistical, Research and Information Directorate (SRID) & Ghana Statistical Service (GSS) (2011).

Table 2.11: Regional Distribution of Annual Average Cassava Productivity Rate (Metric Tonnes Per Hectare) in Ghana, 1994–2015

YEARS	1994 - 1995	1996 - 1997	1998 - 1999	2000 - 2001	2002 - 2003	2004 - 2005	2006 - 2007	2008 - 2009	2010 - 2011	2012 - 2013	2014 - 2015
Ashanti	9.95	10.65	10.81	9.96	10.43	10.18	9.84	10.50	15.48	18.65	20.19
Brong Ahafo	16.60	15.50	11.43	13.79	14.52	14.78	14.23	14.27	15.33	17.76	19.77
Central	10.46	11.00	11.38	17.92	14.51	13.57	14.16	15.83	16.04	15.57	16.22
Eastern	12.21	11.77	12.24	11.57	12.00	13.53	14.58	16.37	20.11	22.75	23.69
Greater Accra	4.15	7.78	5.99	6.05	6.44	6.80	7.71	10.16	10.32	13.33	15.70
Northern	7.34	6.81	6.64	7.01	8.44	8.77	7.59	10.46	14.13	15.88	16.32
Volta	16.87	17.48	17.68	16.19	15.15	12.97	11.84	14.21	15.36	15.31	16.22
Western	9.16	9.36	9.46	9.69	10.66	10.68	9.68	9.45	9.29	10.25	11.41

Source: Ministry of Food and Agriculture (MoFA) – Statistical, Research and Information Directorate (SRID) & Ghana Statistical Service (GSS) (2011).

Yam is also one of the highly produced crops for both food and cash crop. Analysis of the average growth rate for the production of yam in Ghana across the regions is presented in Table 2.12 below. However, data for Greater Accra and Upper East is not captured and this could be due to very low levels of yam production in those regions. Table 2.12 shows that in general, Brong Ahafo Region recorded the highest average growth rate of 99.69 per cent in 1998–1999 while Central Region recorded the highest negative average growth rate of 23.72 per cent in 2004–2005.

A decomposition analysis of Table 2.12 indicates that both Northern and Western Regions showed a progressively increasing average growth rate from 1996–2015, despite the high level of fluctuations. For instance, the Northern Region recorded its highest average growth rate of 43.88 per cent in 2010–2011, while it recorded a negative growth rate of one per cent in 1996–1997. On the other hand, Upper West recorded its highest growth rate of 49.32 per cent in 2000–2001 and a negative growth rate of 11 per cent in 1996–1997. The trend for Volta Region shows that the region recorded the highest growth rate in 2008–2009 and 1996–1997 respectively while the least growth rates were recorded in 1998–1999 and 2004–2005. On average Ashanti, Brong Ahafo and Central Regions show a decline or decreasing average growth rates from 1996–2015. The growth rate for Western Region shows a more constant growth despite the few (3) negative growth rates recorded over the period.

The results for the output per hectare as shown in Table 2.13 are mixed. The result shows that the average productivity level for yam ranges between five and 20 metric tonnes per hectare. Meanwhile Eastern Region recorded the highest average yam productivity rate of 20.64 metric tonnes per hectare in 2014–2015 while the lowest was recorded at 4.71 metric tonnes per hectare in 1998–1999 in Central Region. Once again, the data shows there is a significant gap between the actual yield obtained and the potential yield of 52 metric tonnes per hectare expected. A further analysis based on regional productivity shows that Eastern and Brong Ahafo Regions recorded the highest productivity levels and the trend from 1994–2015 shows progressively increasing productivity levels. Ashanti, Northern, Upper West and Volta regions on average have shown increasing productivity rates, while the average productivity level for Western Region from 1994–2015 also shows a relatively increasing productivity but at slow pace. Central Region, on the other hand, has shown a low productivity rate, but on average the productivity levels have been constant from 1994–2015.

Table 2.12: Regional Distribution of Annual Average Yam Growth Rate (%) in Ghana, 1996–2015

YEARS	1996 - 1997	1998 - 1999	2000 - 2001	2002 - 2003	2004 - 2005	2006 - 2007	2008 - 2009	2010 - 2011	2012 - 2013	2014 - 2015
Ashanti	31.12	6.05	10.10	-0.56	24.83	31.09	11.71	13.49	4.53	8.05
Brong Ahafo	50.92	99.69	4.03	19.86	-3.04	7.13	19.77	3.54	4.03	3.68
Central	5.00	-2.50	12.45	5.37	-23.72	-23.59	23.34	-7.57	-1.59	-4.09
Eastern	19.63	26.90	-12.30	10.45	-9.36	6.08	14.55	-3.66	5.53	13.44
Northern	-1.00	8.87	32.56	26.36	0.67	21.07	37.98	43.88	27.61	-0.85
Upper West	-11.00	5.19	49.32	7.59	-2.75	-1.65	23.57	36.10	9.82	15.62
Volta	38.64	-8.04	-3.74	3.01	-6.80	13.98	42.27	12.38	14.30	10.70
Western	20.12	22.28	7.27	10.57	-1.61	6.38	-3.28	-18.57	22.01	3.13

Source: Ministry of Food and Agriculture (MoFA) – Statistical, Research and Information Directorate (SRID) & Ghana Statistical Service (GSS) (2011).

Table 2.13: Regional Distribution of Annual Average Yam Productivity Rate (Metric Tonnes Per Hectare) in Ghana, 1994–2015

YEARS	1994 - 1995	1996 - 1997	1998 - 1999	2000 - 2001	2002 - 2003	2004 - 2005	2006 - 2007	2008 - 2009	2010 - 2011	2012 - 2013	2014 - 2015
Ashanti	10.91	12.59	12.20	12.79	12.69	12.12	11.81	12.91	13.90	14.66	15.45
Brong Ahafo	11.01	14.24	18.45	14.96	15.22	15.03	15.70	17.64	17.63	17.23	17.22
Central	5.75	5.40	4.71	5.01	5.05	5.11	5.48	5.82	5.61	5.49	5.41
Eastern	18.37	18.39	19.24	16.82	17.21	16.17	15.99	18.29	17.81	18.36	20.64
Northern	10.47	10.50	10.44	9.31	9.70	9.44	10.51	11.29	13.58	15.72	16.15
Upper West	10.82	10.31	9.72	11.75	11.37	14.23	13.56	16.39	18.20	17.95	19.17
Volta	11.41	12.47	11.21	10.41	9.91	10.69	11.51	14.05	14.92	15.24	16.46
Western	5.79	6.37	6.45	6.48	7.97	7.67	8.36	7.84	7.40	7.99	7.72

Source: Ministry of Food and Agriculture (MoFA) – Statistical, Research and Information Directorate (SRID) & Ghana Statistical Service (GSS) (2011).

2.7. STATE OF WELFARE IN GHANA: TRENDS AND ANALYSIS

The state of welfare in Ghana has seen a constant decline from 51.7 per cent in 1991/92 to 24.2 per cent in 2012/13 using monetary measurement based on consumption. However, the number of headcounts whose welfare is low stands at 42.7 per cent using the non-monetary measurement of welfare. A further classification of this shows that, 72.3 per cent of the proportion of Ghanaians living in the rural areas have a low welfare as compared to those in the urban areas (27.7 per cent).

Although from the national perspectives there is evidence of decline in welfare trend, an analysis of this trend with focus on the regions shows some disparities as some regions still record a high number of people with low welfare. Table 2.14 shows that Northern, Upper East and Upper West are the regions with the lowest welfare as compared to the remaining regions. This is not different from using the non-monetary measurement of welfare. The Volta, Ashanti and Brong Ahafo regions have shown consistent decline from 1991/92 through to 2012/13. However, Greater Accra is the region with the least number of people with low welfare as shown by both the monetary (consumption) and non-monetary measurements. Western, Central and Eastern have also recorded a huge decline in the number of people with low welfare in 2012/13 as compared to the number in 1991/92.

From the perspective of agro-ecological zones, Table 2.14 shows that people with low welfare are more skewed to those living in the rural savannah zones. However, both rural coastal, rural forest and urban savannah have all recorded a high number of people with low welfare in those zones. This means that people living in savannah zones record a low level of welfare more than those in the other zones. In Ghana, agricultural activities take place mostly in rural areas and in the savannah zones. Since agriculture is the main economic activity in these areas, one can infer that in terms of economic activities the agricultural sector records the highest number of people with low welfare. This means that, people in rural areas and in the savannah zones whose main economic activity is agriculture have low income and low level of education. They also lack access to basic facilities such as proper sanitation, potable water, health care and electricity facilities.

Table 2.14: Monetary and Non-Monetary Welfare Trends in Ghana – National, Regional & Ecological

	MONETARY CONSUMPTION				NON-MONETARY POVERTY 2010 (Population Census Data)	
	1991/92	**1998/99**	**2005/06**	**2012/13**	**Percentage of Household**	**Headcount ratio**
NATIONAL	51.7	39.5	28.5	24.2	31.8	42.7
Urban	27.7	19.4	10.7	10.6		27.7
Rural	63.6	49.5	39.3	37.9		72.3
REGIONAL						
Western	59.6	27.3	18.4	20.9	32.2	40.5
Central	44.3	48.4	19.9	18.8	31.0	39.1
Greater Accra	25.8	5.2	11.8	5.6	12.9	18.5
Volta	57	37.7	31.4	21.7	35.9	44.3
Eastern	48	43.7	15.1	33.8	27.7	35.6
Ashanti	41.2	27.7	20.3	14.7	23.1	30.8
Brong Ahafo	65	35.8	29.5	27.9	41.2	51.7
Northern	63.4	69.2	52.3	50.4	74.6	80.9
Upper East	66.9	88.2	70.4	70.7	75.0	80.8
Upper West	88.4	83.9	87.9	44.4	70.2	77.6
ECOLOGICAL ZONES						
Accra (GAMA)	23.1	3.8	10.6	3.5		
Urban Coastal	28.3	24.2	5.5	10.1		
Urban Forest	25.8	18.2	7	9.9		
Urban Savannah	37.8	43	36.9	26.4		
Rural Coastal	52.5	45.2	23.9	30.3		
Rural Forest	61.6	38	27.9	27.9		
Rural Savannah	73	70	60.3	55		

Source: Ghana Statistical Service (GSS), Ghana Living Standard Surveys (GLSS, rounds 3–6) & Population Census (2010).

2.8. CONCLUSION

This chapter highlighted the facts and figures on agricultural growth and productivity as well as welfare trends in Ghana. The evidence clearly shows that the low nutrients of the soil, the unpredictable rainfall or weather conditions, and the low application of fertilizer and pesticides are significant physical and biological factors that impact on increasing agricultural growth and productivity. The facts have also shown that, despite the introduction and implementation of policies, programs and projects aimed at improving agricultural productivity, Ghana has not yet been able to achieve and sustain its target annual agricultural growth rate of six per cent. Similarly, there is a wide gap between the levels of productivity attained and the expected levels of productivity or yield.

In addition, evidence shows that though the welfare trend at the national level is declining indicating improvement in the level of welfare of majority of Ghanaians, the welfare trend in the Northern, Upper East and Upper West regions remain alarming. These regions are known to be part of the savannah zones where the main economic activities of the people are in agriculture. However, the evidence shows not much effort has been made to improve the welfare of farm households in these areas and Ghana at large.

These challenges facing Ghana's agricultural development are testament to the urgent need to develop and adopt more pragmatic and innovative agricultural enhancing strategies for the growth and transformation of the sector. Access to finance and market participation are critical exogenous factors that hamper agricultural growth and thus development of such policies to integrate access to finance and market participation of smallholder farmers into the existing farming system are expected to increase productivity and improve welfare.

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CHAPTER 3

THE IMPACT OF FINANCE ON PRODUCTIVITY OF SMALLHOLDER AGRICULTURAL FARMERS[7]

3.1. INTRODUCTION

Access to finance remains a critical hurdle for smallholder farmers in most developing economies including smallholder farmers in Africa (Mukonyora & Bugo, 2013). Economic theory states that access to finance plays a significant role in the quest to transform the agricultural sector from traditional or subsistence farming to mechanised and commercial farming (Mellor, Streeten & Khan, 1995; Barry & Robison, 2001; Ahmad, 2011). According to Von Pischke (1978), finance is necessary to improve farming methods through the adoption of modern technologies and improved agricultural inputs to raise productivity. Petrick (2004) and Foltz (2004) argue that a smallholder farm household that is finance constrained is limited in terms of the choice to increase investment, thereby reducing the capital (finance) output ratio. This implies that access to finance plays a significant role in farm households' productive investment decisions.

Notwithstanding the significant role of access to finance, the allocation or extension of finance to smallholder farmers by financial institutions has been perceived as challenging. This is because agricultural production is considered as a high-risk investment by financial institutions due to the constraints associated with agricultural production in terms of seasonality, irregular cash flows and diseases (Maurer, 2014; Rahman & Smolak, 2014; IFC, 2014). Indeed, lending to the agricultural sector in Africa is estimated at approximately one per cent of financial institutions' total lending (IFC, 2014). It is observed that limited access to finance is mainly caused by imperfect financial markets, which is due to information asymmetry leading to credit rationing (Stiglitz & Weiss, 1981). In the light of the risks associated with agricultural financing, Karlan, Osei, Osei-Akoto & Udry (2013) are of the view that shifting the production frontier or outputs of a smallholder farmer does not primarily depend on access to finance but rather on insurance and, for that matter, on risks.

Empirical assessments of the effect of access to finance on productivity in past studies have shown mixed results. Some of these studies have shown that access to finance has a positive and statistically significant impact on productivity (Iqbal, Ahmad & Abbas, 2003; Ayaz & Hussain, 2011; Akwaa-Sekyi, 2013;

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Wicaksono, 2014; Gomina, Ali & Johana, 2015). A similar study by Martey, Wiredu and Etwire (2015) also documents a positive impact of finance on efficiency. On the other hand, studies by Zuberi (1989) and Hussain (2012) documented no effect of access to finance on agricultural productivity in Pakistan. A number of gaps are worth mentioning in the literature: there is almost no focus on production credit, which is crucial for smallholder farmers. Furthermore, most studies do not distinguish between the impact of credit on resource (human, technical and financial) constrained and non-resource constrained farmers. In addition, most of these studies fail to control for endogeneity and issues of selection bias. There is also a paucity of literature on Sub-Saharan Africa.

We examined the impact of credit on smallholder farmers in the Northern Region of Ghana under the DANIDA AVCF project implemented from 2011–2015. Our paper therefore differs from other studies in four distinct ways. First, unlike Martey et al. (2015), we focus on production credit, which is crucial for smallholder farmers. Production credit, which is generally short to medium-term working capital, is important in allocative efficiency and consequently productivity. This is particularly so for smallholder farmers who are already heavily constrained in terms of human, technical and financial capital. Second, unlike the studies of Martey et al. (2015), our paper uses direct productivity-yield (which incorporates efficient land use) instead of technical efficiency which excludes land use. Third, in testing for the productivity impact of finance, we define two types of smallholder farmers – the constrained (smallholder farmers with little intervention, knowledge or resource in production), and the relatively unconstrained (farmers who have benefitted from interventions aimed at augmenting productivity). Finally, we control for the problem of endogeneity and selection bias to ensure that the results of the estimations meet the test of both internal and external validity.

Ghana poses an interesting case worth examining, mainly because of the numerous agricultural policies and strategies that the country has implemented over the past decades. These are geared towards inducing financial interventions to modernise and bring about structural changes in Ghana's agricultural sector (MoFA, 2003). Some of these policies and programs are the MTADP, Food and FASDEP, and the Rural and Agricultural Finance Programme (RAFiP). Although finance to the agricultural sector has been increasing, albeit slowly, productivity in the agricultural sector remains low in Ghana (MoFA, 2011). According to the World Bank (2012), only eight per cent of rural households in Ghana have access to finance for agricultural activities. The limited access to finance therefore poses a continuous threat to smallholder farmers in Ghana, leading to low agricultural productivity (Ayeh, 2011; Kuwornu, Ohene-Ntow & Asuming-Brempong, 2012). Despite the numerous policies that have been implemented within the agricultural and financial sectors in Ghana, there is little evidence of the impact of these policies mainly due to a lack of data. This gap in the literature offers us the opportunity to use DANIDA's Agricultural Value Chain Facility (AVCF) project to evaluate the impact of access to finance on smallholder farm productivity in the Northern Region of Ghana.

The rest of the paper is organised into the following sections: Section 2 presents Ghana's agricultural production and finance outlook, while Section 3 discusses the theoretical and empirical literature reviews. An overview of the AVCF project and data is offered in Section 4. Section 5 details the econometric framework for estimation of results and discussion of empirical results, with a conclusion in Section 6.

3.2. AGRICULTURAL FINANCE AND PRODUCTION OUTLOOK IN GHANA

Ghana's financial sector has witnessed several policy reforms, more especially since the 1980s (World Bank, 2012). During the period of the ERP and SAP, from 1983 to 1991, the financial sector reforms were an integral part of the economic diversification, stabilisation and growth agenda of the Government of Ghana (Antwi-Asare & Addison, 2000). During the period of ERP, the ASRP was introduced with the objective of supporting or contributing towards the economic stabilisation and liberalisation policies of Ghana. The ASRP focused on agriculture-led economic growth with policies that, among others, focused on agricultural support services (AfDB, 2002).

The introduction and implementation of the Financial Sector Reform Program (FINSAP) from 1988 to 2000 and, subsequently, the Financial Sector Strategic Plan (FINSSIP) from 2001–2008 largely contributed to the restructuring of Ghana's financial landscape, leading to improvement in financial legislation and supervisory systems and the emergence of new financial institutions (Sowa, 2002; Owusu-Antwi, 2009). In support of these financial sector reforms, the Rural Financial Project (RFP) was introduced and implemented from 1989 to 1994 with the objective of building the capacity of Rural and Community Banks (RCBs). By this, attention was directly devoted to restructuring RCBs and strengthening their operational services towards delivery of financial services with a focus on agricultural finance (Nair & Fissha, 2010).

Similarly, focusing on agriculture as the engine of growth, the Government of Ghana developed medium Term Agricultural Development Programme (MTADP) in 1989, which involved broad-based agricultural policies that include investment in agricultural extension, infrastructure development and the provision of financial services (Asante & Awo, 2017). To help implement these policies, the Agricultural Sector Adjustment Program (AgSAP) was developed and supported by the Agricultural Sector

Adjustment Credit (AgSAC) from 1992 (World Bank, 1997). In line with the objective of enhancing agricultural production and productivity, the Accelerated Agricultural Growth and Development Strategy (AAGDS) was also developed in 1996. The objectives of AAGDS include promoting access to agricultural financial services. To help achieve the objectives of AAGDS, the Agricultural Services Sub-Sector Investment Program (AgSSIP) was established in 2001 and supported by the introduction of the Rural Financial Services Project (RFSP) in 2002 (Asante & Awo, 2017).

While the Government of Ghana remains committed to promoting economic growth and development, agricultural sector policies are expected to contribute towards achieving these goals. In this regard, by building on the thematic areas of AAGDS, the FASDEP I and II were formulated and implemented from 2002–2007 and 2007–2015 respectively to focus on modernisation and transformation of the agricultural sector. Key for this development agenda is improving financial services delivery for agricultural production including strengthening of rural financial institutions towards extending finance to farmers (MoFA, 2002 and 2007). At the heart of the implementation of Food and Agricultural Sector Development Policy (FASDEP) II was the focus on a value-chain approach towards agricultural development and, more specifically, improving productivity (Ministry of Food and Agriculture, 2007). The Rural and Agricultural Finance Programme (RAFiP) is one of the programs that sought to improve access to financial services among smallholder farmers in Ghana (IFAD, 2013).

To complement the implementation of FASDEP II, the Medium-Term Agriculture Sector Investment Plan (METASIP) was developed to support the medium-term investments of the Government of Ghana’s agricultural sector modernisation programs from 2011–2015. METASIP is also linked with the Economic Community of West African States (ECOWAS) Agricultural Policy (ECOWAP) and the Comprehensive African Agricultural Development (CAADP) that targets a six per cent agricultural growth rate per annum for African countries (MoFA, 2010).

The implementation of the financial sector policies as well as the agricultural sector policies and programs have yielded some results. Table 3.1 below presents allocation of finance (credit) to the agricultural sector by the Deposit Money Banks (DMBs) and corresponding agricultural sector growth.

Table 3.1 shows that credit allocation to the agricultural sector by the Deposit Money Banks has not been stable but instead has been declining consistently. The average credit allocation to the agricultural sector since the introduction of the FINSSIP, that is, from 2001 to 2015, stands at 6.05 per cent. On the other hand, agricultural growth rate is low as it is below the expected annual growth rate of six per cent except for 2003, 2004, 2008 and 2009 growth rates. The average agricultural growth rate from 2001 to 2015, that is, the periods for the implementation of FASDEP I & II, stands at 4.38 per cent. It is therefore clear that though some achievements have been made because of financial sector policy reforms and policies geared towards growth and modernisation of the agricultural sector, the outcome for the agricultural sector explicitly shows that agricultural financing and production need to improve.

Table 3.1: Allocation of Credit by Deposit Money Banks (DMBs) to Agricultural Sector and the Agriculture Growth Rates, 1993–2017 (%)

Year	Deposit Money Banks' Credit to Agricultural Sector (%)	Agriculture Growth Rates (%)
1993	8.60	2.84
1994	8.50	1.87
1995	9.70	3.74
1996	10.80	5.22
1997	12.00	4.30
1998	12.20	5.11
1999	11.80	3.88
2000	9.60	2.12
2001	9.60	4.02
2002	9.40	4.36
2003	9.40	6.07
2004	7.70	6.97
2005	6.70	4.14
2006	5.40	5.74
2007	4.90	-1.72
2008	4.30	7.40
2009	4.74	7.23
2010	6.13	5.28
2011	5.74	0.85
2012	5.11	2.30
2013	4.09	5.68
2014	3.64	4.65
2015	3.84	2.78
2016	3.20	3.00
2017	3.57	8.40

Source: Bank of Ghana and Ghana Statistical Service / Ministry of Food and Agriculture – Statistical, Research and Information Department (2017).

Beyond the DMB's lending to the agricultural sector, which is woefully inadequate, a number of financial institutions (Non-Bank Financial Institutions, Rural and Community Banks and Microfinance

Institutions) provide financial services to farmers. In addition to that, Seini (2002) and Quartey, Udry, Al-Hassan and Seshie (2012) point to the informal financial sector as the main source of finance for agricultural activities in Ghana. Steel and Andah (2008) as well as Diaz-Serrano and Sackey (2015) described the actors providing financial services within the informal financial sector as *Susu* collectors, rotating savings and credit associations (ROSCA), money-lenders, trade creditors and friends and relatives who provide personal loans.

3.3. THEORETICAL FRAMEWORK

Access to finance plays a significant role in increasing productivity through investments in production activities. David and Meyer (1980) described the effect of access to finance as the "additionality" that occurs because of the use of farm inputs with the corresponding effects on farm outputs. In his study, Carter (1989) identified three channels through which access to finance has a positive correlation with the production function of a smallholder farmer. First, access to finance offers the smallholder farmer the opportunity to be allocatively efficient. That is to say, when a smallholder farmer receives finance, the farmer is able to invest in farm inputs at a minimum cost of production but with the expectation of maximising the quantity of outputs. For instance, the outputs per farm size are expected to increase through the purchase of farm inputs such as fertilizer, leading to a marginal increase in productivity when a smallholder farmer is not financially constrained.

The second channel through which access to finance impacts on farm productivity, as stated by Carter (1989), is through investment in high-end tools and equipment, including farm inputs such as high-yield seeds and other high-value farm inputs needed for farm production. This contributes to shifting both the farm's inputs and outputs and ultimately impacts on increasing productivity. That is, through access to finance, the smallholder farmer becomes technically efficient as a result of technical changes in his production capacity, which positively impacts on productivity. Carter's (1989) third pathway states that access to finance offers the opportunity to intensify the use of fixed inputs of land as well as investments in labour and technical skills of farmers. Access to finance therefore serves as a catalyst to resource use in terms of financing fixed cost of maintenance to undertake farm activities for optimum and improved productivity.

Feder, Lau, Lin and Luo (1989) also identified binding finance constraint as another channel through which finance impacts on productivity. The binding finance constraint theory simply holds that an individual or agent who is financially constrained is expected to experience lower productivity. It therefore shows a positive relationship between binding finance constraint and productivity. The impetus is that less investment is made into production engagements because of limited access to finance leading to lower performance in outputs per input. Similarly, Carter and Wiebe (1990) argue that access to finance is the means of financing the cost of production that brings about structural changes from a traditional to a modernised sector. They theorised that through the ex-ante access to finance channels, productivity is expected to increase. By ex-ante access to finance, Carter and Wiebe (1990) refer to the financing of an individual or agent's production needs prior to the take-off stage of the main production activity. For instance, it is about increasing the investment in farm inputs such as fertiliser, labour, high yield seeds and other farm services that are expected to contribute towards increasing agricultural productivity. Foltz (2004) adds that when smallholder farmers are credit constrained, the choices they make towards the purchase of variable inputs and farm investments are influenced in both short and long runs.

Using a production function in the form of Cobb-Douglas to explain low agricultural productivity, Udry (2010) identified finance constraint as one main contributing factor. In other words, access to finance is part of the fabric of increasing productivity. According to Udry (2010), using labour, farm inputs and land as factors of agricultural production yielded low productivity. In respect of this, the production function was extended to include human capital measured by the skills or level of education of the farmer. The inclusion of this variable is on the assumption that a farmer's low level of skills or competencies has an adverse effect on the intensive use and application of farm inputs, thereby lowering agricultural productivity. This continues to show an agricultural yield gap using the extended production function. In the quest for increasing agricultural productivity, Udry (2010) identified the financial constraint of a farmer as a bottleneck to increasing productivity and limiting the expected optimum yield per farm size. Thus, to stimulate agricultural growth and productivity, access to finance is required for purposes of investments in farm inputs.

3.4. EMPIRICAL LITERATURE REVIEW

Ali, Deininger and Duponchel (2014) argued that there are significant disparities in the agricultural productivity of smallholder farmers who are financially constrained compared to those with access to finance. We, therefore, present an overview of two strands of the empirical literature. First, we present empirical studies that have shown positive correlation between finance and productivity and whose results were found to be statistically significant; second, we present studies in which the results have been shown to be statistically insignificant or not different from zero.

Positive - Statistically Significant

Amongst the studies that showed a positive and significant impact of credit on agricultural productivity, Feder et al. (1990), using data collected in 1987 from 200 farm households surveyed in Gongzhuling County in the north-eastern part of China, applied the endogenous switching regression model and revealed that for every one per cent change in additional access to finance, agricultural output increased by 0.04 per cent. Similarly, using the maximum likelihood estimates of the endogenous switching regression model to evaluate the impact of access to finance on productivity, Dong, Liu and Featherstone (2010) showed that smallholder farmers with access to finance in Xinglonggang County in Northeast China increased their productivity by 31.6 per cent. A similar study in China using cross-sectional data of 152 households that were surveyed in 2009 was conducted by Li, Wang, Segarra and Nan (2013). Using three-stage least squares (3SLS), they found that the impact of access to finance on agricultural productivity was 6.2 per cent.

Binswanger and Khandker (1992) assessed the impact of access to finance on the productivity of farm households using the two-stage least squares (2SLS) estimation technique. The findings revealed that access to finance increased farm household productivity by 6.3 per cent. The data for the study were drawn from 765 observations collected from 85 districts from 1972/73 to 1980/81 in India. Likewise, Martey et al. (2015) evaluated the impact of access to finance on the technical efficiency of farm households in Ghana and provided evidence that access to finance has a positive and significant impact on technical efficiency by 8.2 per cent. The study was carried out using field survey data collected on 223 farm households in northern Ghana.

In a similar study by Bashir, Mehmood and Hassan (2010), evidence indicates that for a percentage increase in access to finance, wheat productivity increased by 2.45 per cent. The study was carried out in Pakistan using data from United Bank Limited (UBL). Estimation was carried out using cobb-douglas production function. An empirical study carried out by Chisasa and Makina (2013) in South Africa, using data from the Department of Agriculture, Fisheries and Forestry (DAFF) of South Africa as well as the South African Weather Service (SAWS), established that a one per cent increase in access to finance causes agricultural production to increase by 0.6 per cent. The result of the impact of finance on agricultural productivity was estimated using the cobb-douglas production function.

Positive - Statistically Insignificant

Hazarika and Alwang (2003), who estimated the impact of finance on the productivity of smallholder farmers in Malawi, revealed that the result was not statistically significant. Data for the analysis, which were drawn from the 1995 Malawi Financial Markets and Household Food Security Survey, were estimated using the maximum weighted likelihood estimator. Similarly, Reyes, Lensink, Kuyvenhoven & Moll (2012), who evaluated the impact of access to finance on farm productivity in Chile, found the result to be statistically insignificant. The data, which were analysed and estimated using a switching regression model, were gathered from a survey conducted in 2006 and 2008 on 200 farmers.

Clearly, the above empirical studies on the impact of finance on the productivity of farmers have shown conflicting results. The studies in China (Feder et al,1990; Dong et al, 2010; Li et al, 2013) have shown that access to finance has a significant impact on the productivity of farmers. Except for Li et al. (2013) that used remittance as a measure of finance and calculated productivity using output per labor, Feder et al. (1990) and Dong et al. (2010) used credit, which is finance from formal financial institutions, and measured productivity per farm household in monetary values (net revenue) using total factor productivity. In their study, a farmer who is financially constrained is considered a farmer who applied for a loan but received an amount less than the amount applied for or a farmer who needed finance but could not borrow.

For studies by Bashir et al. (2010) in Pakistan and Chisasa and Makina (2013) in South Africa, the source of credit is bank credit. Meanwhile, although the outcome of the impact of finance and agricultural productivity showed positive and statistically significant effect, these studies failed to control for selection bias and the problem of endogeneity since the allocation of credit could be allocated selectively to farmers with more resources or have shown higher productivity. In the light of this, the issue of endogeneity could also arise due to unobserved heterogeneity.

The outcome of studies by Hazarika and Alwang (2003) in Malawi and Reyes et al (2012) in Chile, showed that the impact of finance on the productivity of farmers is positive but statistically insignificant effect. In the study by Hazarika and Alwang (2003), access to finance is defined by the size of a farmer's credit limit or the maximum amount a farmer can borrow the credit and savings program while productivity, which is captured in monetary values, is measured by output per farm size. However, similar to Feder et al. (1990) and Dong et al. (2010), Reyes et al. (2012) also defined finance constraint as the situation whereby a farmer receives credit facility from a bank with the amount below the expected amount applied for or a farmer's decision not to borrow due to high transaction cost. The weakness of these studies is that, the credit from financial institutions, credit and savings programs and the remittances received by a farmer could also be diverted either fully (for consumption) or partially (for consumption and investment) purposes. This could have an effect on the magnitude of the effects of finance on productivity in these studies.

This study contributes to the empirical literature on the impact of finance on farm level productivity. The contribution to this literature is four-fold. First, it is one of the very few studies that used data from an agricultural value chain structured project for analysis. By this, the farmer is networked or linked with other actors within the value chain comprising the agro-dealer and distributors of farm produce. Within this strand of literature, the closest of the existing work to our knowledge is Martey et al. (2015). Second, this paper differs from existing studies in its focus on production credit, which is a short to medium-term credit facility essential for smallholder farmers to finance their operating expenses such as seeds, fertilizer and chemicals. Production credit was disbursed in the form of input supply from agro-dealers to smallholder farmers. Third, we measured productivity by output per farm size (partial productivity). Lastly, we controlled for selection bias and endogeneity using rigorous estimation techniques.

3.5. OVERVIEW OF PROJECT AND DATA

Data used in this study were drawn from the Agricultural Value Chain Facility (AVCF) project, an initiative of the DANIDA, which was implemented in the Northern Region of Ghana from 2011–2015 under the management of the Alliance for Green Revolution in Africa (AGRA). The objective of the project was to "increase income and employment in rural areas, particularly in breadbasket areas of Northern Ghana, through increased agricultural production, productivity and value addition" (Danida, 2009). The implementation of the AVCF project (production component) was implemented under the auspices of two project names. These projects are the Agricultural Value Chain Mentorship Project (AVCMP), which was implemented by a consortium of three institutions – the International Fertilizer Development Center (IFDC), Savanna Agricultural Research Institute (SARI) and the Ghana Agricultural Associations Business Information Centre (GAABIC). The second project is the Integrated Agricultural Productivity Improvement and Marketing Project (INTAPIMP), which was directly implemented by the Adventist Development and Relief Agency (ADRA). Both projects have the same mandates.

The survey used questionnaires to gather vital information on farmers' demographic characteristics and key socioeconomic variables which, among others, include farmers' level of education, access to financial services, production and household asset ownership. The data for the study were collected based on one-year (2014/15) farming season. Data collection was carried out by thirty-eight personnel who were recruited from the University of Development Studies (UDS) and the Tamale Polytechnic. The data were captured using Computer-Assisted Personal-Interview (CAPI) software over a period of two months from July to August 2015.

Finance for this project was in the form of production credit which is a short to medium term working capital for smallholder farmers to procure farm inputs such as fertilizers, agro-chemicals and certified seeds. Finance (production credit) was sourced from Sinapi Aba Savings and Loans company and the Centre for Agricultural and Rural Development (CARD) a financial non-governmental organization (FNGOs).

This study evaluates the impact of access to finance on the productivity of smallholder farmers. For the data, we applied a combination of convenient, stratified and proportional sampling techniques. The record consisted of 27,856 farmers across the Northern Region of Ghana who participated in the ACVF project. These farmers are into farming of selected staple crops, namely maize, rice, soyabean and groundnut. Following a four-stage approach, the population was classified into different subgroups or strata, then the final subjects were proportionately selected at random from the different population groups or strata. First, we selected seven communities from each of the 22 districts representing the Northern Region of Ghana. The choice of these seven communities was influenced by the number of beneficiary farmers within a community. This brought the total number of communities to 154.

The second stage was to randomly select a sample of 1,700 farmers from the 154 communities for data collection. After data editing and cleaning of outliers and various inconsistencies, we had 1,564 farmers. To achieve the objective for this study, we focused on maize farmers bringing the data to 1,152 farmers. The maize farmers were chosen because finance (production credit) was allocated to only them. At the third stage, we categorised the data into two separate groups, namely maize farmers with access to finance (treatment group) and maize farmers who are financially constrained (control group). The data indicated a total number of 154 farmers with access to finance and 998 farmers who are financially constrained. At the fourth stage, 398 maize farmers were sampled from the 998 farmers who were financially constrained for analysis.

To ensure robustness in the checking of results, the study used a second control group. The second group of farmers are the non-beneficiary group of AVCF. Data for the non-beneficiary group was also collected on farmers in selected communities within the Northern and Brong Ahafo (BA) regions, with a total number of 295 farmers and 200 farmers respectively. The selected areas for this group are within the same agro-ecological zone as the beneficiary group. They share similar agricultural practices as well as community and socioeconomic characteristics. The selection of the areas or communities of these farmers was influenced by the fact that they are remote from communities where Government provides agricultural extension services to farmers and by the fact that non-governmental organizations (NGOs) are not there to provide agricultural services. After data cleaning and editing, the total number of smallholder farmers who did not benefit from the AVCF project intervention was recorded at 466. Of this number of smallholder farmers, the data revealed 366 of them were maize farmers.

3.5.1. Demographic and Socioeconomic Characteristics of Farmers

Table 3.2 shows a summary of the socioeconomic characteristics of the sampled farmers and takes a test of similarities between two groups, that is, farmers with access to finance (the treatment group) and farmers without access to finance (control groups). As noted earlier, we have two control groups:

1. Control group 1 are beneficiaries of the AVCF who did not benefit from the production credit.
2. Control group 2 are similar farmers from similar ecological zones who were non-beneficiaries of the AVCF project (akin to non-equivalent control). This group can also be defined as a more constrained group compared to the AVCF beneficiaries, who have not been resourced with management, technical and skill endowments to enhance farming.

Table 3.2 shows that farmers with access to finance are statistically similar to farmers without access to finance except for slight differences in gender, household size, and years of farming.

Table 3.2: Demographic and Socioeconomic Characteristics of Sampled Farmers with Access to Finance

		AVCF beneficiary with Access to Finance (Treatment Group)	AVCF beneficiary without Access to Finance (Control Group 1)	AVCF non-beneficiary and without Access to Finance (Control Group 2)
Variable	**Sub-Categories**			
Gender	Male	73.38	66.33	84.15***
Education Grade	No Formal Education	75.97	78.89	77.6
Household Size	Household Size	12	13	10***
Marital Status	Married	92.21	91.96	94.54
Years of Farming		15	15.9	18.25***
Farm Size (Ha)		2.95	2.56**	2.94
Total No. of Observations		**154**	**398**	**366**

Notes: We used Chi-Square (X^2) for categorical variables and t-test for continuous variables to test for similarities for the beneficiary and non-beneficiary groups. P-values *** p<0.01, ** p<0.05, * p<0.1 indicate the level of significance.

3.6. DISCUSSION OF VARIABLES

The following variables are included in the estimation of the production model: gender, farmers' education level completed, number of years of farming, labour, and the use of farm inputs (inorganic fertilizer, certified seeds, pesticides and herbicides/weedicides).

Thapa (2008) argues that gender matters in agricultural development and contributes towards increasing productivity. However, there is a productivity gap between male and female due to limited access to farm inputs and finance by female-managed farms as compared to the male counterparts. Also important are the social and cultural factors that serve as limitations to female-owned farms. Thus, female farmers are less likely to record higher productivity than male farmers.

Education and the development of human capital are significant in increasing agricultural productivity. The rationale for this is that, with high knowledge and skills gained from formal schooling, the farmer can apply the required farm inputs and can also adopt the various modern technologies, including effective application of high-yield crop varieties (Weir, 1999; Huffman & Orazem, 2007).

The number of years of farming is expected to enhance productivity. The justification is that a farmer with more years of practice is expected to gain some experience, become innovative and develop technical skills and competencies that are expected to contribute towards improving productivity.

However, since number of years is associated with age, the level of productivity is expected to diminish beyond a point in time (Tauer, 1994).

Labour is a strong predictor of production and productivity. Thus, the agricultural sector remains the sector with the largest number of employees in developing countries. Labour is therefore the resource base for the transformation and modernisation of agriculture, resulting in increased productivity (Cheong & Jansen, 2013).

According to Beets (1990), increasing productivity requires agricultural inputs. The use of certified seeds combined with fertilizer and other chemicals such as pesticides and herbicides/weedicides contribute to increasing productivity. For instance, farmers in most developing countries use their own or saved seedlings for their production; thus, the shift from saved seeds to the use of new varieties of certified seeds is expected to contribute towards increasing productivity. The application of fertilizer has also been promoted to control for nutrients of the soil hence its application is expected to increase productivity (Abate et al., 2015). Similarly, the application of pesticides and herbicides/weedicides is used to control for pest and diseases of farm produce, thus this is expected to also contribute towards increasing productivity (Aktar, Sengupta & Chowdhury, 2009; Popp, Pető & Nagy, 2013).

3.7. ECONOMETRIC FRAMEWORK FOR ESTIMATION

As stated earlier, the allocation of finance (production credit) to the smallholder farmers was not carried out at random; thus, a problem of possible selection bias could arise. According to Heckman (1979), non-randomisation fuels the problem of selection bias caused by either an individual's self-selection or selection methods used by the project implementing agencies. The problem of selection bias may also emerge as a result of unobservable or missing characteristics. Under this prevailing circumstance, an OLS estimator will not produce a result which is consistent due to bias in the selection of farmers with access to finance and also endogeneity of access to finance (Baum, 2006). Other farmer characteristics that are also likely to influence productivity are the conditions of health and the general capabilities of the farmer. To control for such biases to produce an estimation that is consistent, we used both the Heckman selection model and the IV.

3.7.1. Heckman Selection Model

The Heckman sample selection model (Heckit) is a consistent two-step estimator used for the evaluation of a non-randomised program aimed at correcting selection bias and missing variables (Heckman, 1978 and 1979). Based on this and for this study, we estimate the impact of access to finance on smallholder farm productivity. According to Heckman (1978 and 1979) and Maddala (1983), the two-step estimator first begins with the estimation of the selection equation by running a probit regression model of access to finance (Fin_i) on the set of exogenous variables (q_i). This estimation assigns the farmers into the treatment group (those who received finance) and control group (those who did not receive finance). This is explained by the fact that access to finance (Fin_i) is an endogenous binary-treatment variable which takes the value one (1) if smallholder farmer i has received finance and zero (0) if otherwise. This is shown in the equation below:

$$Fin_i = \begin{cases} 1 \ \ if\ smallholder\ farmer\ i\ received\ finance \\ 0\ if\ smallholder\ farmer\ i\ did\ not\ receive\ finance \end{cases} \qquad \text{Eq. (3.1)}$$

Equation (Eq.) 3.1, is expressed in the selection equation as follows:

$$Fin_i = q_i\varphi + u_i \qquad \text{Eq. (3.2)}$$

Thus $\text{Prob}(Fin_i = 1|q_i) = \Phi\,(q_i\varphi)$ and $\text{Prob}(Fin_i = 0|q_i) = 1 - \Phi\,(q_i\varphi)$

where q_i is the set of exogenous variables that predict smallholder farmer *i* access to finance (Fin_i) as the endogenous binary-treatment variable and $\Phi\,(.)$ is the distribution function of the standard normal. Equation 3.2 is estimated using a probit regression model. The parameter Φ, and the estimated value of the density function of the standard normal ϕ are used to compute the *inverse Mills ratio* also known as the *hazard lambda*. The *inverse Mills ratio* (λ) is used to correct for selection bias and any omitted variables and is computed as the ratio of the predicted value of the density function of the standard normal ($\hat{\phi}$) to the distribution function of the standard normal ($\hat{\Phi}$). This is shown below:

$$\lambda_i = \frac{\hat{\phi}(\varphi_i)}{\hat{\Phi}(\varphi_i)} \qquad \text{Eq. (3.3)}$$

The generated *inverse Mills ratio* (λ) is plugged into the outcome equation (Eq.) 3.4, the second step of the two-step estimator to estimate the impact of access to finance on smallholder farm productivity.

$$Prod_i = \mu_0 + \beta_1 Fin_1 + \beta_2 q_i + \beta_3\lambda + \varepsilon_i \qquad \text{Eq. (3.4)}$$

The error terms (u_i, ε_i) in equations (3.2) and (3.4) respectively are assumed to be correlated bivariate normal with zero mean.

Furthermore, Cuddeback, Wilson, Orme and Combs-Orme (2004), and Bushway, Johnson and Slocum (2007), also show that the Heckman selection bias model generates standard errors that are inflated. This is so because the correction factor, in this case the *inverse Mills ratio* (λ), correlates with the exogenous factors and/or the dependent variable of interest. This makes the estimation worse off, paving the way for the introduction of exclusion restrictions as promulgated by the IV model. The models with exclusion restrictions are therefore preferred to Heckman selection models because they are better to establish causality and address selection bias (Bushway et al., 2007).

3.7.2. Instrumental Variable (IV) Model

The Heckman selection model may however not completely eliminate the biases and control the endogeneity problem fully. The IV technique has been widely accepted as being able to deal with any further selection, especially omitted variable bias and endogeneity problems (Heckman, 1979; Angrist & Pischke, 2009). The IV technique has two main assumptions or conditions popularly referred to as the "exclusion restriction". The assumptions state that the IV requires an observed variable that must be (1) strongly correlated with the endogenous regressor (access to finance) and (2) uncorrelated with the error term. The assumptions are summarised as follows:

1. Instrument relevance (correlated with finance): corr $(z_i, Fin_i \neq 0)$
2. Instrument exogeneity (uncorrelated with error term): corr $(z_i, \varepsilon_i = 0)$

where z_i is the instrument variable, Fin_i is the endogenous regressor (access to finance) and the error term (ε_i).

To address the potential endogeneity problem, we chose household isolation level (HIL) as the instrumental variable(z_i). This is calculated as the average of the distance to the nearest source of potable water, the nearest primary school, the nearest health centre, the nearest electricity pole and, finally, distance to the nearest motorable road. The instrument has no direct effect on the outcome (productivity) but will influence the endogenous regressor (finance). The rationale for the choice of this instrument is that, the more a household is isolated or deprived of economic (including financial institutions) and social amenities and services within a community, the less likely the household will have access to and use of financial services (Amendola, Boccia, Mele & Sensini, 2016). Furthermore, the data do not have crop insurance as a variable. That said, crop insurance itself will be a weak instrument since it has a direct effect on productivity.

Using the IV estimation technique, we estimate the impact of access to finance on productivity by first running a probit model and then a two-stage least squares (2SLS) which is referred to as the Probit-2SLS model (Cerulli, 2015). The first stage is to run the probit model to generate the predicted probability value of access to finance ($PFin_i$) as follows:

$$PFin_i = \alpha + q_i\delta + z_i\delta + \varepsilon_i \qquad \text{Eq. (3.5)}$$

Where Fin_i is access to finance (production credit) and is equal to one (1) if farmer i received finance; otherwise, it is zero (0). q_i denotes the exogenous covariates, z_i the instrumental variable and ε_i the error term.

Next is the 2SLS estimation where we first run an OLS regression of access to finance (Fin_i) on q_i and the predicted probability value of access to finance ($PFin_i$) to generate the fitted values of access to finance (Fin_i^*). This is shown as follows:

$$Fin_i^* = \alpha + q_i\delta + PFin_i\delta + \varepsilon_i \qquad \text{Eq. (3.6)}$$

Finally estimate the outcome model that is, productivity ($Prod_i$) on q_i and the fitted values of access to finance (Fin_i^*) using a second OLS regression model. This is specified in the equation below:

$$Prod_i = \mu_0 + \beta_1 Fin_i^* + \beta_2 q_i + u_i \qquad \text{Eq. (3.7)}$$

From equation (eq) 3.7, the estimated impact of access to finance on farm productivity of smallholder farmer is β_1.

We selected both farmer and farm-level characteristics for the exogenous covariate (q_i). Some of these farmer observable characteristics include: gender, educational grade completed and number of years of farming. The farm-level characteristics are the use of various farm inputs and farm management practices such as the use of fertilizer, use of certified seeds, the application of minimum tillage and ploughing across slope practices. Other variables used are market participation (sale of output) and the number of years of participating in the agricultural value chain facility (AVCF) project. The vector of exogenous covariates (q_i) is used in both the selection and outcome equations.

3.8. DISCUSSION OF RESULTS

We present the results of the study in two parts, following the descriptive analysis presented in Table 3.2 above. We present the results of the Heckman selection and the IV estimation techniques for each of the groups. The estimations are carried out using a user-written Stata command ivtreatreg (Cerulli, 2015).

Using "Finance – Control Group 1"[8] for analysis, the probit results for the Heckman selection (Heckit) and Probit – 2SLS IV models are shown in Table 3.3. The probit estimation result for access to finance reveals that, the instrument (z_i) household isolation level (HIL) is negatively correlated with access to finance and the coefficients are statistically significant. This indicates that the use of the instrument is very meaningful and appropriate for the instrumented variable (access to finance). The results also indicate that, gender (sex) and labour are the variables most likely to influence access to finance (production credit). The estimation of the Heckman selection model (Heckit) also showed no evidence of selection bias, since the Inverse Mills ratio (lambda) (λ) is not statistically significant.

[8] "Finance – Control Group 1" – this data is beneficiaries of AVCF with access to finance (Treatment Group) and the beneficiaries of AVCF who are finance constraint (Control Group 1) used for the probit estimation

Table 3.3: Probit Estimate of Average Household Distance to Facilities on Access to Finance (Control Group 1)[9]

VARIABLES	Heckman Selection	Instrumental Variable
Gender (Sex)	0.298**	0.298**
	(0.139)	(0.139)
Education Grade Completed:		
Basic	0.000700	0.000700
	(0.170)	(0.170)
Secondary	-0.0567	-0.0567
	(0.260)	(0.260)
Tertiary	-0.427	-0.427
	(0.478)	(0.478)
Number of Years of Farming	-0.00600	-0.00600
	(0.00645)	(0.00645)
Household Size	-0.00927	-0.00927
	(0.00831)	(0.00831)
Fertilizer	0.118	0.118
	(0.152)	(0.152)
Certified Seed	0.187	0.187
	(0.137)	(0.137)
Pesticides	-0.214	-0.214
	(0.137)	(0.137)
Herbicides/Weedicides	-0.230	-0.230
	(0.147)	(0.147)
Labour	0.393***	0.393***
	(0.135)	(0.135)
Household Isolation Level	-0.0201***	-0.0201***
	(0.00540)	(0.00540)
Constant	-0.500**	-0.500**
	(0.219)	(0.219)
Inverse Mills Ratio (Lambda)	-0.345	
	(0.274)	
rho	-0.419	
sigma	0.825	
Wald chi2(23)	38.67	
Prob > chi2	0.0215	0.0003
LR chi2(12)		36.19
Pseudo R2		0.0554
Observations	552	552

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The results of the outcome equations for the Heckman selection (Heckit) and IV models are shown in Table 3.4 below. The results of the impact of access to finance on productivity of smallholder maize

[9] "Finance – Control Group 1" – this data is beneficiaries of AVCF with access to finance (Treatment Group) and the non-beneficiaries of AVCF who are financially constrained (Control Group 1) used for the probit estimation

farmers was found to have a positive correlation between access to finance and farm-level productivity of maize. However, the results are statistically insignificant. The result of the study could also be expected because this group of farmers are close to each other and both farmers within the treatment group and control group 1 have also acquired and upgraded their knowledge in agronomic practices and farm management. Thus, the training and skills gained strongly contribute to the result.

Table 3.4: Treatment-effects Estimation of Access to Finance on Crop Productivity (Maize) – (Control Group 1)

VARIABLES	Heckman Selection (Heckit)	Instrumental variables (2SLS) regression
Finance	0.658	0.661
	(0.457)	(0.431)
Gender (Sex)	-0.189**	-0.189**
	(0.0900)	(0.0901)
Education Grade Completed:		
Basic	-0.00655	-0.00663
	(0.104)	(0.105)
Secondary	0.128	0.128
	(0.159)	(0.161)
Tertiary	0.273	0.273
	(0.285)	(0.288)
Number of Years of Farming	0.00221	0.00221
	(0.00408)	(0.00410)
Household Size	0.00458	0.00459
	(0.00517)	(0.00519)
Fertilizer	0.244***	0.244***
	(0.0927)	(0.0934)
Certified Seed	0.0684	0.0682
	(0.0919)	(0.0921)
Pesticides	0.0224	0.0226
	(0.0871)	(0.0876)
Herbicides/Weedicides	0.0360	0.0361
	(0.0933)	(0.0939)
Labour	-0.182*	-0.182*
	(0.0942)	(0.0934)
Constant	0.729***	0.728***
	(0.164)	(0.162)
Prob > F		0.1162
R-squared		-
Observations	552	552

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Using "Finance – Control Group 2"[10], Table 3.5 provides the results for the estimation of the probit regression using the Heckman selection and the instrumental variable. The estimation of access to finance (Fin_i) on the exogenous covariates (q_i) and the instrument (z_i) which is the household isolation level (HIL) shows that the instrument (z_i) is negatively correlated with access to finance and the coefficients are statistically significant. This indicates that the use of the instrument is very meaningful and appropriate for the instrumented variable (access to finance). The result again shows that, household size, use of fertilizer, use of certified seeds, use of pesticides and labour are the factors that are more likely to predict access to finance (production credit). Other factors such as access to basic education and number of years of farming have shown a negative and significant effect on the probability of access to finance by a smallholder farmer. Put differently, these variables are less likely to influence access to finance.

[10] "Finance – Control Group 2" – this data is beneficiaries of AVCF with access to finance (Treatment Group) and the non-beneficiaries of AVCF who are financially constrained (Control Group 2) used for the probit estimation

Table 3.5: Probit Estimate of Average Household Distance to Facilities on Access to Finance (Control Group 2)[11]

VARIABLES	Heckman Selection	Instrumental Variable
Gender (Sex)	-0.264	-0.264
	(0.214)	(0.214)
Education Grade Completed:		
Basic	-0.608***	-0.608***
	(0.228)	(0.228)
Secondary	-0.365	-0.365
	(0.350)	(0.350)
Tertiary	-0.374	-0.374
	(1.044)	(1.044)
Number of Years of Farming	-0.0327***	-0.0327***
	(0.00861)	(0.00861)
Household Size	0.0730***	0.0730***
	(0.0142)	(0.0142)
Fertilizer	0.774***	0.774***
	(0.182)	(0.182)
Certified Seed	1.957***	1.957***
	(0.339)	(0.339)
Pesticides	0.494**	0.494**
	(0.218)	(0.218)
Herbicides/Weedicides	0.143	0.143
	(0.189)	(0.189)
Labour	0.372**	0.372**
	(0.190)	(0.190)
Household Isolation Level	-0.0523***	-0.0523***
	(0.00693)	(0.00693)
Constant	-0.495*	-0.495*
	(0.283)	(0.283)
Inverse Mills Ratio (Lambda)	-0.194**	
	(0.0817)	
rho	-0.352	
sigma	0.550	
Wald chi2(23)	207.27	
Prob > chi2	0.000	0.000
LR chi2(12)		310.03
Pseudo R2		0.4907
Observations	520	520

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 3.6, therefore, presents the Heckman selection (Heckit) and the IV (2SLS) regression results for the estimations of the impact of access to finance on crop productivity (maize) of smallholder farmers.

[11] "Finance – Control Group 2" – this data is beneficiaries of AVCF with access to finance (Treatment Group) and the non-beneficiaries of AVCF who are financially constrained (Control Group 2) used for the probit estimation

Clearly, the results show a positive relationship between access to finance and maize productivity, which was found to be statistically significant. Using the IV estimation, the result further indicates that, a smallholder farmer who received training in integrated soil fertility management (ISFM) practice and received finance (production credit) increased maize productivity by 0.44 metric tonnes per hectare more than the farmer who did not receive ISFM training nor received finance (production credit). This means a hybrid treatment (finance and training) contributes to a higher impact on average productivity of smallholder farmers. Our result confirms the results of other studies in Nigeria by Awotide, Abdoulaye, Alene and Manyong (2015) and indirectly that of Martey et al. (2015). More importantly we show that the productivity impact of credit is starkly visible when we use a more constrained smallholder farmer (Control group 2).

Table 3.6: Treatment-effects Estimation of Access to Finance on Crop Productivity (Maize) – (Control Group 2)

VARIABLES	Heckman Selection (Heckit)	Instrumental variables (2SLS) regression
Finance	0.432***	0.438***
	(0.124)	(0.128)
Gender (Sex)	-0.0575	-0.0570
	(0.0680)	(0.0689)
Education Grade Completed:		
Basic	0.197***	0.197***
	(0.0668)	(0.0677)
Secondary	0.425***	0.425***
	(0.121)	(0.123)
Tertiary	0.693**	0.693**
	(0.325)	(0.330)
Number of Years of Farming	-0.00129	-0.00126
	(0.00259)	(0.00263)
Household Size	-0.00321	-0.00328
	(0.00439)	(0.00446)
Fertilizer	0.197***	0.196***
	(0.0613)	(0.0623)
Certified Seed	0.0293	0.0264
	(0.107)	(0.109)
Pesticides	-0.170**	-0.171**
	(0.0852)	(0.0865)
Herbicides/Weedicides	0.0400	0.0398
	(0.0558)	(0.0565)
Labour	0.0223	0.0223
	(0.0568)	(0.0575)
Constant	0.604***	0.603***
	(0.0837)	(0.0848)
Prob > F		0.000
R-squared		0.153
Observations	520	520

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

3.9. TEST OF INSTRUMENT (POSTESTIMATION)

According to Staiger and Stock (1997), the condition to satisfy is that an instrument (z_i) is strong if the F statistic, which is a test of the instrument, is equal or greater than 10. The results of the first-stage summary statistics as reported in Tables 3.9 and 3.10 clearly suggest that the instrument (z_i) is not weak. Following the application of the instrument in the two estimations, the F statistic has shown a value of 13.80 and 87.80. These values exceed the value of 10 as the rule of thumb. Meanwhile, Cameron and

Trivedi (2010) argue that the *F* statistic may not present a sufficient reason or justification for a decision to be made and, more importantly, when a clear critical value has not been established.

Based on the above, we carried out an advanced test of the instrument by adopting the Cragg–Donald minimum eigenvalue statistic, which is measured against the critical values provided by Stock and Yogo (2005). The critical values are provided following 2SLS and LIML estimators to signify the degree of bias relative to the OLS measurement. Using the 2SLS estimator the reported minimum eigenvalue statistic in the case of the test for the instrument as applied in the two IV estimations shows the values of 13.76 and 51.40 respectively. The first (Table 3.9) result shows that by accepting a rejection rate of fifteen per cent for a five per cent Wald test based on the 2SLS, we reject the null hypothesis (H_0). This implies that the instrument is not weak because the minimum eigenvalue statistic of 13.76 is greater than the critical value of 8.96.

Similarly, we also accept a rejection rate of, at most, ten per cent for a five per cent Wald test based on the 2SLS estimator for the second IV regression model estimating the effect of access to finance on maize productivity. The test statistic reported a minimum eigenvalue of 80.10, which is far in excess of 16.38. In effect, we reject the null hypothesis (H_0) to mean that the instrument is strong.

3.10. CONCLUSIONS

Access to finance serves as a catalyst for value addition to agriculture in terms of increasing agricultural productivity of smallholder farmers. This study assessed the impact of access to finance on smallholder maize farm productivity in Ghana. The data for the study was obtained from the AVCF project that was implemented in the Northern Region of Ghana from 2011–2015. From the survey, we used two separate data sets for analysis and robustness check of results.

In the absence of randomization of treatment (access to finance), we deployed the instrumental variable (IV) estimation techniques using the Probit – 2SLS model for the estimations of the Average Treatment Effects (ATEs). The rationale for the choice of the IV is to control for selection bias and the problem of endogeneity. We use two types of control groups: Control Group 1 (beneficiaries who did not have access to finance – a less constrained group) and Control group 2 (non-beneficiaries who are likely to be more constrained due to the absence of the AVCF benefits).

The analysis of the treatment effect of access to finance on productivity of smallholder farmers using the effect of finance on Control Group 1 showed a positive relationship between finance and productivity but has no significant effect. This result we also find to be plausible because of the training that both farmers within the treatment group and Control Group 1 received in agronomic practices therefore contributing productivity. Secondly, the AVCF project also focused on improving market access and market participation (sale of outputs) of smallholder farmers. This also serves as a catalyst for the beneficiaries of AVCF to increase productivity whether the farmer has access to finance or is financially constrained. However, we find that the treatment effect (access to training and finance) has a significant impact on productivity of smallholder farmers when we compare beneficiaries to a more constrained Control group 2. With the access to training and finance, the smallholder farmers in the Northern Region of Ghana were efficient in allocating the required farm inputs, resulting in shifting the maize production frontier outwards and increasing productivity.

This paper makes a unique contribution to the literature in several ways. First, we show that finance in the form of production credit is crucial for smallholder farmers. For smallholder farmers a critical challenge to productivity is the ability to access short to medium-term credit on a regular basis to finance the cost of inputs, market access issues and other operational costs. Access to finance helps to mitigate against the shocks and risks (real and perceived) associated with smallholder farming and which make commercial banks shy away from lending in this area. We also show that the treatment effect of access to training and finance on productivity is evident when you control for a constrained smallholder farmer.

Policy reforms on extending finance to smallholder farmers could be more targeted and specific to meet their finance needs. For instance, smallholder farmers, a majority of whom are finance constrained, will need short to medium term working capital in the form of production credit to enable them to boost their farm production. However, such policies to increase access to finance to smallholder farmers should consider incorporating training on agronomic and farm management practices leading to the introduction of a new farming system.

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APPENDIX 'A'

Table 3.7: Definition and Summary Statistics of Variables Used for the Econometric Estimations of Access to Finance on Productivity of Maize Using Control Group 1[12]

Variable	Obs	Mean	Std. Dev.	Min	Max	Label
Productivity	552	1.00	0.80	0.08	9.88	Productivity of maize measured in metric tonnes
Access to Finance	552	0.28	0.45	0	1	1 if Farmer has access to finance or otherwise zero (0)
Gender	552	0.68	0.47	0	1	1 if Farmer is a Male or otherwise zero (0)
Education Level	552	0.22	0.41	0	1	1 if Farmer has gained some level of education or otherwise zero (0)
Number of Years of Farming	552	15.70	9.74	1	50	Number of Years of farming of a Farmer
Household Size	552	12.65	7.53	0	50	Number of household size per Farmer
Inorganic Fertilizer	552	0.78	0.41	0	1	1 if Farmer incurred cost on Inorganic Fertilizer or otherwise zero (0)
Certified Seed	552	0.23	0.42	0	1	1 if Farmer incurred cost on Certified Seed or otherwise zero (0)
Pesticides	552	0.27	0.44	0	1	1 if Farmer incurred cost on Pesticides or otherwise zero (0)
Herbicides & Weedicides	552	0.76	0.42	0	1	1 if Farmer incurred cost on Herbicides/Weedicides or otherwise zero (0)
Labour	552	0.69	0.46	0	1	1 if Farmer hired labour or otherwise zero (0)

[12] "Finance – Control Group 1" – this data is beneficiaries of AVCF with access to finance (Treatment Group) and the non-beneficiaries of AVCF who are financially constrained (Control Group 1) used for the probit estimation

Table 3.8: Definition and Summary Statistics of Variables Used for the Econometric Estimations of Access to Finance on Productivity of Maize Using Control Group 2[13]

Variable	Obs	Mean	Std. Dev.	Min	Max	Label
Productivity	520	0.81	0.60	0.06	4.14	Productivity of maize measured in metric tonnes
Access to Finance	520	0.30	0.46	0	1	1 if Farmer has access to finance or otherwise zero (0)
Gender	520	0.81	0.39	0	1	1 if Farmer is a Male or otherwise zero (0)
Education Level	520	0.23	0.42	0	1	1 if Farmer has gained some level of education or otherwise zero (0)
Number of Years of Farming	520	17.33	10.94	1	50	Number of Years of farming of a Farmer
Household Size	520	10.42	6.07	1	45	Number of household size per Farmer
Inorganic Fertilizer	520	0.51	0.50	0	1	1 if Farmer incurred cost on Inorganic Fertilizer or otherwise zero (0)
Certified Seed	520	0.10	0.30	0	1	1 if Farmer incurred cost on Certified Seed or otherwise zero (0)
Pesticides	520	0.11	0.32	0	1	1 if Farmer incurred cost on Pesticides or otherwise zero (0)
Herbicides & Weedicides	520	0.65	0.48	0	1	1 if Farmer incurred cost on Herbicides/Weedicides or otherwise zero (0)
Labour	520	0.61	0.49	0	1	1 if Farmer hired labour or otherwise zero (0)

[13] "Finance – Control Group 2" – this data is beneficiaries of AVCF with access to finance (Treatment Group) and the non-beneficiaries of AVCF who are financially constrained (Control Group 2) used for the probit estimation

Table 3.9: First-stage regression summary statistics – "Finance – Control Group 1"

Variable	R-sq.	Adjusted R-sq.	Partial R-sq.	F(1, 1154)	Prob > F
Finance	0.063	0.042	0.025	13.80	0.000

Cragg and Donald (1993) Minimum eigenvalue statistic = 13.76

Critical Values Ho: Instruments are weak	# of endogenous regressors: 1 # of excluded instruments: 1			
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	16.38	8.96	6.66	5.53
LIML Size of nominal 5% Wald test	16.38	8.96	6.66	5.53

Table 3.10: First-Stage Regression Summary Statistics – "Finance – Control Group 2"

Variable	R-sq.	Adjusted R-sq.	Partial R-sq.	F (1,510)	Prob > F
Finance	0.439	0.426	0.136	87.798	0.000

Cragg and Donald (1993) Minimum eigenvalue statistic = 80.10

Critical Values Ho: Instruments are weak	# of endogenous regressors: 1 # of excluded instruments: 1			
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	16.38	8.96	6.66	5.53
LIML Size of nominal 5% Wald test	16.38	8.96	6.66	5.53

CHAPTER 4

THE IMPACT OF FINANCE ON THE WELFARE OF SMALLHOLDER FARM HOUSEHOLDS IN GHANA[14]

4.1. INTRODUCTION

There is a consensus, based on economic theory, that access to finance has a positive impact on household welfare. By improving and extending access to finance, households can smoothen consumption and reduce exposure to risk. Finance also offers households the opportunity to invest in high-risk investments that ultimately culminate in improving household welfare (Eswaran & Kotwal, 1990; Karlan & Zinman, 2010). Similarly, Ledgerwood (2013) argues that access to finance improves household welfare through investment in health and education, household assets, and enhanced productivity, and that access to finance serves as a buffer against any future shock or risk. In a nutshell, Beck and Demirgüc-Kunt (2008) and Hudon (2009) described the critical role of access to finance as an ingredient needed to improve welfare of households in an economy. Indeed, Mahajan (2005) argues that although finance is relevant, it must be combined with other factors to improve the livelihood of households. In other words, access to finance is not the only means of ensuring improvement in welfare.

Even so, not many studies exist on the welfare impact of finance for smallholder farmers. The few studies that exist (Pitt & Khandker, 1998; Quach, Mullineux & Murinde, 2005; Kotir & Obeng-Odoom, 2009; Richard, Job & Wambua, 2015; Adebowale & Dimova, 2017) dwell on the household welfare impact of finance and not specifically on smallholder farmers. There is therefore relatively little empirical evidence on the welfare impact of finance on smallholder farmers. This perhaps also explains the absence of finance in agricultural development policies aimed at improving the welfare of smallholder farmers. It is imperative to note that in developing countries, especially in Africa, a main channel – income generation from production – through which finance enhances welfare is rooted in agriculture, particularly in smallholder farming. Most household economic activity in Africa is structured around agriculture and smallholder farming. Therefore, smallholder farming is the main production channel through which finance augments production to generate extra income and enhance welfare. This confirms the relevance of studying the finance–welfare link from a smallholder farmer point of view. These gaps create the

[14] This paper was presented at the 30th International Conference of Agricultural Economists. Vancouver, July 28-Aug 2 2018

opportunity for further empirical studies. This essay therefore provides new evidence on the effect of finance on the welfare of smallholder farmer households using the case of Ghana.

In this paper, we provide new evidence on the effect of finance on the welfare of smallholder farm households using a micro level data following a survey carried out in the Northern Region of Ghana. We measure access to finance by production credit which is generally short to medium-term working capital extended to smallholder farmers by a financial institution. Secondly, we used assets-based approach as a measure of welfare which is different from the income or consumption approach that is widely used. Thirdly, in testing for the welfare impact of finance, we control for the problem selection bias to ensure that the results of the estimations meet the test of both internal and external validity. This essay also adds to the contextual literature on Africa.

In Ghana numerous agricultural policies have been implemented to enhance welfare (Nyanteng & Seini, 2000); however, these seem to be devoid of financing strategies. Although a plethora of financial sector initiatives and policies have also been implemented, most of them have little explicit attention to agriculture, aside from a few[15] that mention the possible benefits to agriculture. In addition, despite the numerous policies that have been formulated within the agricultural and financial sector, there is little evidence of whether these policies have positively impacted on farm households' welfare. This makes the case of Ghana an interesting one to study for the impact of finance on smallholder farmers' welfare. Furthermore, the implementation of the DANIDA Agricultural Value Chain Facility (AVCF) project 2011–2015 (with a finance-linked welfare goal) in the Northern Region of Ghana provides a unique case for study.

The rest of the paper is organised in six sections as follows: section 2 presents the overview of agricultural finance and welfare in Ghana. Section 3 discusses the theoretical frameworks that highlight the role of access to finance on welfare and provide a review of empirical literature. Section 4 describes the data and presents the econometric model and estimation techniques for the analysis. The results and key empirical findings are discussed in section 5, with a conclusion in section 6.

4.2. AN OVERVIEW OF AGRICULTURAL FINANCE AND WELFARE IN GHANA

Ghana's financial system has transformed over time through the introduction of financial policy reforms that the country embarked on from the 1980s. The reforms were part of the Economic Recovery Programme (ERP) and Structural Adjustment Programme (SAP) that became necessary because of the

[15] See Brownbridge and Gockel (1998), Quartey and Afful-Mensah (2013) and Asante and Owusu (2013).

financial crisis and low economic growth that Ghana was confronted with from 1976–1983 (Antwi-Asare & Addison, 2000). The two major reforms that took place from the 1980s were the Financial Sectpr Reform Program (FINSAP), which was implemented in 1988–2000, and the Financial Sector Strategic Plan (FINSSIP), also implemented in 2001–2008. Both programs focused on deepening the financial sector by broadening financial services through restructuring the public sector financial institutions and improving the legal and regulatory framework and financial liberalisation (Brownbridge & Gockel, 1998; Sowa, 2002; Biekpe, 2011). The most explicit reference to financing agriculture was prior to the introduction of these reforms, where there was direct state control of the financial sector leading to the provision of preferential lending rates to priority sectors including agriculture (Brownbridge & Gockel, 1998; Quartey & Afful-Mensah, 2013).

Table 4.1 below presents allocation of credit to the agricultural sector by the Deposit Money Banks (DMBs) and specifically by the Agricultural Development Bank (ADB). The rationale for the selection of ADB is that its core mandate is to specifically extend finance to the productive actors within the agricultural sector in Ghana. Overall (from Table 4.1), credit to the agricultural sector by commercial banks has been consistently declining. Although credit from ADB to the agricultural sector is higher than that of commercial banks, just about a third of the portfolio of the ADB goes to agriculture. This further conforms the neglect on agricultural finance.

Table 4.1: Allocation of Credit by Deposit Money Banks (DMBs) and the Agricultural Development Bank (ADB) to the Agriculture Sector, 1993–2015 (%)

YEAR	DMBs (%)	YEAR	DMBs (%)	ADB (%)
1993	8.6	2004	7.7	
1994	8.5	2005	6.7	
1995	9.7	2006	5.4	
1996	10.8	2007	4.9	
1997	12	2008	4.3	24.33
1998	12.2	2009	4.74	24.09
1999	11.8	2010	6.13	28.97
2000	9.6	2011	5.74	27.40
2001	9.6	2012	5.11	29.00
2002	9.4	2013	4.09	27.20
2003	9.4	2014	3.64	32.00
		2015	3.84	35.00

Source: Bank of Ghana and Agricultural Development Bank Annual Reports.

With respect to welfare, the Government of Ghana has implemented several policies. The Ghana Vision 2020 was launched in 1995 with its policy goal of improving the welfare of Ghanaians (Aryeetey & Codjoe, 2005). A five-year Medium-Term Development Plan (MTDP) slated for 1996–2000 and aimed at improving welfare and social well-being of the people of Ghana was developed within the Ghana Vision 2020 framework.

From 2003–2005 the Ghana Poverty Reduction Strategy (GPRS I) was launched with a focus on priority areas that are similar to that of MTDP (GPRS, 2003). A second phase of GPRS, the Growth and Poverty Reduction Strategy (II), was initiated from 2006–2009. From 2010–2013, the Ghana Shared Growth and Development Agenda (GSGDA) I was implemented with a focus on development policies and strategies that promote employment creation and income generation to improve welfare (NDPC, 2010). The second phase of the GSGDA II (2014–2017) is currently under way.

Table 4.2 captures welfare trends in Ghana from 1991/92 to 2012/13 using the Ghana Living Standard Survey (GLSS). From a monetary perspective, using household consumption expenditure as a measure of welfare, the evidence shows that at the national level, the standard of living or welfare of the average person in Ghana has improved. The available statistics show that from 1991/92 to 2012/13, the average number of persons with poor welfare decreased from 51.7 per cent to 24.2 per cent. As noted, the incidence of welfare among those within the rural localities is poorer than those within the urban localities. However, the welfare of the people in both rural and urban localities has witnessed significant improvement as the number of persons with poor living standard or welfare decreased from 27.7 per cent to 10.6 per cent in the urban localities from 1991/92 to 2012/13. In the same vein, there is evidence that the number of persons living in rural communities with low levels of welfare declined from 63.6 per cent in 1991/92 to 37.9 per cent in 2012/13. However, Northern, Upper East and Upper West regions still record the highest levels of poor welfare ranging from 44.4 per cent in Upper West to 70.7 per cent in Upper East regions in 2012/13.

Table 4. 2: Monetary and Non-Monetary Welfare Trends in Ghana – National, Regional & Ecological

	MONETARY CONSUMPTION				NON-MONETARY POVERTY 2010 (Population Census Data)	
	1991/92	**1998/99**	**2005/06**	**2012/13**	**Percentage of Household**	**Headcount ratio**
NATIONAL	51.7	39.5	28.5	24.2	31.8	42.7
Urban	27.7	19.4	10.7	10.6		27.7
Rural	63.6	49.5	39.3	37.9		72.3
REGIONAL						
Western	59.6	27.3	18.4	20.9	32.2	40.5
Central	44.3	48.4	19.9	18.8	31.0	39.1
Greater Accra	25.8	5.2	11.8	5.6	12.9	18.5
Volta	57	37.7	31.4	21.7	35.9	44.3
Eastern	48	43.7	15.1	33.8	27.7	35.6
Ashanti	41.2	27.7	20.3	14.7	23.1	30.8
Brong Ahafo	65	35.8	29.5	27.9	41.2	51.7
Northern	63.4	69.2	52.3	50.4	74.6	80.9
Upper East	66.9	88.2	70.4	70.7	75.0	80.8
Upper West	88.4	83.9	87.9	44.4	70.2	77.6
ECOLOGICAL ZONES						
Accra (GAMA)	23.1	3.8	10.6	3.5		
Urban Coastal	28.3	24.2	5.5	10.1		
Urban Forest	25.8	18.2	7	9.9		
Urban Savannah	37.8	43	36.9	26.4		
Rural Coastal	52.5	45.2	23.9	30.3		
Rural Forest	61.6	38	27.9	27.9		
Rural Savannah	73	70	60.3	55		

Source: Ghana Statistical Service (GSS), Ghana Living Standard Surveys (GLSS, rounds 3–6) & Population Census (2010).

It is evident that policies to improve agricultural development, productivity and general welfare abound in Ghana. Yet there is clearly a gap in identifying the strategic finance component in agricultural policy, a link which is crucial to welfare. Consequently, although welfare has improved in Ghana, there remains a lot to worry about. More specifically, there has been no explicit focus on the welfare of smallholder farmers, the majority of whom make up the bulk of economic activity in Ghana.

4.3. RELATED THEORETICAL FRAMEWORK

The welfare implications of finance for smallholder farmers are not explicitly modelled but can be found to be embedded in the conceptual link between finance and household welfare. This section highlights some of the pathways through which finance improves welfare.

Zeller, Schrieder, Von Braun and Heidhues (1997) and Zeller and Sharma (2002) outline pathways through which access to finance positively impacts on household welfare. The first channel is through income generation. They argue that where finance is accessed to invest in agricultural production or economic activities, it creates the opportunity for income generation with the expected positive effect on household welfare. For instance, with access to finance, the smallholder farmer can procure high-yielding seeds, hire high-skilled labour and adopt fertiliser and mechanised farming methods that increase farm productivity. As a result, this raises agricultural production, increases sales of farm produce and, ultimately, contributes towards income generation. Through income generation, households can meet food and non-food consumption, thereby improving their welfare. As observed by Gonzalez-Vega (1981), access to finance is the root of income generation through engagement in productive opportunities observed.

In the same vein, according to Ayyagari et. al. (2013), access to finance improves welfare through the channel of entrepreneurship. This is so because, finance can be used in entrepreneurial activities which spurs economic growth and improve welfare (Claessens and Perotti, 2007). Thus, by having access to finance smallholder farmers invest in agricultural production or economic activities, which creates the opportunity for income generation with the expected positive effect on household welfare. For instance, with access to finance, the smallholder farmer can procure high-yielding seeds, hire high-skilled labour and adopt fertiliser and mechanised farming methods that increase farm productivity

It is also hypothesized that, through human capital accumulation channel, access to finance improves welfare (Banerjee and Newman, 1993; Galor and Zeira, 1993). The implication is that, those with access to finance would invest in human capital which will enable them to earn high return on their investment thereby improving household welfare. For instance, with access to finance, smallholder farmers are able to invest in education and as a result acquire skills and competences for productive engagement thereby improving household welfare. In other words, when there is binding credit constraint as a result of imperfect credit market, it limits access to finance therefore serves as a hindrance to household welfare enhancement.

Bruhn and Love (2014) theorise that access to finance impacts on household welfare through the labour market channel. They argue that access to finance improves household welfare through self-employment, expansion and smooth operation of informal businesses and income generation. That is, with access to finance, entrepreneurs within the informal sector can invest in their economic activity thereby sustaining their business instead of closing them due to finance constraints resulting to household welfare enhancement. Additionally, access to finance creates the opportunity for job creation that is, contributing to the reduction in unemployment levels leading to improvement in household welfare. Thus, access to finance fills the household consumption gap during periods of uncertainties and unpredictable income generation.

Consumption smoothening is also another channel through finance has effect on welfare, (Zeller et al., 1997; Zeller and Sharma, 2002). They argue that when households are faced with external economic shocks, finance is required to stabilise and sustain food and non-food consumption during the period of economic deprivation. This channel had earlier been argued by Deaton (1990), who hypothesised that access to finance fills the household consumption gap by improving their welfare during periods of uncertainties and unpredictable income generation. Kus (2013) further affirms this channel by stating that access to finance is the channel through which households enhance consumption.

In sum, the theoretical framework shows that access to finance drives income generation which is a direct welfare benefit, mitigates risks during periods of shocks by smoothening consumption, and promotes diversification of risks that expose households to hardships.

4.4. RELATED EMPIRICAL REVIEW

Like the theoretical gap, most empirical studies on the impact of access to finance on welfare is generally on households, with little or no evidence about smallholder farmers. From the empirical evidence, some studies have documented positive impacts, while others do not find any significant impact.

Beginning with studies that have shown positive and statistically significant results, Khandker and Faruqee (2003) provided empirical evidence by estimating the impact of access to finance on welfare in Pakistan. The result of the study revealed that a ten per cent increase in access to finance has a positive and significant effect on welfare by 0.04 per cent. The study deployed a two-stage least squares (2SLS) for estimation using data from 1995/96 agricultural year. Similarly, Ghalib, Malki and Imai (2011) empirically established that access to finance improves household welfare. The findings of the study followed the use of rural household data from Pakistan and was estimated using propensity score matching (PSM) to control for selection bias.

In Vietnam, Quach et al. (2005) evaluated the impact of access to finance on household welfare and found that access to finance had a positive impact on household welfare by 6.9 per cent and 5.8 per cent respectively, using a cross-sectional data drawn from 1992/93 and 1997/98 Vietnam Living Standards Survey. The estimation was carried out using a 2SLS and the results were found to be statistically significant. In the same vein, a study by Nguyen and Van den Berg (2011) on the impact of access to finance on welfare in Vietnam also indicated that the welfare impact of access to finance improves as the number of poor households decreased by 1.53 per cent in 2004 and 1.38 per cent in 2006. Data for analysis was drawn from the 2004 and 2006 Vietnam Household Living Standard Surveys (VHLSS) and was estimated using instrumental variables to control for endogeneity.

Adams (2006) studied the impact of finance on household welfare in Ghana. The study revealed that access to finance reduces the number of poor households by 34.8 per cent. In other words, access to finance contributes towards improving the welfare or living standards of households in Ghana. The multinomial logit two-stage least squares model was deployed for estimation, while the data for the study was sourced from the 1998/99 Ghana Living Standards Survey (GLSS). Similarly, by estimating the impact of access to finance on welfare, Geda, Shimeles and Zerfu (2006) found that access to finance has a statistically significant effect on welfare. The instrumental variable model was used for estimation to control for endogeneity. The study used household panel data from Ethiopia covering the period from 1994 to 2000.

With regard to studies that found no welfare impact of finance, Diagne (1998) estimated the impact of access to finance on the welfare of 404 households in Malawi. The study showed that the impact of access to finance on welfare was insignificant. The estimation was carried out using 2SLS estimator. A similar study carried out by Amendola, Boccia, Mele, and Sensini (2016) in Mauritania using data from a survey of household living conditions – EPCV 2014 – reached a conclusion of no significant effect of access to finance on welfare. The instrumental variable was used for estimation.

The studies as presented above have clearly shown mixed results. Empirical findings have shown that access to finance has positive and statistically significant effect on household welfare (Khandker and Faruqee, 2003; Ghalib et al, 2011; Quach et al, 2005; Nguyen and Van den Berg, 2011; Adams, 2006;

and Geda et al, 2006). On the other hand, some empirical results show that access to finance has positive effect but not statistically different from zero. By access to finance, these studies refer to bank credit, credit from microfinance institutions, informal credit and remittance that serve as value addition to help improve income generation activities and welfare of households. Also, most of these studies also measured welfare from either uni-dimensional or multi-dimensional perspectives with variables or welfare indicators such as household income, expenditure on food or non-food expenditure (education, health, electricity and water) for their assessment of finance – welfare net effect. However, except for Diagne (1998) that used agricultural data for analysis, the data for the others were drawn from nationally representative household surveys for analysis. In other words, there was no focus on smallholder farm households and there was no mention of asset as a proxy to welfare.

We contribute to the literature on effect of finance on welfare by using a micro level data on smallholder farm households. This is a paradigm shift away from most studies including Quach et al. (2005), Adams (2006) and Nguyen and Van den Berg (2011) that used macro-level data for analysis. We also define access to finance as production credit which, in this study, is a short to medium-term working capital extended to smallholder farmers by financial institutions through agro-dealers. Finally, we used assets-based approach as a measure of welfare which is again different from the widely used income and consumption measurements of welfare.

4.5. DESCRIPTION OF THE PROJECT AND DATA

Data used in this study were drawn from the Agricultural Value Chain Facility (AVCF) project, an initiative of the DANIDA, which was implemented in the Northern Region of Ghana from 2011–2015 under the management of the Alliance for Green Revolution in Africa (AGRA). The objective of the project was to "increase income and employment in rural areas, particularly in breadbasket areas of Northern Ghana, through increased agricultural production, productivity and value addition" (Danida, 2009). The implementation of the AVCF project (production component) was implemented under the auspices of two project names. These projects are the Agricultural Value Chain Mentorship Project (AVCMP), which was implemented by a consortium of three institutions – the International Fertilizer Development Center (IFDC), Savanna Agricultural Research Institute (SARI) and the Ghana Agricultural Associations Business Information Centre (GAABIC). The second project is the Integrated Agricultural Productivity Improvement and Marketing Project (INTAPIMP), which was directly implemented by the Adventist Development and Relief Agency (ADRA). Both projects have the same mandates.

The survey used questionnaires to gather vital information on farmers' demographic characteristics and key socioeconomic variables which, among others, include farmers' level of education, access to financial services, production and household asset ownership. The data for the study were collected based on one-year (2014/15) farming season. Data collection was carried out by thirty-eight personnel who were recruited from the University of Development Studies (UDS) and the Tamale Polytechnic. The data were captured using Computer-Assisted Personal-Interview (CAPI) software over a period of two months from July to August 2015.

Finance for this project was in the form of production credit which is a short to medium term working capital for smallholder farmers to procure farm inputs such as fertilizers, agro-chemicals and certified seeds. Finance (production credit) was sourced from Sinapi Aba Savings and Loans company and the Centre for Agricultural and Rural Development (CARD) a financial non-governmental organization (FNGOs).

This study evaluates the impact of access to finance on the welfare of smallholder farmers' household. For the data, we applied a combination of convenient, stratified and proportional sampling techniques. The record consisted of 27,856 farmers across the Northern Region of Ghana who participated in the ACVF project. These farmers are into the farming of selected staple crops, namely maize, rice, soyabean and groundnut. Following a four-stage approach, the population was classified into different subgroups or strata, then the final subjects were proportionately selected at random from the different population groups or strata. First, we selected seven communities from each of the 22 districts representing the Northern Region of Ghana. The choice of these seven communities was influenced by the number of beneficiary farmers within a community. This brought the total number of communities to 154.

The second stage was to randomly select a sample of 1,700 farmers from the 154 communities for data collection. After data editing and cleaning of outliers and various inconsistencies, we had a number of 1,564 farmers who either owned a maize farm or groundnut farm or soyabean farm or rice farm only, or a farmer owning a combination of farms of different crops. At the third stage, we categorised the data into two separate groups, namely farmers with access to finance (treatment group) and farmers who are financially constrained (control group). The data indicated a total number of 176 farmers with access to finance and 1,388 farmers who are financially constrained. At the fourth stage, 208 farmers were sampled from the 1,388 farmers for purposes of matching and estimation.

To ensure robustness in the checking of results, the study used a second control group. The second group of farmers are the non-beneficiary group of AVCF. Data for the non-beneficiary group was also collected on farmers in selected communities within the Northern and Brong Ahafo (BA) regions, with a total number of 295 farmers and 200 farmers respectively. The selected areas for this group are within the same agro-ecological zone as the beneficiary group. They share similar agricultural practices as well as community and socioeconomic characteristics. The selection of the areas or communities of these farmers was influenced by the fact that they are remote from communities where Government provides agricultural extension services to farmers and by the fact that non-governmental organizations (NGOs) are not there to provide agricultural services. After data cleaning and editing, the total number of smallholder farmers who did not benefit from the AVCF project intervention was recorded at 466. Of this number of smallholder farmers, 233 farmers were sampled for estimation.

4.5.1. Demographic and Socioeconomic Characteristics of Sample Farmers

Table 4.3 presents a brief overview of the socioeconomic characteristics of the farmers and tests for similarities of the two separate groups, that is, the group with access to finance (the treatment group) and farmers without access to finance (control groups). However, as highlighted in the sample design, this study used two control groups:

1. Control group 1 comprised beneficiaries of the AVCF who were excluded from the production credit.
2. Control group 2 comprised farmers from similar ecological zones who were non-beneficiaries of the AVCF project (akin to non-equivalent control) and were excluded from the production credit.

Table 4.3 shows that farmers with access to finance are statistically similar to farmers without access to finance except for slight differences in gender, education grade attained, household size and years of farming.

Table 4.3: Demographic and Socioeconomic Characteristics of Sampled Farmers with Access to Finance

Variable	Sub-Categories	AVCF beneficiary with Access to Finance (Treatment Group)	AVCF beneficiary without Access to Finance (Control Group 1)	AVCF non-beneficiary and without Access to Finance (Control Group 2)
Gender	Male	71.02	60.10**	73.39
Education Grade	No Formal Education	76.14	85.10**	79.40
Household Size	Household Size	11.84	12.45	9.17***
Marital Status	Married	91.48	93.75	95.71*
Years of Farming		14.64	15.71	17.12**
Farm Size (Ha)		2.75	2.23***	2.64
Total No. of Observations		**176**	**208**	**233**

Notes: We used Chi-Square (X^2) for categorical variables and t-test for continuous variables to test for similarities for the beneficiary and non-beneficiary groups. P-values *** p<0.01, ** p<0.05, * p<0.1 indicate the level of significance

4.6. DISCUSSION OF VARIABLES

The following variables are included in the probit estimation of access to finance: demographic and socio-economic characteristics (gender, farmer's education level attained, number of years of farming), community characteristics (access to potable water, access to nearest primary school, access to nearest secondary school, access to health centre, access to telephone service, access to electricity poles) as well as production characteristics (access to health insurance and access to storage facility).

Gender is a strong predictor of access to finance. Studies have shown that access to finance is more skewed towards men than their female counterparts who are also engaged in economic activities. A contributing factor is the perceived credit risks differences. However, access to microfinance by female entrepreneurs is expected to bridge the inequality gap between males and females and also enhance household welfare (Duflo, 2012). Technical and factual knowledge which is critical for productivity is also critical for smallholder farmers' access to finance (Wachira and Kihiu, 2012). Education, health, experience and storage (warehouse) facilities all depict the human capital, technical and factual knowledge status of farmers and thus important for access to finance. The level of education attained by a smallholder is a human capital determining factor to access to finance. This is because a farmer with a high level of education is more likely to be well equipped with skills and competencies in agronomic and good farm management practices which impacts on farm level productivity. The number of years of farming measures the farmer's experience gained and can influence access to finance. (Weir, 1999; Huffman & Orazem, 2007). Similarly, a farmer with a good health status also signifies better human capital and is more likely to access finance (Tompa, 2002). Access to storage facility is also indicative of good technical knowhow and a predictor of access to finance. The rationale is that a farmer with access to storage facilities would have gained the technical knowledge to smoothen production and yield cycles through storage and thus reduce post-harvest losses and also stabilize income from sales (Kosgey, 2013). This knowhow can influence access to finance.

Access to community characteristics (access to potable water, access to nearest primary school, access to nearest secondary school, access to health centre, access to telephone service, access to electricity poles) influences a farmer's access to finance. This is because a well-developed community with access to economic and social facilities and infrastructure is a determining factor for establishing financial institutions and the supply of finance to borrowers (Asian Development Bank, 2000).

4.7. ESTIMATION OF THE AVERAGE TREATMENT EFFECTS

We adopted two estimation techniques, the PSM and the PSW.

4.7.1. Propensity Score Matching (PSM)

PSM is one of the impact evaluation methods that provide effective estimation of a causal effect in the absence of randomisation evaluation (Glennerster & Takavarasha, 2013). Indeed, randomisation, which is cardinal for experimental evaluation of effects that are attributed to treatments, effectively focuses on the design in terms of the random assignment to beneficiary and non-beneficiary groups before the project or program is rolled out (Christie & Alkin, 2013). In this regard, randomisation evaluation exercises much control in the selection of program or project participants prior to implementation. The method and application of randomisation eliminates the problem of selection bias that occurs in observational studies. However, in the absence of randomisation other quasi experimental tools can identify impact. Rosenbaum and Rubin (1983), Jalan and Ravallion (2003) and Glennerster and Takavarasha (2013) indicate that, under such conditions or assumptions, PSM is an effective tool for evaluation. The application of PSM is to mimic randomisation evaluation in order to control for unbiased results. The advantage of this technique is that it allows projects or programs to be evaluated even after its implementation.

PSM was chosen as the most suitable evaluation technique for the estimation of the average treatment effect of access to finance on household welfare of smallholder farmers. The reason is that the provision of finance to smallholder farmers under the AVCF project was neither randomised nor did the project implementing agencies have a practical and a more accurate baseline survey to indicate the effect of access to finance on household welfare that could be used for comparison and estimation of results. According to Gertler, Martinez, Premand, Rawlings and Vermeersch (2011), if a group did not participate in a project, but a counterfactual can be identified for comparison, PSM can be applied.

PSM is "the conditional probability of assignment to a particular treatment given a vector of observed covariates", according to Rosenbaum and Rubin (1983). By this model, both the beneficiaries and non-beneficiaries are given an equal chance of receiving the treatment, which, in this case, is access to finance. This is made possible following the estimation of the probability that a farmer receives finance given the row of characteristics observed within the survey. This is mathematically expressed in equation (4.1) as follows:

$$e(x) = \Pr(Z = 1 \mid X) \qquad Eq. (4.1)$$

With reference to Eq. (4.1), $e(x)$ denotes the propensity score, Z is the treatment (access to finance) and X the observed covariates. The estimation of the probability model in relation to the treatment Z and the covariates X is carried out using either logit or probit regression model (Austin, 2008 and Li, 2012).

Meanwhile, the estimation of PSM requires some assumptions. According to Rosenbaum and Rubin (1983), both the treatment model and the outcome must be conditionally independent, given the set of covariates. This further means that any exogenous variable that affects the treatment cannot impact on the outcome and vice versa. This is shown below as:

$$(Y_1, Y_0) \perp Z \mid X \qquad Eq. (4.2)$$

The overlap or common support condition is another assumption. This condition limits the units of analysis to a common region based on the propensity score. It offers the opportunity for the beneficiary group to have a comparison observation as per the propensity score. This is also known as statistical matching. A tenet of this assumption is that the conditional probability of each individual (farmer) receiving treatment (access to finance) must be positive and this must be within zero (0) and one (1). This implies that any observation with propensity score outside this region will be dropped to avoid overlapping, which is a violation of the assumption. This assumption is captured as:

$$0 < \Pr(Z_i = 1|X_i) < 1 \qquad Eq.(4.3)$$

Rosenbaum (2010) referred to both conditional independent and overlap assumptions as assumptions of "strong ignorability". Indeed, satisfying these conditions serves as a pre-condition for balancing covariates. By this, each smallholder farmer within the beneficiary group (access to finance) and non-beneficiary group (without access to finance) must have its covariates balanced based on the propensity scores. In other words, both the beneficiary and non-beneficiary groups must have the same or similar distribution, given the row of covariates. This is shown in equation (4.4a) below:

$$\Pr\{X|Z = 1, e(x)\} = \Pr\{X|Z = 0, e(x)\} \qquad Eq.(4.4a)$$

In similar vein, the observed covariates X and treatment Z must be conditionally independent given the propensity score (Rosenbaum, 2010). Explained differently, the set of observed covariates X and treatment Z are not expected to be correlated. This is denoted as:

$$X \perp Z \mid e\,(x) \qquad Eq.(4.4b)$$

Following the above is the estimation of the average treatment or causal effect, that is, the average treatment effect of access to finance on household welfare of smallholder farmers. This is a calculation of the mean outcome of the beneficiary group (Y_1) and that of the mean outcome of the comparative or control (non-beneficiary) group (Y_0). The mean difference in the outcome of the two independent groups' accounts for the average treatment effect (ATE). The ATET is simply the mean difference of the outcome of beneficiary (treated) and non-beneficiary (untreated) groups among farmers who actually received the treatment (access to finance) (Li, 2012). This is expressed by equation (4.5) below:

$$ATET_{psm} = E\{Y|Z = 1, e(x)\} - E\{Y|Z = 0, e(x)\} \qquad Eq.(4.5)$$

4.7.2. Propensity Score Weighting (PSW)

According to Olmos and Govindasamy (2015), PSW is an option to use in any evaluation, given the fact that it addresses the problem of selection bias emerging from a non-randomisation setting. According to Hirano and Imbens (2002) and Cerulli (2015), PSW is drawn from the work of Horvitz and Thompson (1952), who introduced the inverse probability weighting (IPW). The technique was used to estimate the total and mean population following the classification of the population into different strata using a probability selection model. The estimation method has received a lot of attention and is currently used in the evaluation of the average treatment effect. This technique has been observed to be closely associated with PSM (Cerulli, 2015).

In practice, the application of IPW primarily requires the estimation of the propensity score, given the set of covariates. The estimation of the propensity score is carried out using either the probit or logit regression model as shown in Equation (4.1). The second requirement is to construct the weights for each observation, that is, both the beneficiary and non-beneficiary groups. The application of this method is aimed at correcting for missing data that emerge as a result of unknown or unobserved variables, and creating a balance of the beneficiary and non-beneficiary groups based on the covariates (StataCorp, 2015; Olmos & Govindasamy, 2015). The weights are shown in equations (4.6a) and (4.6b) below. Equation 4.6a denotes the weight (w_1) for the beneficiary groups while equation 4.6b also stands for weight (w_0) for the non-beneficiary groups with $\hat{e}(x)$ being the estimated propensity score:

$$w_1 = \frac{1}{\hat{e}(x)} \qquad Eq.(4.6a)$$

$$w_0 = \frac{1}{1 - \hat{e}(x)} \qquad Eq.(4.6b)$$

Following these estimations, the weights are used in a weighted least squares (WLS) regression to estimate the ATE, which is the difference in the outcome variable between the treated and untreated groups (Hirano & Imbens, 2002; Cerulli, 2015; Olmos & Govindasamy, 2015). Lunceford and Davidian (2004) and Cerulli (2015) provide an estimation of the ATE using the IPW as follows:

$$ATE = \frac{1}{N}\sum_{i=1}^{N}\frac{Z_iY_i}{\hat{e}(x_i)} - \frac{1}{N}\sum_{i=1}^{N}\frac{(1 - Z_i)Y_i}{1 - \hat{e}(x_i)} \qquad Eq.(4.7)$$

From Eq. (4.7), N denotes the number of observations, Z_iY_i is the outcome of an individual (smallholder farmer) who has access to finance (beneficiary group) and $\hat{e}(x_i)$ is the estimated propensity score used as weight. On the other hand, $(1 - Z_i)Y_i$ denotes the outcome of an individual (smallholder farmer) who did not receive finance (non-beneficiary group) and the propensity of individual farmers within the non-beneficiary group denoted by $1 - \hat{e}(x_i)$.

Cerulli (2015) estimated the ATET as follows:

$$ATET = \frac{1}{N}\sum_{i=1}^{N}\frac{[Z_i - \hat{e}(x_i)]Y_i}{p(Z=1)[1- \hat{e}(x_i)]} \qquad Eq. (4.8)$$

In addition to the above, there is the selection of the inverse-propensity weight and regression adjustment (IPWRA), which is another weighting estimator. This estimator is a combination of two methods and is known as a "doubly-robust" estimator (Cerulli, 2015). It follows the steps for the estimation of IPW as enumerated above. However, the ATE of IPWRA is estimated using regression adjustment. The estimations of ATE and the ATET models are shown below following connotations used by Cerulli (2015):

$$ATE = \frac{1}{N}\sum_{i=1}^{N}[(\hat{a}_1 - \hat{b}_1 x_i) - (\hat{a}_0 - \hat{b}_0 x_i)] \qquad Eq. (4.9)$$

$$ATET = \frac{1}{N_1}\sum_{i=1}^{N} Z_1\, [(\hat{a}_1 - \hat{b}_1 x_i) - (\hat{a}_0 - \hat{b}_0 x_i)] \qquad Eq. (4.10)$$

From equations (4.9) and (4.10), $(\hat{a}_1 - \hat{b}_1 x_i)$ and $(\hat{a}_0 - \hat{b}_0 x_i)$ are the expected or mean outcome for the treated and untreated groups respectively, both of which are estimated by regression adjustment where N_1 and Z_1 in Eq. (4.10) denote the number of farmers and farmers with access to finance respectively.

4.8. CONSTRUCTION OF THE WELFARE (ASSET) COMPOSITE INDEX

Recent debates on welfare policies reveal a growing paradigm shift from income to asset-based welfare measurement. According to Brandolini, Magri and Smeeding (2010) and Oduro, Baah-Boateng and Boakye-Yiadom (2011), the income-based approach of measuring welfare is not enough measure of household welfare. They, therefore, argued that income, which is the flow of resources to a household over a period, does not fully represent the amount of resources owned and available to a household to depend on in times of economic shock. The rationale is that assets generate income for households in times of economic shock and they could also serve as collateral to access finance or otherwise sold to earn income to cushion a household's consumption. This implies that economic shocks resulting from limited income (that is income below poverty threshold) could be mitigated when a household has accumulated assets. In the same vein, Liverpool-Tasie and Winter-Nelson (2011) argued that asset-based welfare measurement is more preferred to income measurement of welfare for households in rural communities. This is mainly because unlike capturing data on household assets which is easier, the capturing of income of rural folks poses numerous challenges due to the volatile nature of their income.

In the light of the above, household assets ownership significantly contributes to household welfare both in the short and long term. In other words, the accumulation of assets is a pathway through which individuals and households improve their welfare (Sherraden, 1990; Paxton, 2003; Sherraden, Zou, Ku, Deng & Wang, 2015). According to Johnson and Sherraden (1992), the unique characteristic of asset ownership is that assets serve multiple development purposes. For example, asset ownership creates foundation for household stability, it cushions households against risks, empowers households socially and promotes household's participation in decision-making within a community.

However, consistent with the literature, welfare has been measured from either unidimensional or multidimensional perspectives or both, using variables such as household income and consumption expenditure, education, health, and per capita income, among others (Asselin, 2009). This study measured welfare using physical assets as the alternative approach. The significance of adopting assets as the preferred approach to measuring welfare is that assets reflect financial accumulations by an individual or household over a period and its measurement is also consistent with the use of an income or consumption-based approach (Sherraden, 1990; Sahn & Stifel, 2003).

Studies by Sahn and Stifel (2003), Booysen, Van der Berg, Burger, Maltitz and Rand (2008), Filmer and Scott (2011), Wietzke (2015), and Akotey and Adjasi (2015), among others, have all adopted an asset-based approach to measuring welfare. However, diverse methods were deployed for the construction of the asset index and notable among them are principal component analysis (PCA), factor analysis (FA) and multiple correspondence analysis (MCA) (Booysen et al., 2008). Following the work of Asselin (2002), MCA has recently been used by Booysen et al. (2008); Ayadi, Lahga and Chtioui (2008), and Akotey and Adjasi (2015), among others. The use of MCA is driven by the principle that the data is categorical or nominal. A categorical variable is therefore binary in nature, that is, the individual either owns a particular asset or does not (Asselin, 2002). On the other hand, PCA, which has been widely used, thrives on continuous data.

This study adopted the MCA method for the construction of the welfare index. Our contribution is to extend this method to the agricultural sector where we measure the welfare of smallholder farmers' households. This is, therefore, a paradigm shift from measuring the welfare of smallholder farmers using an income and consumption approach to asset-based approach. By adopting the notation used by Ayadi et al. (2008) and Booysen et al. (2008), the method for the construction of the welfare composite index is shown following the equations below:

$$A_i = \frac{\sum_{k=1}^{K} \sum_{j_k=1}^{J_k} W_{j_k}^{k} I_{ij_k}^{k}}{K} \qquad \text{Eq. (4.11)}$$

where:

A_i is the welfare composite index for each farmer's household i

K is the number of categorical indicators;

J_k is the number of categories for indicator k;

$W_{j_k}^{k}$ is the weight attributed to category j_k; and

$I_{ij_k}^{k}$ is a binary variable equal to 1 when farmers' household i had category j_k, and 0 otherwise.

The welfare composite index (A_i), for each farmer's household i is calculated as the average of the weights of binary variables $I_{ij_k}^{k}$

The weight to be assigned to each component of welfare index A_i is the normalised score which is obtained from MCA as $\frac{W_{j_k}^{k}}{\lambda_\alpha} = \frac{score}{engen\ value\ for\ axis\ \alpha}$ of the category $\boldsymbol{I}_{ij_k}^{k}$

where axis alpha (α) = 0 or 1. The full MCA welfare composite index (A_i) for each farmer's household i can also be expressed in the equation below:

$$A_i = I_{i1}W_1 + I_{i2}W_2 + ...I_{ij}W_j \qquad \text{Eq. (4.12)}$$

A total of twenty-six (26) categorical variables, which are assets accumulated by the households of smallholder farmers over a period, are used for the construction of the asset index. The list of assets and their assigned weights based on the binary variables is shown in Table 4.4 below. The welfare composite index indicates that owning an asset improves the welfare of a household while not owning an asset reduces the household's welfare. The result of the welfare index shows that the assigned weight of the assets varies from one asset to the other. The first dimension of the MCA explains 75.07 per cent of the inertia.

Table 4.4: Variables in the Welfare (Asset) Composite Index

Variables (Assets)	Categories	Weights
	Household Ownership of Physical Assets	
Furniture	Owns furniture	1.011
	Does not own furniture	-0.933
Sewing Machine	Owns a sewing machine	2.439
	Does not own a sewing machine	-0.340
Stove (Kerosene)	Owns a stove (kerosene)	4.211
	Does not own a stove (kerosene)	-0.076
Stove (Gas)	Owns a stove (gas)	10.362
	Does not own a stove (gas)	-0.060
Refrigerator	Owns a refrigerator	7.833
	Does not own a refrigerator	-0.223
Freezer	Owns a freezer	8.233
	Does not own a freezer	-0.173
Fan	Owns a fan	3.672
	Does not own a fan	-0.696
Radio	Owns a radio	0.686
	Does not own a radio	-1.770
Radio CD Player	Owns a radio CD player	5.214
	Does not own a radio CD player	-0.267
VCD/DVD Player	Owns a vcd/dvd player	4.941
	Does not own a vcd/dvd player	-0.248
Desktop	Owns a desktop	9.569
	Does not own a desktop	-0.064
Laptop	Owns a laptop	10.351
	Does not own a laptop	-0.035
Television	Owns a television set	3.379
	Does not own a television set	-0.792
Rice Cooker	Owns a rice cooker	12.571
	Does not own a rice cooker	-0.042
Iron (Electric)	Owns electric iron	6.499
	Does not own electric iron	-0.272
Iron (Box)	Owns an iron box	1.955
	Does not own iron box	-0.416
Bicycle	Owns a bicycle	0.520
	Does not own a bicycle	-1.703
Motorbike	Owns a motor bike	1.533
	Does not own a motor bike	-0.942
Car	Owns a car	4.876
	Does not own a car	-0.073
Microwave	Owns a microwave	9.261
	Does not own a microwave	-0.009
Mobile Phone	Owns a mobile phone	0.770
	Does not own a mobile phone	-1.495
House	Owns a house	0.370
	Does not own a house	-0.824

Variables (Assets)	Categories	Weights
Land	Owns a piece of land	0.495
	Does not own a piece of land	-0.890
Jewellery	Owns jewellery	1.404
	Does not own jewellery	-0.358
Mattress	Owns a mattress	1.171
	Does not own a mattress	-1.335
Livestock	Owns livestock	0.465
	Does not own livestock	-0.494

Source: Author's computation based on surveyed data of smallholder farmers in Ghana.

4.9. EMPIRICAL APPROACH & ESTIMATION PROCEDURES

This section discusses the choice of algorithms and the econometric estimation of the propensity score matching and IPW.

4.9.1. Choice of Estimators

This study adopted both matching and weighting estimators for the estimation of the treatment or causal effect of access to finance on household welfare of smallholder farmers. The rationale for the choice of these estimators is that they best address the problem of non-randomisation and selection bias. Matching is done on the propensity score by comparing the outcome of the observed covariate of the treated with the untreated. On the other hand, weighting estimators are based on weighted averages of the observed outcome variables for both the treated and untreated groups.

This study chose two matching estimators, namely nearest-neighbour matching (NNM) and PSM. Both NNM and PSM use specific distance between treated and untreated for matching of observations. In other words, they select the closeness between the treated and untreated observation for matching. In addition, there are two weighting estimators, the IPW and inverse probability weighting regression adjustment (IPWRA). IPWRA is interpreted as a combination of IPW and regression adjustment (RA).

4.9.2. Estimation of Propensity Score

The estimation of the average treatment effect of access to finance on welfare essentially requires the estimation of the probability or propensity score. This could be estimated via the probit or logit regression model. In other words, either of these models is used to predict a farmer's participation in access to finance. We chose the probit regression model for the estimation of the probability of receiving or having access to finance on the assumption that the regression error is standard normally distributed (Cameron and Trivedi, 2010). Access to finance, which is the treatment outcome, is binary, that is, it takes two values. This is shown in the model below, where the treatment variable (access to finance) is denoted as Z. The outcome of the binary variable is:

$$Z = \begin{cases} 1 \text{ if farmer } i \text{ received finance (i.e., beneficiary group)} \\ 0 \text{ if farmer } i \text{ did not receive finance (i.e., non} - \text{beneficiary group)} \end{cases}$$

The data used for this study has adequate information on farmer characteristics as well as community characteristics. Being guided by the information available in our data set, the choice of variables as predictors of access to finance was influenced by economic theory, knowledge about the farmer, farmer's household as well as the design and implementation of the project (Caliendo & Kopeinig, 2008). The results of the estimation of smallholder farmers' participation in access to finance are shown in Table 4.5 below.

Table 4.5: Estimation of Propensity Score (Participation in Access to Finance) – Probit Analysis

Variables	Control Group 1[16]			Control Group 2[17]		
	Coef.	Robust Std. Err	P-Value	Coef.	Robust Std. Err	P-Value
Gender (Sex)	0.295*	1.910	0.056	-0.166	0.166	0.319
Formal Education Grade:						
Basic	0.453**	2.090	0.037	-0.057	0.186	0.760
Secondary	-0.029	-0.100	0.924	0.563	0.405	0.165
Tertiary	0.116	0.180	0.856	0.168	0.703	0.811
Number of Years of Farming	-0.013*	-1.720	0.085	-0.014**	0.007	0.040
Access to potable water	-0.404***	-2.960	0.003	-0.172	0.149	0.248
Access to nearest primary school	-0.207	-1.120	0.264	-0.290*	0.165	0.079
Access to nearest secondary school	0.199	1.310	0.192	0.860***	0.156	0.000
Access to health insurance	0.274	0.960	0.339	0.367	0.237	0.121
Access to nearest health centre	-0.881	-1.100	0.270	1.065***	0.403	0.008
Access to storage facility	-0.049	-0.290	0.774	0.547***	0.196	0.005
Access to telephone service	-0.243	-0.940	0.347	-0.096	0.270	0.722
Access to electricity poles	0.072	0.520	0.601			
Constant	0.667	0.790	0.429	-1.337***	0.453	0.003
Observations		383			409	
Pseudo R^2		0.050			0.121	

*** p<0.01, ** p<0.05, * p<0.1

[16] "Finance – Control Group 1" – this data is beneficiaries of AVCF with access to finance (Treatment Group) and the non-beneficiaries of AVCF who are financially constrained (Control Group 1) used for the probit estimation
[17] "Finance – Control Group 2" – this data is beneficiaries of AVCF with access to finance (Treatment Group) and the non-beneficiaries of AVCF who are financially constrained (Control Group 2) used for the probit estimation

Table 4.5 presents the probit regression based on which the propensity score is estimated and the matching of treated and untreated is carried out. The results show that gender and access to basic school education are more likely to influence access to finance using Control Group 1. However, number of years of farming and access to potable water are less likely to predict smallholder farmer's access to finance. The results of the Control group 2 show that access to nearest secondary school, access to nearest health centre and storage facility are more likely to influence farme's ability to access finance while number of years of farming and access to nearest primary school are less likely to predict smallholder farmer's access to finance.

4.9.3. Distribution of Propensity Score Matching

This section highlights the region of common support following the estimation of the propensity score using the probit regression model. Khandker, Koolwal and Samad (2010) referred to the region of common support as those propensity scores ranging between the minimum and maximum values of the observations (smallholder farmers) that are within the treatment group. Using the Control Group 1, the result shows that the region of common support selected ranges from 0.175 to 0.790. Similarly, for the Control group 2, the region of common support selected is from 0.010 to 0.875. The distribution of propensity score across treated and non-treated groups for both Control Group 1 and Control Group 2 are plotted in Figures 4.1 and 4.2.

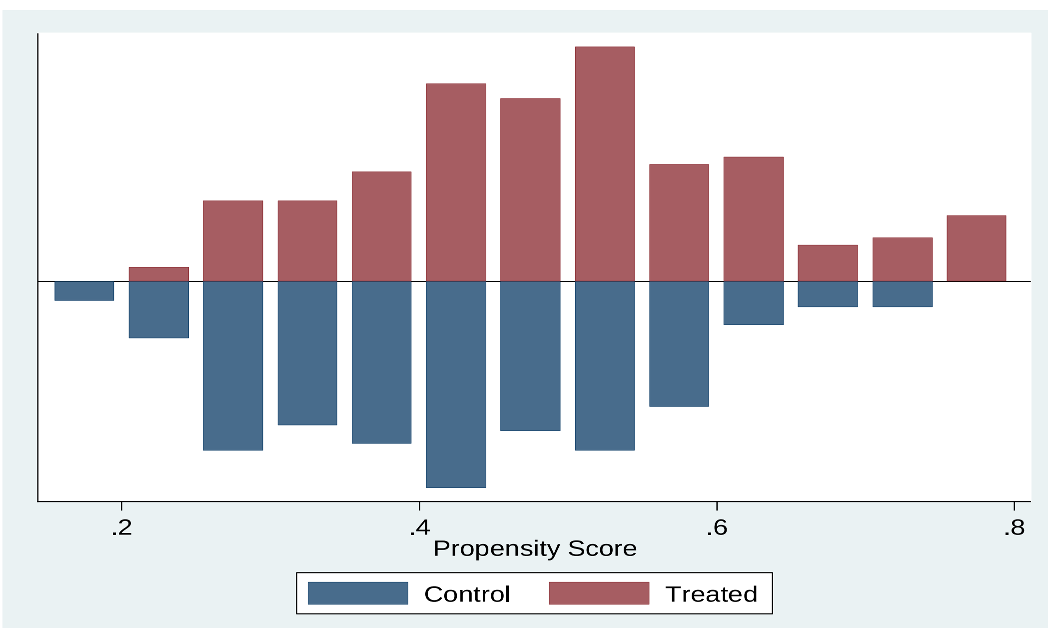

Figure 4.1: "Control Group 1"- Distribution of Propensity Score Among Treated (Farmers With Access to Finance) and Control (Finance Constraints)

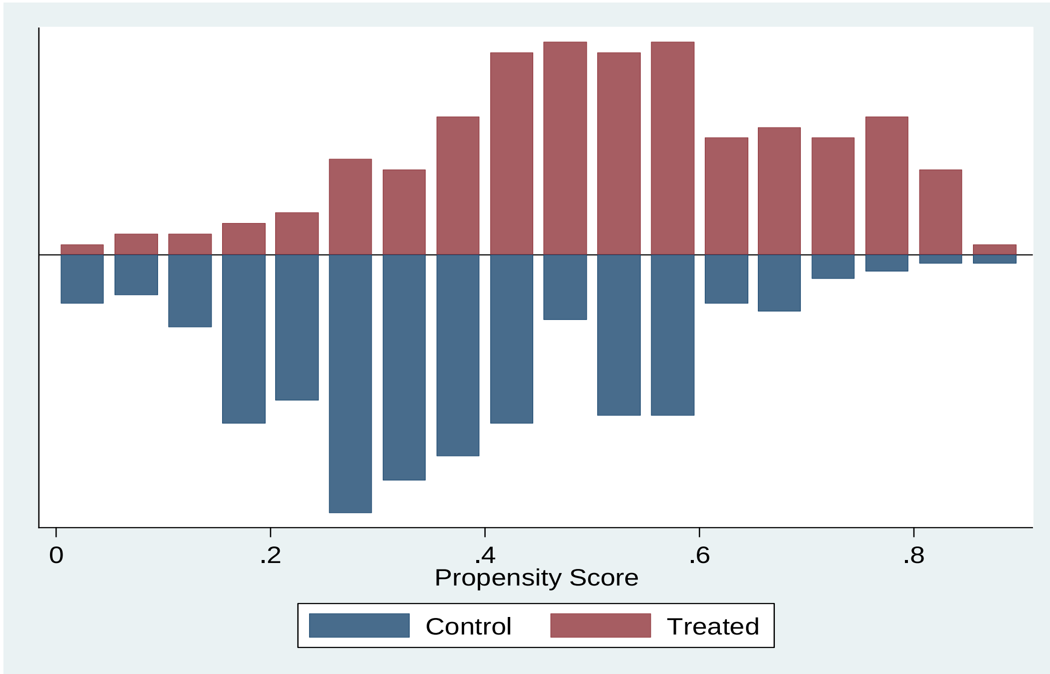

Figure 4.2: "Control Group 2"- Distribution of Propensity Score Among Treated (Farmers With Access to Finance) and Control (Finance Constraints)

4.10. DISCUSSION OF RESULTS

In this section, we present the results of the estimation of the effect of access to finance on the welfare of smallholder farmers using both PSM and PSW (IPW and IPWRA) applications to ensure robustness of results. Under the PSM estimators we used one to five (1 to 5) matching for estimating the ATET. For these, we used *teffects* stata commands. We also employ an additional PSW or reweighting estimator using *treatrew* which is user written stata command Cerulli (2015). The results of the treatment-effects estimations of access to finance on welfare of smallholder farm household are shown in Table 4.6.

Table 4.6: Treatment-effects Estimation of Access to Finance on Welfare of Smallholder Farm Household

Algorithms	Finance – Welfare (Control Group 1)			Finance – Welfare (Control Group 2)		
	ATET			ATET		
	Coefficient	Standard Errors	P-value	Coefficient	Standard Errors	P-value
Nearest-neighbour Matching (nnmatch) – (1 to 5 matching)	0.040***	0.013	0.001	0.079***	0.012	0.000
Propensity-score Matching (psmatch) – (1 to 5 matching)	0.029**	0.013	0.022	0.083***	0.013	0.000
Inverse-Probability Weights (IPW)	0.030**	0.013	0.018	0.068***	0.019	0.001
IPW Regression Adjustment (IPWRA)	0.030**	0.012	0.014	0.077***	0.013	0.000
Reweighting (treatrew)	0.031*	0.016	0.050	0.068*	0.041	0.097

Significance levels are based on AI Robust standard (errors in parentheses)
*** p<0.01, ** p<0.05, * p<0.1

Table 4.6 presents the estimation of the ATET using Control Group 1 and Control Group 2. The evidence as established by this study is that access to finance improves the welfare of smallholder farmers. Using all five estimators, the results were found to be statistically significant. A comparison of the two estimation results has clearly shown that the gains or impact of finance on the welfare of the household of smallholder farmers in Control Group 2 is higher than the impact of finance on welfare of farmer households in Control Group 1. For instance, regarding the Control Group 1, the results of the PSM and IPW show that the welfare of a smallholder farmer with access to finance is 2.9 per cent and 3 per cent respectively higher than a farmer who is financially constrained. However, the evidence from Control Group 2 using the same estimators reveals that the welfare of a smallholder farmer with access to finance is 8.3 per cent and 6.8 per cent respectively higher than a farmer who is financially constrained. The rest of the estimators have shown similar trends.

A comparative analysis of the results of the two groups as shown in Table 4.6 also revealed that though access to finance has a significant effect on welfare, a higher effect in terms of welfare enhancement is observed when the treatment of a hybrid service (access to finance and training) is compared with the welfare outcome of a more resource constraints group (Control Group 2). Clearly, the results show that the implementation of the AVCF project yields some positive returns on the welfare enhancement of smallholder farm household.

This study therefore provides the evidence on the effect of finance on the welfare of smallholder farm households using the case of Ghana. Although we used production credit and also focused on only smallholder farmers, our results confirm the results of other studies in Pakistan by Khandker and Faruqee (2003), in Vietnam by Quach et al. (2005) and in Ethiopia by Geda, et al. (2006).

4.11. POSTESTIMATION RESULTS

This section provides a test of the reliability of the results. It establishes a proof of balance of the covariate and a test of a hidden bias.

4.11.1. Covariates Balance

According to Austin (2011), "propensity score is a balance score". In this light, the baseline covariates or characteristics are expected to be similar when comparing the treated and the untreated groups using the propensity score or weight. The objective is to ensure that the model for the propensity score is accurate. This implies that where the covariates are not balanced, the propensity score is either over or under estimated (Ibid). To establish the accuracy of the propensity model on account of a balanced covariate, the application of the standardised difference is therefore required. Flury and Riedwyl (1986) and Tritchler (1995) define standardised difference as "mean difference in units of standard deviation". This is interpreted as the difference between the mean outcome of the treated and the untreated groups over the units of pooled standard deviation or the standard deviation among the total number of observations.

The vector of variables selected from the dataset used for the estimation of the propensity score are binary variables. Following the work of Austin (2011), we used the mathematical formula that considers binary variables to calculate the standardised difference (SD) as shown in Eq. 8 below. With reference to equation (8), $\hat{X}_{treated}$ and $\hat{X}_{untreated}$ represent the population means of the treated and the untreated groups respectively.

$$SD = \frac{(\hat{X}_{treated} - \hat{X}_{untreated})}{\sqrt{\frac{\hat{X}_{treated}(1 - \hat{X}_{treated}) + \hat{X}_{untreated}(1 - \hat{X}_{untreated})}{2}}} \qquad Eq.8$$

The results of the estimation of the weighted standardised difference of the various estimators are presented in Table 4.7. According to Austin and Stuart (2015), there is no universal agreement on the benchmark or limit to the score or value of the standardised difference at which one can reach a conclusion on the covariates being balanced or otherwise. Cohen (1992) provided population effect size index for various tests and described a standardised difference (effect size) with a value of 20 per cent (0.2) as small, 50 per cent (0.5) as medium and 80 per cent (0.8) as large. Accepting the value of 0.2 implies that the standardised difference that exists between the two groups on the account of the baseline covariate is small. On the other hand, Austin (2009) argues that a standardised difference of not greater than ten per cent (0.1) can be accepted as "negligible imbalance". However, Stuart, Lee and Leacy (2013) have clearly indicated that a standardised difference of value ranging from 0.1 to 0.25 is an acceptable imbalance. The evidence as shown in Table 4.7 indicates that all covariates are within the acceptable imbalance score of 0.1 to 0.25.

Table 4.7: Covariate Balance Summary

STANDARDIZED DIFFERENCE								
	Finance – Welfare (Control Group 1)				**Finance – Welfare (Control Group 2)**			
VARIABLES								
	Raw	NNM	PSM Weighted	IPW/IPWRA	Raw	NNM	PSM Weighted	IPW/IPWRA
Gender (Sex)	0.235	0.097	-0.008	-0.008	-0.053	-0.070	0.149	0.024
Formal Education Grade:								
Basic	0.253	0.133	0.020	0.040	-0.018	0.028	0.144	0.083
Secondary	0.040	0.044	-0.027	-0.046	0.179	0.034	-0.065	-0.164
Tertiary	0.017	0.077	0.062	-0.002	0.028	0.077	-0.048	-0.024
Number of Years of Farming	-0.110	-0.071	0.010	-0.005	-0.226	-0.042	-0.086	-0.087
Access to potable water	-0.304	-0.168	-0.034	0.012	0.008	-0.023	0.032	-0.058
Access to nearest primary school	-0.098	0.038	-0.046	-0.001	0.120	0.028	0.011	-0.019
Access to nearest secondary school	0.100	0.072	0.051	0.009	0.597	0.168	0.008	0.016
Access to health insurance	0.082	-0.025	0.034	0.070	0.355	-0.035	0.066	0.051
Access to nearest health centre	-0.073	-0.110	0.056	0.020	0.309	-0.011	0.086	-0.003
Access to storage facility	0.016	0.084	0.062	0.026	0.270	0.186	0.016	-0.004
Access to telephone service	-0.082	0.025	0.027	0.031	0.004	0.025	0.141	0.071
Access to electricity poles	0.041	0.042	-0.020	0.020				
Total Number of Observations	383	352	352	383	409	352	352	409.0
Treated Observations	176	176	176	191.8	176	176	176	204.8
Control Observations	207	176	176	191.2	233	176	176	204.2

4.11.2. Sensitivity Analysis

According to Rosenbaum (2002), although the result of the study clearly shows a relationship between access to finance and welfare enhancement of smallholder farmer, it is also short of stating, the welfare enhancement of a smallholder farmer is caused by the smallholder farmer's access to finance. On that note, we carry out a sensitivity analysis which is a test of the effect of hidden bias on the outcome. The rational is to ascertain whether indeed the welfare enhancement of a smallholder farmer is caused by the smallholder farmer's access to finance or it is possibly due to any variable that is not observed and, for that matter, not controlled as part of the covariates in the estimation model. This study applied the Rosenbaum bounds (rbounds) technique for the sensitivity analysis.

Table 4.8 shows that the result is free from a hidden bias. For Control Group 1, for instance, the critical level – gamma (Γ) at which a decision is made indicates that from 1.0 to 1.5, there is no effect of unknown variable. Similarly, Control Group 2 also showed no effect of unknown variable. The decision is made based on five per cent significant level using the upper bound. On that note, to show a hidden bias in Control Group 1 implies that there must be an upward movement or a change in magnitude of gamma (Γ) by more than a factor of Γ=1.5.

Table 4.8: Rosenbaum Sensitivity Analysis for Hidden Bias

Gamma (Γ)	Control Group 1 sig+	Control Group 2 sig+
1	0.000	0.000
1.1	0.000	0.000
1.2	0.001	0.000
1.3	0.004	0.000
1.4	0.013	0.000
1.5	0.033	0.000
1.6	**0.069**	0.001
1.7	0.123	0.003
1.8	0.198	0.008
1.9	0.288	0.017
2	0.389	0.031

4.12. CONCLUSION

This essay evaluated the impact of access to finance on the welfare of smallholder farm households using data from a field survey carried out in the Northern Region of Ghana. To control for selection bias as a result of the observational study, we adopted the PSM and the PSW estimators. By using the PSM techniques for intensive evaluation, we compared the mean outcome of the beneficiary (treated) group, that is smallholder farmers with access to finance, with the mean outcome of non-beneficiary (control) group to assess the net effect of access to finance on the welfare of a smallholder farm household.

Using two non-beneficiary (control) groups for robustness checks, that is beneficiaries of AVCF project who are financially constrained (Control Group 1) and the non-beneficiaries of AVCF who are also financially constrained (Control Group 2), the results or the treatment-effects have shown a positive and statistically significant effect of access to finance on the welfare of a smallholder farm household. We can conclude that access to finance stimulates improvements in welfare of smallholder farm households through smallholder farmer's income generation and entrepreneurial activities. In other words, through increasing agricultural productivity and market participation or commercialization of farm produce, smallholder earn income to meet consumption needs. However, we also observed that the combined treatment-effects of access to finance and training yield a higher impact.

The result is therefore consistent with theory on the link between finance and welfare. The study has also shown that the use of production credit which is a short to medium-term working capital is significant for smallholder farmers. In Africa, smallholder farming is a fundamental production activity through which households can use finance (production credit) to increase their welfare. Most household economic activity in Africa is structured around agriculture and smallholder farming. However, very little is known about the impact of finance on smallholder farmers.

The evidence of this study has clearly shown that financial sector policies could be focused not only on rural finance in general but instead should be geared towards unlocking the challenges of agricultural financing at all levels. To this end, developing a comprehensive agricultural value-chain finance policy will play a cardinal role towards improving access to finance and improving the welfare of smallholder farmers. Agricultural policies could also have significant financing subcomponents aimed at financing the agricultural value chain.

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APPENDIX 'A'

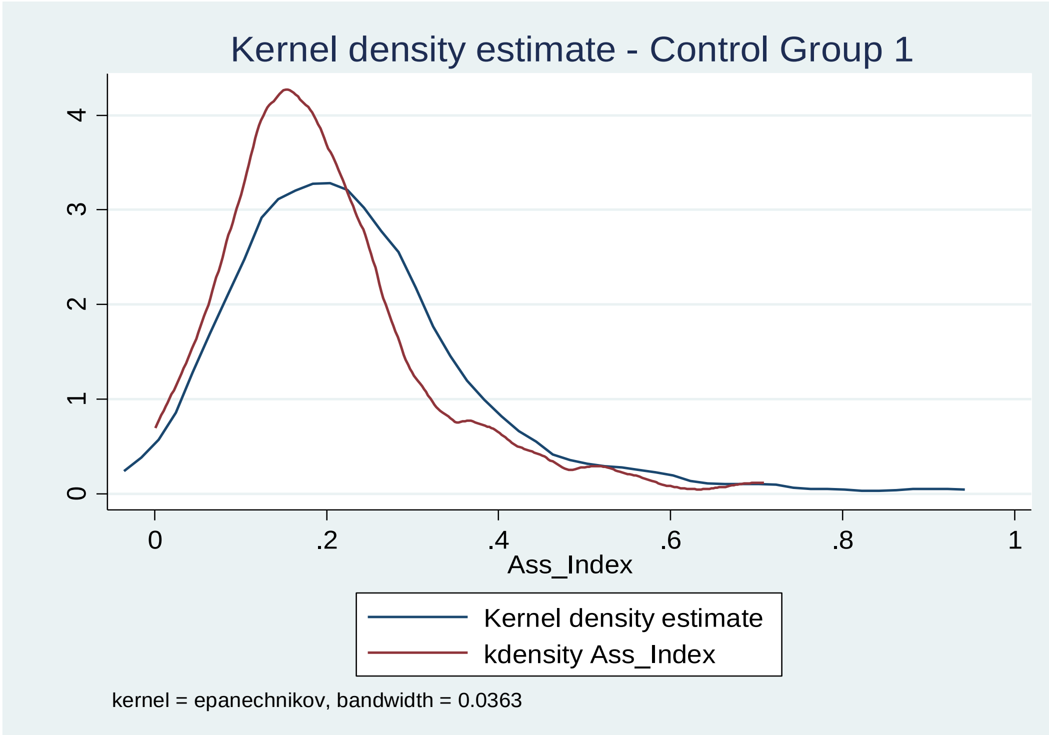

Figure 4.3: Control Group 1 - Distribution of welfare per a beneficiary farmer (access to finance) compared to non-beneficiary farmer (without access to finance).

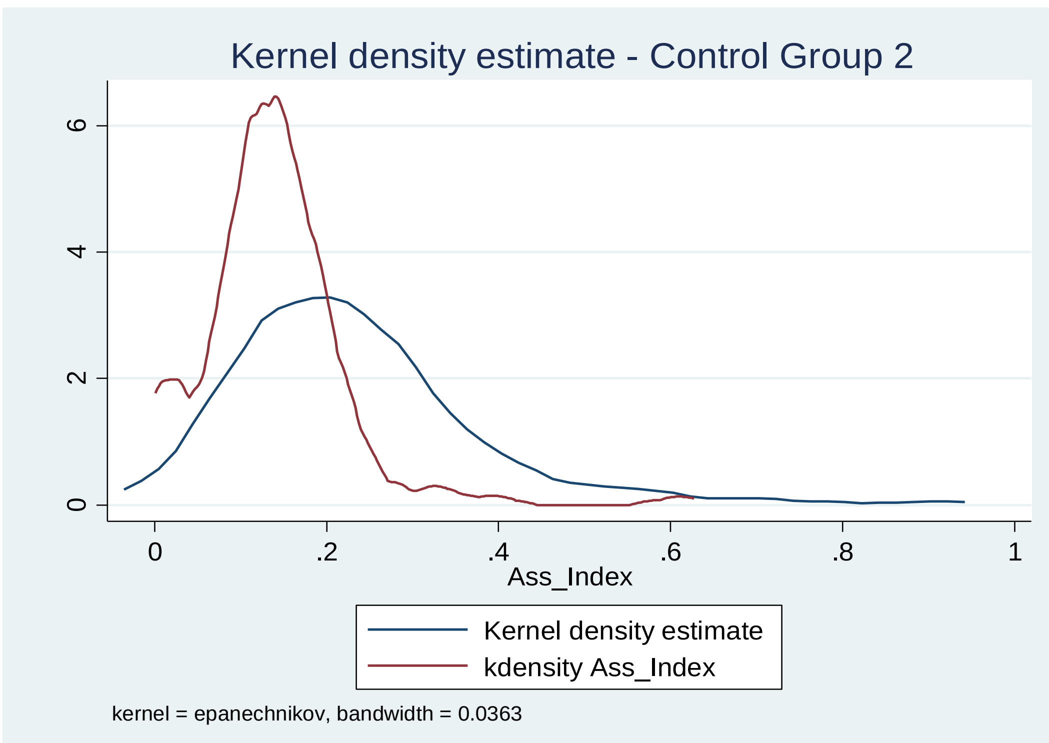

Figure 4.4: Control Group 2 – Distribution of welfare per a beneficiary farmer (access to finance) compared to non-beneficiary farmer (without access to finance).

APPENDIX 'B'

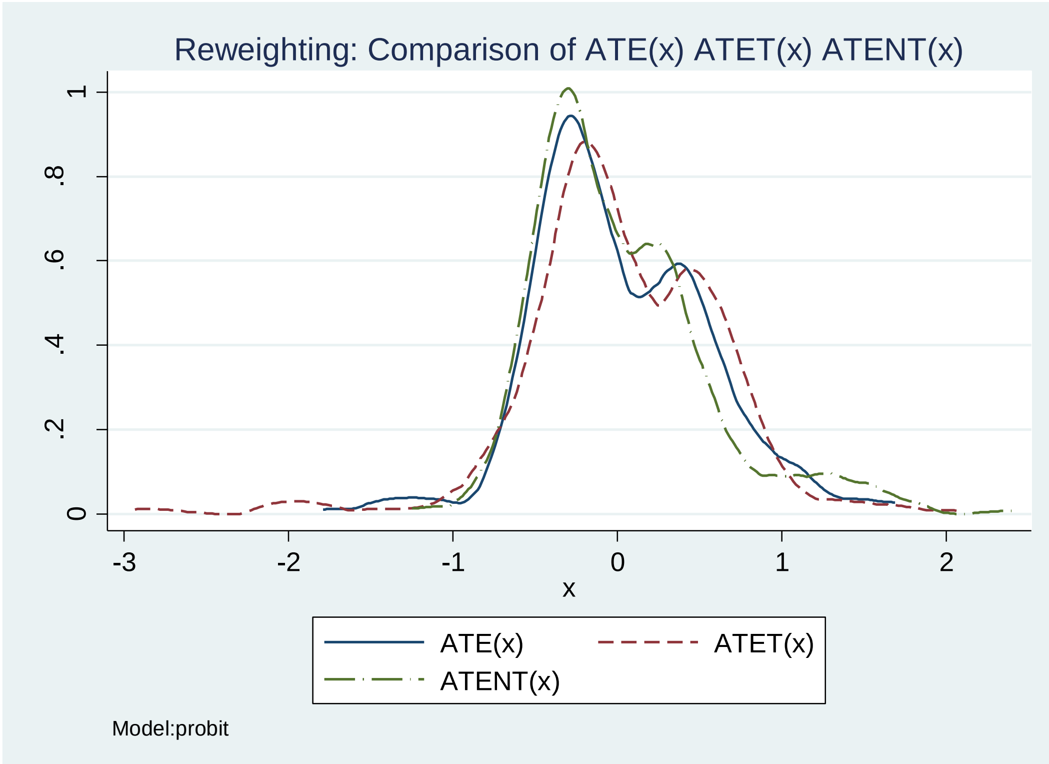

Figure 4.5: Control Group 1 – Estimation of the Distribution of ATE(x), ATET(x) and ATENT(x) by Reweighting on the Propensity Score

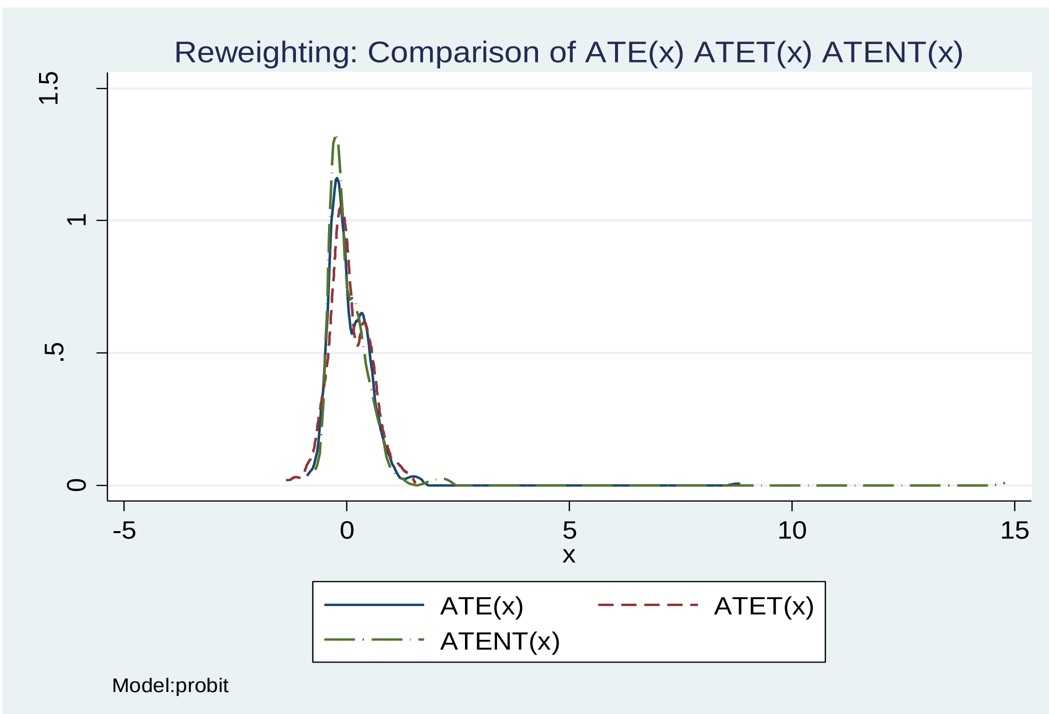

Figure 4.6: Control Group 2 – Estimation of the Distribution of ATE(x), ATET(x) and ATENT(x) by Reweighting on the Propensity Score

APPENDIX 'C'

Table 4.9: Definition and Summary Statistics of Variables Used for Probit Estimation and Econometric Estimation of the Impact of Finance on Welfare of Smallholder Farm Household in Ghana - For Finance – Control Group 1

Variable	Obs	Mean	Std. Dev.	Min	Max	Label
Welfare	383	0.214	0.133	0.001	0.906	Farmer's household welfare status
Finance	384	0.458	0.499	0	1	1 if farmer has access to finance or otherwise zero (0)
Gender (Sex)	384	0.651	0.477	0	1	1 if farmer is male or otherwise zero (0)
Formal Education Grade:						
Basic	384	0.122	0.328	0	1	1 if farmer completes basic school education or otherwise zero (0)
Secondary	384	0.057	0.233	0	1	1 if farmer completes secondary school education or otherwise zero (0)
Tertiary	384	0.010	0.102	0	1	1 if farmer completes tertiary education or otherwise zero (0)
Number of Years of Farming	384	15.219	9.945	1	50	Number of years farmer has been engaged in farming
Access to potable water	383	0.392	0.489	0	1	1 if farmer has access to potable water or otherwise zero (0)
Access to nearest primary school	383	0.783	0.413	0	1	1 if farmer has access to primary school or otherwise zero (0)
Access to nearest secondary school	383	0.501	0.501	0	1	1 if farmer has access to secondary school or otherwise zero (0)
Access to health insurance	383	0.932	0.252	0	1	1 if farmer has access to health insurance or otherwise zero (0)
Access to nearest health centre	383	0.992	0.088	0	1	1 if farmer has access to health centre or otherwise zero (0)
Access to storage facility	383	0.201	0.401	0	1	1 if farmer has access to storage facility or otherwise zero (0)
Access to telephone service	383	0.068	0.252	0	1	1 if farmer has access to telephone services or otherwise zero (0)
Access to electricity poles	383	0.546	0.499	0	1	1 if farmer has access to electricity pole or otherwise zero (0)

APPENDIX 'D'

Table 4.10: Definition and Summary Statistics of Variables Used for Probit Estimation and Econometric Estimation of the Impact of Finance on Welfare of Smallholder Farm Household in Ghana - For Finance – Control Group 2

Variable	Obs	Mean	Std. Dev.	Min	Max	Label
Welfare	409	0.178	0.122	0.001	0.906	Farmer's household welfare status
Finance	409	0.430	0.496	0	1	1 if farmer has access to finance or otherwise zero (0)
Gender (Sex)	409	0.724	0.448	0	1	1 if farmer is male or otherwise zero (0)
Formal Education Grade:						
Basic	409	0.169	0.375	0	1	1 if farmer completes basic school education or otherwise zero (0)
Secondary	409	0.042	0.200	0	1	1 if farmer completes secondary school education or otherwise zero (0)
Tertiary	409	0.010	0.099	0	1	1 if farmer completes tertiary education or otherwise zero (0)
Number of Years of Farming	409	16.051	11.134	1	50	Number of years farmer has been engaged in farming
Access to potable water	409	0.311	0.463	0	1	1 if farmer has access to potable water or otherwise zero (0)
Access to nearest primary school	409	0.731	0.444	0	1	1 if farmer has access to primary school or otherwise zero (0)
Access to nearest secondary school	409	0.369	0.483	0	1	1 if farmer has access to secondary school or otherwise zero (0)
Access to health insurance	409	0.880	0.325	0	1	1 if farmer has access to health insurance or otherwise zero (0)
Access to nearest health centre	409	0.954	0.211	0	1	1 if farmer has access to health centre or otherwise zero (0)
Access to storage facility	409	0.149	0.357	0	1	1 if farmer has access to storage facility or otherwise zero (0)
Access to telephone service	409	0.056	0.231	0	1	1 if farmer has access to telephone services or otherwise zero (0)

CHAPTER 5
MARKET PARTICIPATION OF SMALLHOLDER FARMERS IN NORTHERN GHANA

5.1. INTRODUCTION

This paper assesses the market access and market participation amongst smallholder farmers. An accepted view for structural transformation in the agricultural sector, according to the World Bank (2008), is for smallholder farmers to adopt a market-oriented farming system to improve market access and enhance market participation. For several reasons, smallholder farmers' market participation contributes to increased income earned from the sale of farm produce, increased agricultural productivity and improved welfare (Beets, 1990; Obi, Van Schalkwyk & Van Tilburg, 2012). However, market participation remains one of the constraints facing smallholder farmers due to imperfect market information, physical infrastructure challenges and institutional factors (Minot, 1986; Chamberlin & Jayne, 2011; Jari & Fraser, 2012).

According to Pingali and Rosegrant (1995) and Wickramasinghe, Omot, Patiken and Ryan (2014), the relevance of market participation lies in the fact that it leads to product specialisation with its expected outcome of improved quantity and quality of products. Pingali and Rosegrant (1995) argue that East Asia, Southeast Asia and part of Latin America are actively pursuing a market participation drive as compared to South Asia and SSA that are placed lower on the ladder of market participation. This raises concern for African countries. What are the determining factors to market access and participation amongst African smallholder farmers?

Indeed, there are many gaps in the literature on explaining factors that determine market participation of smallholder farmers. Delgado (1999) argues that smallholder farmers are crowded out of market participation because of the high transaction costs associated with production and marketing. Transaction cost includes information gathering, negotiation, bargaining and enforcing of contracts and monitoring of agents (Jaleta, Gebremedhin & Hoekstra, 2009). Oruko and Ndung'u (2009) add that in addition to information, inputs such as seeds and fertilizer, and access to finance affect market participation and intensity of participation. Jouanjean (2013) highlight access to transport, energy and communication infrastructure and agro-climatic conditions as the factors that drive market participation. In the view of Wickramasinghe and Weinberger (2013), transportation and transaction costs are the main determinants of market participation. However, the literature is also mixed on explaining factors that affect the market access and market participation. For instance, Karaan (2009) argues that most of the factors in the literature mainly influence market access and market participation of large-scale farmers in terms of reduction in transaction costs as compared to smallholder farmers.

Livingston, Schonberger and Delaney (2014) argue that the smallholder farmer is challenged with high transportation cost mainly because of the geographical location of the farmer, which is far from market centres coupled with the poor road network in SSA. This raises deep and broad questions for contexts like Africa where most of the farming is smallholder based and further justifies the need to investigate the determinants of access to market and market participation. It is also important to note that the decision to access market and market participation are two different issues, especially for smallholder farmers. Market access refers to having access to spot market where economic activities takes place in terms of the exchange of goods and services between a seller (supplier) and a buyer (consumer) through a price mechanism (van Tilburg and van Schalkwyk, 2012). On the other hand, market participation refers to the sale of output or the degree by which an economic agent sells in the market (Gebremedhin and Jaleta,2012). Clearly there is a distinction between market access and market participation and therefore, factors that affect these decisions can influence them separately and in different directions.

In this paper, we attempted to bridge the gap by modelling the decision to have access to market and market participate in a comprehensive manner and show the importance of context-specific factors in these decisions and their determining factors. In addition, studies on market participation in Africa are very scanty and rare, mainly due to non-availability of data. We further contribute to the literature by providing new results on factors that influence market access and market participation using the Agricultural Value Chain Facility (AVCF) project. The project was designed with focus on smallholder farmers increasing quantity and at the same time improving on quality to meet the needs of the customer.

Ghana's commitment towards boosting agricultural productivity and growth through its agricultural modernisation policies with focus on market participation makes the country an interesting case worth evaluating. The Accelerated Agricultural Growth and Development Strategy (AAGDS), the Food and Agricultural Sector Development Policy (FASDEP) I & II are some of the policy frameworks that highlight market participation as part of the core Ghanaian agricultural development strategies (MoFA, 2007). FASDEP II is unique because of its focus on a value-chain approach, which links actors within the agricultural sector from production to domestic market (Shwedel, 2006). However, smallholder farmers' market participation is constrained by poor road infrastructure, lack of storage facilities, lack of agro-processing facilities, and a poor marketing system (Sutton & Kpentey, 2012). The negative effect of these challenges is the high transaction costs of production and marketing which translate into high prices of farm produce in Ghana. The impact is the low (33%) market participation of smallholder farmers in Ghana (IFAD-IFPRI, 2011).

The rest of the paper is outlined as follows: Section 2 presents an overview of market participation policies in Ghana with stylised facts on wholesale prices of selected food crops and overview of the AVCF project. Section 3 discusses the conceptual framework of market participation and empirical literature reviews. Data and an econometric framework are presented in section 4. Section 5 presents discussion of empirical results with the conclusions in section 6.

5.2. OVERVIEW OF MARKET PARTICIPATION POLICIES IN GHANA

Ghana's agricultural policies over the years mainly focused on modernisation of the agricultural sector and development of a market-oriented drive that seeks to strongly promote both domestic and foreign products (Nyanteng & Dapaah, 1997; Aryeetey & Nyanteng, 2006). The rationale is to meet the growing local demand because of population growth and to improve food security. This section presents Ghana's agricultural policies geared towards market participation.

Seini (2002) opines that the establishment of food marketing institutions from 1963–1970 in Ghana focused on developing marketing policies and controlling food pricing to protect and encourage smallholder farmers to participate in the market. The institutions are the Task Force Food Distribution Corporation (TFFDC) and the Grains Marketing Board (GMB), which later merged to form the GFDC. The objective for the establishment of GFDC was to provide marketing opportunities for smallholder farmers. Despite the role played by GFDC, the implementation period was characterised by low marketing as it was only able to manage less than ten per cent of marketable surplus (Aryeetey & Nyanteng, 2006). However, the introduction and implementation of trade liberalisation and free market policies under the ERP and the SAP era led to the demise of the GFDC in the 1990s.

The MTADP, which was implemented after the ERP / SAP era from 1991–2000, focused on enhancing market participation of agricultural products through the promotion of effective linkage between agriculture and industry. This promoted growth based on comparative advantage and resource endowment and created opportunity for a market pricing system (Nyanteng & Dapaah, 1997; Asante & Awo, 2017). As part of Ghana's vision 2020 agenda, the implementation of agricultural policies that are closely associated with marketing from 1996–2000 also focused on developing agricultural infrastructure with advanced technologies to increase production, promote an export diversification agenda, establish competitive pricing for farm produce, and reduce post-harvest losses. Additionally, the Government of Ghana introduced production incentives to stimulate smallholder farmers' market participation. Some of these incentives are input supply and distribution, input price subsidies, institutional credit, output market outlets, guaranteed producer prices and production bonus (Nyanteng & Dapaah, 1997).

Several projects emerged under the above-mentioned policies. An example is the Smallholder Credit, Input Supply and Marketing (SCISM) project that focused on infrastructure development, which includes developing access roads in farming communities. The Agricultural Sector Investment Project (ASIP) also focused on investment in road infrastructure in rural areas and the agro-processing industry, and development of market infrastructure through the provision of storage facilities (Asante and Awo, 2017). Similarly, the Village Infrastructure Programme (VIP) focused on strengthening rural transport systems, water infrastructure, storage, processing and marketing facilities (IFAD).

Like the above policies, the AAGDS, which was developed and implemented from 1997 to 2000, focused on increasing smallholder farmers' market participation through the promotion of selected products, improvement in access to technology and infrastructure, including small-scale irrigation projects and access to financial markets (Aryeetey & Nyanteng, 2006). The implementation of the FASDEP I from 2001 to 2004 followed the same direction as AAGDS (Asante & Awo, 2017). Building on FASDEP I, FASDEP II (2005–2008) paid attention to modernisation and mechanisation of agriculture, and provision of irrigation infrastructure as well as enhancing the competitiveness and integration of farmers into domestic and international markets. The policy initiatives of FASDEP II are associated with policies under the AU's New Partnership for Africa's Development (NEPAD) and the CAADP geared towards improving rural infrastructure and trade-related capacities for improved market participation (MoFA, 2007).

Other agricultural marketing policy initiatives implemented in Ghana have also been captured by the METASIP (2011–2015). This seeks to promote market participation by developing agro-business facilities such as storage and processing facilities, and equipment for mechanisation (MoFA, 2010). Several projects that have been initiated under these broad polices are Agricultural Mechanization Service Centre (AMSEC), Block Farming Program and the National Food Buffer Stock Company (NAFCO) (Asante & Awo, 2017), and the Ghana Commercial Agricultural Project (GCAP), which was established in 2012. According to Aryeetey and Nyanteng (2006), the agricultural E-Commerce project is one of the new market participations enhancing initiatives. The objective of the project is to provide information on market and prices of agricultural products to the various market segments (local, regional and international markets).

Despite the numerous policies that have been initiated and implemented to transform the agricultural sector of Ghana through increasing market participation, there remain several challenges that serve as a hindrance to achieving the set objectives. According to Seini (2002) and Aryeetey and Nyanteng (2006), Ghana experiences low market participation because of poor marketing, poor transport infrastructure and poor storage facilities, which increase transaction costs. The result is the high cost of transportation, accounting for 70 per cent of total marketing cost (Aryeetey & Nyanteng, 2006). The resultant post-harvest loss of agricultural products is estimated to range between 30 per cent and 40 per cent of total production (Sutton & Kpentey, 2012).

5.3. MARKET OUTLETS AND AVERAGE PRICE OF SELECTED CROPS IN GHANA

Several outlets are used for marketing of agricultural crops in Ghana, namely the primary, secondary and tertiary markets (Aryeetey & Nyanteng, 2006). Primary markets are located within the rural communities that are close to the farming areas. These markets do not function daily, which limits the rate of market participation. Secondary markets are located in major cities and towns that operate daily, yet there are specific days within the week known as “market days”. Tertiary markets are located in both rural and urban areas where the dominant players are the wholesalers and retailers who are intermediaries between the farmers (producers) and consumers (Aryeetey & Nyanteng, 2006). These middlemen transport the farm produce from the farm to the tertiary market, thereby playing a critical role in the formulation and establishment of prices of the various commodities (Quartey, Udry, Al-Hassan & Seshie, 2012). Other market outlets in Ghana include the pre-harvest contractor, farm gate buyer, market trader, consumer, state trading organisation, cooperative and exporter (Quartey et al., 2012).

Table 5.1 highlights the average farm gate price of selected crops in Ghana from 2012–2016. It shows that, generally, the average farm gate prices of the selected crops have been increasing over the years with only a few of them showing a reduction in price. For instance, in 2012–2013 the price of maize decreased by 20 per cent and, during the same period, the price of cowpea also reduced by 12 per cent and millet by two per cent. Similarly, the price of paddy rice decreased by eight per cent in 2013–2014 and the price of groundnut (unshelled) also decreased by seven per cent in 2015–2016.

Table 5.1: National Average Farm Gate Prices of Selected Crops in Local Currency (Ghana Cedis)

YEAR	Maize (100 kg/bag)	Local Rice (100 kg/bag)	Groundnut (Unshelled) (37 kg/bag)	Cowpea (109 kg/bag)	Soyabean (109 kg/bag)	Millet (93 kg/bag)	Paddy Rice (84 kg/bag)	Sorghum (109 kg/bag)
2012	83.41	136.12		192.89		101.73	65.24	83.03
2013	66.33	143.61		169.94		99.79	78.71	85.53
2014	85.54	187.51	83.74	202.64		102.96	72.69	95.09
2015	108.75	229.16	111.59	228.70		117.12	86.42	110.63
2016	123.32	307.98	104.26	275.86	162.51	136.50	105.64	127.41

Source: Ministry of Food and Agriculture (MoFA) - Statistics, Research and Information Directorate.

Table 5.2: National Average Wholesale Prices of Selected Crops in Local Currency (Ghana Cedis)

YEAR	Maize (100 kg/bag)	Local Rice (100 kg/bag)	Groundnut (Unshelled) (37 kg/bag)	Groundnut (Shelled) (82 kg/bag)	Cowpea (109 kg/bag)	Soyabean (109 kg/bag)	Millet (93 kg/bag)	Paddy Rice (84 kg/bag)	Sorghum (109 kg/bag)
2007	27.11	58.21	20.24	62.17	53.18		37.62		35.60
2008	46.87	86.89	32.46	94.28	92.21		60.62		59.03
2009	53.87	104.35	36.44	117.93	107.79	58.13	74.21		71.65
2010	49.15	107.53	40.04	128.67	116.02	71.80	76.48	59.57	73.51
2011	64.90	119.81	53.56	181.72	136.70	99.44	83.20	63.93	83.17
2012	89.65	146.06	71.76	261.28	206.50	126.37	116.85	77.94	108.50
2013	75.06	164.90	85.31	254.92	218.39	130.83	135.54	133.42	124.85
2014	104.61	218.91	121.87	310.96	266.91	184.99	151.06	99.94	147.44
2015	140.51	264.83	111.77	404.18	305.13	253.21	179.04	120.61	177.89

Source: Ministry of Food and Agriculture (MoFA) – Statistics, Research and Information Directorate

Table 5.2 presents the average wholesale price of selected crops in Ghana from 2007 to 2015. The table reveal that the prices for these crops have shown a consistent increase. Except for paddy rice that recorded an average change in price of 12 per cent from 2007 to 2015 within the same periods, the remaining products recorded on average an increase in price ranging between 21 per cent and 28 per cent. The highest price change was groundnut (shelled) at 27.55 per cent and the lowest, soybean, at 21.36 per cent. However, some of the crops recorded some reduction in price at some points in time. For instance, the price of maize reduced by eight per cent from 2009 to 2010 and by 16.27 per cent from 2012 to 2013. Paddy rice also recorded a 25.09 per cent reduction in price from 2013 to 2014. There is a significant high change in price for all crops (no data for soyabean and paddy rice) from 2007 to 2008, ranging from a minimum of 49.27 per cent for local rice to 73.39 per cent for cowpea. The change in price of these commodities from year to year could be explained by inflation. This affects production and transportation costs and ultimately impacting on prices of goods.

By comparing the average farm gate prices to the wholesale prices, it is evident that wholesale prices are higher than the farm gate prices. This could be attributed to transportation and transaction costs and margins of profit gained by the wholesaler. The data from 2012–2015 shows that the price difference between wholesale price and that of the farm gate price for millet, paddy rice and sorghum are the highest as compared to the price gaps for maize and cowpea.

5.4. OVERVIEW OF THE AGRICULTURAL VALUE CHAIN FACILITY (AVCF)

The AVCF was a program which was funded by the Danish International Development Agency (DANIDA) and implemented under the guidance, management and coordination of the Alliance for Green Revolution in Africa (AGRA). The project was implemented over a five-year period from 2010 to 2015 with the goal to "increase income and employment in rural areas, particularly in breadbasket areas of Northern Ghana, through increased agricultural production, productivity and value addition" (DANIDA, 2009).

The AVCF adopted a comprehensive and holistic value chain approach to address key challenges facing agricultural development in Ghana such as low productivity, poor market access and the lack of access to finance. Thus, the focus is on input supply, production, processing. distribution and then to consumption. As a result, the project focused on strengthening and widening the link between smallholder farmers and agro-dealers for input market supply; providing mentorship and technical skills support through training of smallholder farmers to increase productivity; training on business and entrepreneurial skills to improve access to market and providing financial services support to the target groups to meet their finance needs. In brief, AVCF focused on "improving medium to long term access to finance combined with mentorship/technical assistance to key players in the value chains, including commercial farmers, seed producers, input suppliers and agro-dealers, agribusiness and agro-processors, marketers, farmer-based organizations and groups/associations of out-grower farmers" (Ibid). That is, the AVCF takes the form of interconnectivity of actors within the agricultural sector which in this case is, agro-dealer or services provider supplying farm inputs to smallholder farmers for production and then followed by distribution or marketing using various marketing outlets to the consumer. This creates the opportunity for finance and information to flow through the chain. Through this chain or interconnectivity, AVCF is expected to increase farm inputs through agro-dealers, increase productivity, increase market access and participation and finally increase access to finance.

To achieve the AVCF objective of "improving entrepreneurial and technical skills of small and medium entrepreneurs (SMEs) (agro-businesses) and farmers while also strengthening linkages between actors across the agricultural value chains", AGRA which is the agent responsible for facilitating, coordinating and managing the project engaged a consortium of three institutions to implement the mentorship and advisory services under the project name the Agricultural Value Chain Mentorship Project (AVCMP) given the fact that each institution has its unique focus. These institutions are as follows:

1. International Fertilizer Development Center (IFDC) - responsible for small and medium enterprise (SME) support component. The focus among others include training SMEs and business associations in business development and entrepreneurial skills and facilitating business partnerships (market linkages) between SMEs, agro-dealers and identified markets;
2. Savanna Agricultural Research Institute (SARI) - responsible for productivity support component. That is to improve improve technical and farm business management skills of Farmer Based Organizations (FBOs) and their member farmers to adopt the application of Integrated Soil Fertility Management (ISFM) technologies; and
3. Ghana Agricultural Associations Business Information Centre (GAABIC) - responsible for agro-dealer support component. The focus of this component is to facilitate access to finance to agro-dealers for farm inputs and support farmers to expand productivity, improve food security and increase agro-dealer market access.

The Adventist Development and Relief Agency (ADRA) was also engaged by AGRA to implement the mentorship and advisory services under the project name Integrated Agricultural Productivity

Improvement and Marketing Project (INTAPIMP). The project was implemented with the support service providers.

5.5. THEORETICAL LITERATURE

Within the domain of smallholder farmers' market participation is the subject of transaction cost. It is hypothesised that a reduction in transaction cost coupled with increased productivity influences smallholder market participation (Fafchamps, 1992; FAO, 2014). De Janvry et al. (1991) present a model using household food and cash crops to examine household investment decisions as a measure of market participation. The model suggested that transaction costs can be used as the motivation for a smallholder farmer to participate in the market. In their model, De Janvry, Fafchamps and Sadoulet (1991) argued that market participation is realised when the cost of transaction is less than the gap between the market price and the self-sufficiency or "shadow" price. At the heart of market participation is the gain or the maximum satisfaction that the smallholder farmer derives. That satisfaction is expected to be above the cost of transaction for a smallholder farmer to access the market. Where the gain is below the cost of transaction, the result is market failure. In the light of this, De Janvry et al. (1991) argued that market failure is a function of households' decision to participate in the market but not of the availability of commodity.

According to Mather, Boughton and Jayne (2013), a smallholder farmer's investment behaviour towards market participation is influenced by the gap between the sales price and purchase price of a product. In this case, decision on market participation is influenced by the basis of the transaction between a producer and a buyer. The underpinning factors of such transactions are the price related effects that run from production through market to consumption (Mather et al., 2013). The production related factors are financed for improved farm inputs and low productivity. The marketing related factors include transport costs, storage, searching and processing of information, negotiation contracts, monitoring of agents and contract enforcement (Jaleta et al., 2009). According to Fafchamps (1992), self-sufficiency of food and food security influence smallholder farmers' participation in the market. As a result, when farmers are faced with the risks of food price or market volatility at a time that they are not covered by any insurance policy, they are influenced to access the market. In this regard, the consumption effects of price volatility are significant to market participation of a smallholder farmer.

It is also hypothesised that resource endowments (household productive assets) are determinants of market participation (Boughton, Mather, Barrett, Benfica & Abdula, 2007; Barrett, 2008; Mather et al., 2013). Boughton et al. (2007) argued that, because of the heterogeneity of resource endowment across the spectrum of farm households, there are also corresponding market segments for each farm household's participation. In other words, a smallholder farmer's participation in a particular market depends on the depth of resource endowment holdings of the farm household. Jaleta et al. (2009) are of the view that the rationale for the significance of resource endowment that influences smallholder market participation strongly points to the effect on consumption-related factors. This means that resource endowment such as human and physical endowments of a farm household reduces the risk of a smallholder farmer in market participation. Jari and Fraser (2012) classified these markets as informal and formal markets. The informal market is the market characterised by unofficial transaction between the producer and the buyer. Formal market, on the other hand, is driven by a well-structured procedure grounded within the norms, rules and regulations guiding the transaction. Thus, smallholder farmers' participation in a particular market is associated with the level of market returns and risk exposure.

According to Pingali (1997), market participation is a decision-making process of production and marketing which is carried out simultaneously. Thus, investment in agricultural technologies and adaptation of improved agronomic practices that result in increase in both food and cash crops production stimulate market participation of a smallholder farmer (Barrett, 2007; Jaleta et al., 2009; FAO, 2014). In this regard, the choice for the adoption of a productive technology is influenced by the nature and efficiency of the market. In this vein, the difference between a smallholder farmer using an advanced production technology and a farmer using obsolete tools and technologies is that the farmer with improved technologies is focused on participating in the market, thereby increasing productivity.

Other determinants of market participation are some characteristics of the external environment. In other words, an improved external environment influences market participation. According to Von Braun (1995) and Barrett (2008), investments in public goods and infrastructural development such as roads, energy and communication are essential ingredients that influence the decision-making of a smallholder farmer to participate in the market. The rationale is that, with an improved infrastructure, the cost of transportation and other related transaction costs of producing and marketing of agricultural products are expected to decrease, thereby serving as a catalyst for smallholder farmers' market participation.

It is also argued that improving market participation requires the creation of an enabling business environment, including promoting resilient macroeconomic policies and developing appropriate or relevant market policies (Von Braun, 1995; Jaleta et al., 2009). In effect, a smallholder farmer is not able to participate in the market when macroeconomic factors such as inflation and the financial market are unfavourable. Similarly, the development of market policies, which entails developing pricing systems, location and facilities as well as improving quality and standards at various segments of the market, such as rural, national and regional, significantly influence decision-making in market participation by a smallholder farmer. Also significant is the role of institutions. By institution, we refer to rules, regulations and legal frameworks that shape interactions between a producer and a buyer in a market (Ostrom, 2005). Thus, in the absence of such structured rules and norms, the smallholder farmer who is an actor is influenced by the choice of not participating in the market.

Similarly, different crops (maize, groundnut, soyabean, rice) serve different needs. For instance, maize is more of food crop than cash crop while groundnut, soyabean and rice are mainly cash crops hence the sale of these products is targeted at different customers. These crops also mature with different cycles. For instance, it takes between 75 to 90 days for maize to grow, 115 to 125 days for groundnut, 100 to 118 days for soyabean and for rice, it takes between 130 – 160 days to grow. The variations in the growth pattern therefore influence marketing patterns and strategies. This confirms the need to address smallholder farmers' needs in unique ways especially where these farmers grow different crops.[18]This confirms the need to address smallholder farmer's needs in unique ways especially where these farmers grow different crops. Using different marketing processes for different crops with each crop accounting for its transactions costs and the fact that a crop may be cash or food crop could account for the differences in the factors that predict market access and market participation.

5.6. EMPIRICAL LITERATURE

There are few studies on market participation and intensity of participation by smallholder farmers. These studies have shown that numerous factors influence the decision of smallholder farmers to access the market and to participate in the market. This section reviews some of these studies and presents their findings. The estimation techniques used are also highlighted.

In Africa, Randela, Alemu and Groenewald (2008) focused on examining the effect of transaction costs on market participation in South Africa and found that ownership of transport, access to market information, and age have a positive effect on farm households' decision to market their produce. Distance to market also established a positive relationship with market participation, a result found to be contrary to the *a priori* expectation. The implication is that the longer the distance the more likely the farmers will participate in the market. A logistic regression model was applied for estimation of results. Similarly, in Kenya, Omiti, Otieno, Nyanamba and McCullough (2009) examined factors influencing

[18] CSIR Crop Varieties Released and Registered in Ghana

market participation and found that farmers in peri-urban areas have a higher level of market participation than those in rural areas. In effect, distance to market hinders market participation. The study also revealed that output price and market information have significant positive effects on market participation. The results of the study were estimated using a truncated regression model.

A study in Nigeria by Osebeyo and Aye (2014) on the effect of transaction costs on market participation decisions revealed that market information has a positive effect on such decisions of smallholder tomato farmers in Makurdi, Benue State. The study also found that transport cost and distance to market have a negative effect on market decision. The results showed that access to finance has a positive relationship with market participation, but the effect was not statistically significant. A logit model was used for estimation of results. Similarly, in Ghana, Musah, Bonsu and Seini (2014) assessed the determinants of market participation among smallholder maize farmers in the Upper West Region of Ghana and found that private assets, public assets, transaction costs and access to finance are factors that significantly influence farmers' access to market and market participation.

In Ethiopia, Demeke and Haji (2014) provided some empirical evidence on factors affecting smallholder farming. The results of their study revealed that farmers' age, gender, labour expenditure, and farm size have a positive effect on their market participation. Access to finance was found to have a positive relationship with market participation but the effect was statistically insignificant. Data for the study were obtained from the Ethiopian Rural Household Survey (ERHS) and were estimated using the multinomial logistics regression model. Similarly, in a study by Ahmed et al. (2016) in the Oromia Region of Ethiopia on the determinants of smallholder farmers' potato market participation, they found that the level of education, commodity market price and access to market information have a positive effect on the decision to participate in the market. A probit regression model was used for the estimation of results.

In yet another study, Sebatta, Mugisha, Katungi, Kashaaru and Kyomugisha (2014) examined smallholder farmers' decision-making and extent of potato market participation in Uganda. The results of the study indicated that sex (gender) and membership of a cooperative union are strong determinants of market participation. The Heckman selection model was applied for estimation of the result. Similarly, in Tanzania, Ismail, Srinivas and Tundui (2015) examined the effect of transaction cost on market participation and found that transaction cost significantly influenced smallholder farmers' decision in maize market participation. The study also found transportation cost and middlemen costs as determinants of market participation. The study, which used data on smallholder farmers in Kongwa and Mpwapwa districts, adopted a binary logistic regression model for estimation.

In Asia, Osmani and Hossain (2015) assessed the determinants of market participation of smallholder farmers in Bangladesh and found that there is a high level of market participation as they increased sales by 57 per cent. The study also revealed that farm size, household labor, farm and non-farm income are some of the determinants of market participation. In this study, access to finance was found to have a negative relationship with market participation. However, the effect was statistically insignificant. The data for the study were drawn from 100 smallholder farmers in Rajshadi District and were estimated using the probit regression model.

The empirical results of the studies (Randela et al, 2008; Omitiet al., 2009; Osebeyo and Aye 2014; Musah et al., 2014; Demeke and Haji 2014; Sebatta et al., 2014; Ismail et al., 2015; Osmani and Hossain 2015; Ahmed et al., 2016) presented have shown that the factors influencing smallholder farmers' market access and market participation are conflicting. The empirical literature has, therefore, shown that the choice of factors influencing market access and market participation widely varies across the various studies and is also not classified under marketing channels such as transaction costs and/or production costs. More so, most of these studies except for Omitiet al. (2009), Musah et al. (2014) and Sebatta et al. (2014), who used rigorous econometric estimations that sought to show that a farmer's decision to access the market and participate are made jointly or are separable. The rest of the studies only used predictive analysis techniques such as probit or logit models, which is also a weakness of these previous studies.

This paper, therefore, contributes to the empirical literature on the determinants of market access and market participation of smallholder farmers. This paper differs from others as it assesses the determinants of market access and participation with a focus on multiple farm products (maize, groundnut, soyabean and rice) of a farmer with a minimum of one crop. Under this condition, the farmer (producer and seller) with more than one crop is faced with the challenge of which factors affect the decision to access the market and to participate in the cultivation of a specific farm product. Second, we classified the choice of factors based on marketing channels such as socio-economic factors and transaction and production costs factors, and estimated our results using rigorous econometric methods on the assumption that a farmer's decision to access the market and participate in the market are separable. Data for the study were also drawn from the AVCF project that focused on increasing market access and participation of smallholder farmers.

5.7. ECONOMETRIC METHODOLOGY

This study estimated the factors influencing smallholder farmers' market access and those that influence market participation in terms of quantity of maize, groundnut, soyabean and rice sold. The OLS estimation was not used because the outcome (dependent) variable contains discrete values that are also observed over a range (Maddala, 1983; Cameron & Trivedi, 2010). Goetz (1992) pointed out that when the discrete and continuous decisions to access the market are affected by unobservable factors (cultural values), an estimation using OLS will produce a result that is not consistent. There is also the problem of zero cases with regard to farmers who do not sell maize. One can control for these zero cases as a missing data problem via sample selection models or treat them as a corner solution modelled by Tobit or a Double hurdle model (Mather et al., 2013). The decision not to access the market is, therefore, influenced by economic factors or conditions of the farmer (Martínez-Espiñeira, 2006; Mather et al., 2013). For estimation techniques, Yen and Huang (1996) and Reyes, Donovan, Bernsten and Maredia (2012) point out three models that deal with data with multiple zeros: the Tobit model by Tobin (1958), the double hurdle (DH) model by Cragg (1971) and the Heckman model by Heckman (1979).

5.7.1. The Tobit model

The application of the Tobit model follows the restrictive assumption, which holds that the set of factors that influence a smallholder farmer to access the market are the same factors that influence market participation, measured by the quantity of products sold. This implies that the decision to access the market and market participation are non-separable and thus happen jointly.

The specification of the Tobit model is defined as follows:

$$y_i^* = x_i\beta + \varepsilon_i \qquad \text{Eq. (5.1)}$$

$$y_i = \begin{cases} y_i^* \; if \; y_i^* > 0 \\ 0 \; if \; y_i^* \leq 0 \end{cases} \qquad \text{Eq. (5.2)}$$

where y_i^* is the latent variable equation indicating a smallholder farmer's decision to access the market and y_i denotes the market participation. The vector of exogenous and observed variables which simultaneously explain both the decision to access and to participate in the market is denoted as x_i, while β is the coefficient of the set of exogenous x to be estimated and ε_i the error term.

5.7.2. Double hurdle model

An alternative to the Tobit model is the double hurdle (DH) model. The underlining principle of the DH model is the element of separability, implying that the decision of a smallholder farmer to access the market and the decision as regards to market participation are influenced by two separate factors. According to Martınez-Espineira (2006), the factors influencing the decision to access the market are the characteristics of the farmer. At the second stage of the decision process, which is the decision on market participation (the quantity of sales), such a decision is only made given that the farmer is now participating in the market. The factors driving such decision depend on separate indicators.

In the light of the theory of the DH model, the specifications are in two parts, consisting of a model for market access, which is estimated using a probit regression, and a second model for market participation, estimated using truncated regression (Yen & Huang, 1996; Martınez-Espineira, 2006; Elek, Köllő, Reizer & Szabó, 2011). The models are presented below:

Market access equation:

$$q_t^* = z_t\alpha + u_t \qquad \text{Eq. (5.3)}$$

$$q_t = \begin{cases} 1 \ if \ q_t^* > 0 \\ 0 \ if \ q_t^* \leq 0 \end{cases} \qquad \text{Eq. (5.4)}$$

Market participation equation:

$$y_t^* = x_t\beta + \varepsilon_t \qquad \text{Eq. (5.5)}$$

$$y_t = \begin{cases} y_t^* \ if \ y_t^* > 0 \ and \ q_t^* > 0 \\ 0 \ if \ y_t^* \leq 0 \end{cases} \qquad \text{Eq. (5.6)}$$

From Eqs. (5.3) and (5.5), q^* and y^* are the latent market access and market participation respectively with z and x denoting exogenous variables, while α and β are the coefficients and u_t and ε_t the respective error terms. Equation (5.6) also indicates that market participation depends on the farmer's decision to market access.

Although both Tobit and DH models are possible estimation techniques, the DH model is usually the preferred choice due to its ability to model the separability principles of the decision to access the market and market participation at the same time. Though the DH is our model of choice, we also estimate the

Tobit model for robustness. Here we apply the Vuong (1989) model selection criteria to choose between the DH and Tobit models. The selection criteria equation is given as:

$$\lambda = 2\,(LL_{probit} + LL_{truncreg} - LL_{tobit}) \qquad \text{Eq. (5.7)}$$

Where the rule of thumb is that the Tobit model is rejected in favour of the DH when the log likelihood ratio (λ) exceeds the specific chi-square critical value. Although the DH is often used, it may also be a problem in the presence of selection bias. We therefore also estimated the Heckman sample selection model for further robustness.

5.7.3. Heckman selection model

The Heckman selection model, as earlier mentioned, also follows the principle of separability. However, the use of this model controls for selection bias, which occurs as a result of non-randomisation, resulting in self-selectivity (Heckman, 1978 and 1979). The estimation requires a consistent two-step estimator, which are the probit and OLS below:

$$q_k^* = z_k\alpha + \upsilon_k \qquad \text{Eq. (5.8)}$$

$$q_k = \begin{cases} 1 \;\; if \;\; q_k^* > 0 \\ 0 \;\; if \;\; q_k^* \leq 0 \end{cases} \qquad \text{Eq. (5.9)}$$

Thus Prob$(q_k = 1|z_k)$ = $\Phi\,(z_k\alpha)$ and Prob$(q_k = 0|z_k)$ = 1 - $\Phi\,(z_k\alpha)$

First is the estimation of the selection equation (Eq.) 5.8, a probit regression of market access (q_k) on the vector of exogenous variables (z_k) with υ_k as the error term. This selects the probability of smallholder farmers' market access or otherwise. The rationale is that market access (q_k) is an endogenous binary-treatment variable which takes the value one (1) if smallholder farmers access the market and zero (0) if otherwise. This is explained by Eq. (5.10).

The estimation of Eq. (5.9) generates the cumulative distribution function (CDF) $\Phi(.)$ and the probability density function (PDF) $\phi(.)$ of the standard normal. These parameters are used to compute the *inverse Mills ratio,* also known as the *hazard lambda* denoted as λ. The estimation of the *inverse Mills ratio* (λ) is simply the ratio of the predicted value of the probability density function of the standard normal (ϕ) to the cumulative distribution function of the standard normal (Φ). The function of the *inverse Mills ratio* (λ) is to correct or account for the selection bias. The computation of the *inverse Mills ratio* (λ) is shown below:

$$\lambda_k = \frac{\phi(z_k\widehat{\alpha})}{\Phi(z_k\widehat{\alpha})} \qquad \text{Eq. (5.10)}$$

The generated *inverse Mills ratio* (λ) is plugged into the outcome equation (Eq.)11 for the estimation of the market participation (y_k).

$$y_k = x_k\beta + \lambda + \varepsilon_k \qquad \text{Eq. (5.11)}$$

Following Gabre-Madhin, Dawit and Dejene (2007) we define market participation as the ratio of total quantity of agricultural goods or products sold (sales) by a smallholder farmer to the total quantity of agricultural production. The set of determinants of market participation is denoted by x and ε_k the error term.

Though we performed the model selection technique as shown per the above estimation technique, our preferred choice is the double-hurdle model. The motivation for the choice of this model for all the estimations is that farmers in Ghana and for that matter Northern Region make decisions to access the market and decisions to participate in the market based on different factors. Thus, those decisions are separable. Within the context of Northern Region of Ghana, farmers first and foremost consider farming as a tradition, thus way of life, and the ability to meet their consumption needs. Secondly, it is a matter of pride for a farm household to store farm produce for the unknown. Thus, farmers' decisions in the two instances are separable; for instance, market participation in some cases is influenced by the need to raise income to finance the traditional needs or healthcare or educational needs of households.

Following the literature, the theoretical underpinning of determinants to market access and market participation is classified into two transaction costs split into market (transportation and search cost) and production-related costs. These costs and socioeconomic factors are discussed next. The variables capture factors determining market access and market participation and this is presented in Table 5.3. For socioeconomic factors, we include household characteristics such as gender, farmers' years of farming, farmers' level of education and household size as explanatory variables. By closing the gender disparity gap, women are offered farms and have access to market information (Marenya, Kassie, Jaleta & Rahut, 2017). To this end, gender is expected to either positively or negatively influence market access or market participation. Experience, measured by the number of years in farming, could contribute towards developing the farmer's bargaining and negotiation skills, knowledge of the nature of the market as well as understanding the pricing system. However, this effect could also be negative, as diminishing returns set in after some years of farming (Mukundi, Mathenge&Ngigi, 2013). The level of education of a farmer enables him or her to acquire skills and knowledge that impact on technical efficiency. This is expected to reduce searching and transaction costs and therefore expected to have a positive effect on production and ultimately market access and market participation (Huffman &Orazem, 2007). According to Alene et al. (2008) household size is indicative of labour size and could influence market access and market participation.

Table 5.3: Variable Description

Variable	Description	Measurement	Expected sign
Market Access (q)	Decision to access the market	1 if Farmer have access to market or otherwise zero (0)	
Market Participation (y)	Quantity of sales	Quantity of products sold	
Socioeconomic Factors			
Gender	Sex of a farmer	1 if Farmer is a Male or otherwise zero (0)	+ / -
Education Grade	Education level of farmer	1 if Farmer has completed at least basic education or otherwise zero (0)	+ / -
Years of Farming	Years of farming	Number of years	+ / -
Household Size	Household size of a farmer	Number of people in the household	+ / -
Market-Related Factors			
Participation in AVCF	Beneficiary of AVCF	1 if Farmer participates in AVCF or otherwise zero (0)	+
Radio	Ownership of radio	1 if Farmer owns a radio or otherwise zero (0)	+
Mobile	Ownership of mobile phone	1 if Farmer owns a mobile phone or otherwise zero (0)	+
Access to Storage Facility	Access & use of storage facility	1 if Farmer uses storage facility or otherwise zero (0)	+
Information on Commodity Prices	Information on commodity prices	1 if Farmer has information on commodity prices or otherwise zero (0)	+
Information on Market Buyers	Information on market buyers	1 if Farmer has information on market buyers or otherwise zero (0)	+
Motorbike	Ownership of motorbike	1 if Farmer owns a motorbike or otherwise zero (0)	+
Expenditure on Transport	Transportation cost	1 if Farmer incurred cost on transport or otherwise zero (0)	-
Distance to Market	Distance to the nearest market	Kilometres	-
Distance to Road	Distance to the nearest motorable road	Kilometres	-
Production-Related Factors			
Farm Size (Ha)	Farm Size	Hectares	+ / -
Finance (Production Credit)	Access to production credit (finance)	1 if Farmer has access to finance or otherwise zero (0)	+
Access to Extension Officer	Access to extension services	1 if Farmer has access to extension services or otherwise zero (0)	+

In the case of transaction cost factors from market related factors, participating in the AVCF is expected to have a positive effect on market access and market participation. This is because the program was designed with a focus on market participation. Members of AVCF were part of farmer-based organisations (FBOs) who received training on business development services that include marketing. This, therefore, is expected to influence search and information costs. Ownership of radio and mobile phone offers smallholder farmers the opportunity to readily access market-related information that is broadcasted through various channels of accessing information. The effect is the reduction on search and information costs and is thus expected to have a positive effect on their decision about market access and their market participation (World Bank, 2007; Reardon &Timmer, 2007; Heinemann, 2014; Tadesse&Bahiigwa, 2015; Muricho, Kassie&Obare, 2015). Access to storage facilities is expected to influence market access and participation of smallholder farmers. According to Beets (1990), farmers with access to storage facilities are reluctant to sell their products irrespective of the bargaining power of buyers (farm gate). Access to information on commodity prices and market buyers reduces search and transaction costs and is therefore expected to influence market access and participation positively (Barrett, 2008). Ownership of a means of transport (e.g. motorbike), distance to market, and distance to nearest motorable roads are expected to have a positive effect on smallholder farmers' decision to access the market and to participate in the market. This is because the absence of such factors increases the transportation and market search costs (Key, Sadoulet& De Janvry, 2000; Mather et al., 2013).

The production-related factors to transaction costs captured in our models are access to extension services, access to finance (production credit and savings), and farm size. Access to extension officers' influences smallholders' market access and market participation (Alene et al., 2008). With the support of extension officers, smallholder farmers adopt new varieties of farm inputs such as seeds and can adopt advanced and efficient technological methods of farming, which is expected to improve production. In addition, extension officers also provide farmers with market information in terms of prices and market conditions (Anderson &Feder, 2007). To this end, we expect access to extension officers to have a positive effect on market access and market participation. Farm size is expected to have either a positive or negative effect on market access and market participation. With access to finance, smallholder farmers can finance their production needs, for instance, financing the cost of farm inputs such as fertilizer and seedlings. This is expected to improve production, which will in turn transform or lift smallholder farmers from subsistence through semi-commercial to commercial farming (Miller & Jones, 2010). Consequently, finance is expected to improve market access and market participation.

5.8. DATA

This study relied on data drawn from the AVCF project. The data was collected through a survey which was carried out using a questionnaire as the instrument to gather vital information on farmers' demographic characteristics and key socioeconomic variables which, among others, include farmers' level of education, production, market access, financial access and household asset ownership. The project focused on staple crops: maize, rice, soyabeans and groundnut farmers. The data for the study was collected based on 2014/2015 farming season.

This study examines the determinants of market access and market participation of smallholder farmers. The focus of analysis for this paper is on the farm level. The data for this study consisted of two groups of farmers (the AVCF group and the non-AVCF group). Both groups consisted of farmers who were farming in either one or a combination of the following crops: maize, rice, soyabean and groundnut. The total number of the beneficiaries of AVCF consisted of 27,856 farmers across the Northern Region of Ghana. To obtain the sampled data, we applied a combination of convenient, stratified and proportional sampling techniques. This was made possible following a two-stage approach: we first selected seven communities from each of the 22 districts representing 154 communities from the Northern Region of Ghana. In the second stage, we randomly selected 1,700 farmers from the 154 communities. After data cleaning and editing we had data on 1,608 farmers. The total number of plot farms owned by the 1,608 smallholder farmers stands was recorded at 2,724 plot farms covering all the four crops. Of the total number of 2,724 plot farms, 1,163 were for maize plot farms, 698 were for groundnut plot farm, 645 soyabean plot farms and 218 rice plot farms.

The data for the non-AVCF group were collected on farmers in selected communities of the Northern and Brong Ahafo (BA) regions with a total number of 295 farmers and 200 farmers respectively. The selected communities for this survey have in common the same agro-ecological zone and areas where agricultural practices and socioeconomic characteristics of the farmers are similar to the beneficiary group. After data cleaning and editing, the total number of smallholder farmers was recorded at 484. The total number of plot farms owned by the 484 smallholder farmers stands at 701 plot farms covering all the four crops. The data reveal 369 maize plot farms only, 261 groundnut plot farms only, 44 soyabean plot farms and 27 rice plot farms.

5.9. DESCRIPTIVE STATISTICS

Table 5.4 shows that the characteristics of maize farmers are similar except for slight differences in gender (sex), household size, years of farming and farm size. For groundnut farmers, the tests show that the characteristics are similar except for slight differences in gender (sex), education grade, household size and farm size. The test of similarities for soyabean farmers also shows that the two groups are similar. For rice farmers, we found that the two groups were similar except for a slight difference in household size.

Table 5.5 also shows the marketing channels through which a smallholder farmer sells his or her farm produce. For all four crops (maize, groundnut, soyabean and rice), the data shows that over 80 per cent of farm produce are sold through the market trader channel while on average, the number of farmers who sell their farm produce through farm gates is less than 10 per cent. However, a key stakeholder or actor in the marketing of agricultural commodities and financing of farmers in Ghana is "middlemen". In other words, the middlemen play intermediary role between the farmer and the market trader (Quartey et al., 2012). According to Nyarko (2016), the role of middlemen among others include building trust as well as social and economic ties with the farmer and the market trader, facilitating suppliers' credit and buyers' credit, monitoring the progress of farm produce being cultivated and finally ensuring that farm produce are transported to the market for sale. Thus, the role of middlemen in the agricultural sector is multifaceted.

Specifically, Quartey et al. (2012) and Nyarko (2016) referred to the relationship between farmers and middlemen in Ghana to be very significant. This is because, providing finance for farm inputs through input suppliers or agro-dealers creates the avenue for the farmer to sell the farm produce to the market trader based on a specified agreement reached by the parties. This implies that middlemen are sources (informal) of financing agricultural production as a result of the perceived risks associated with financing smallholder farmers by financial institutions. The source of finance for the middlemen is either through the market traders or the "market queens" or from the middlemen's own resources. The structuring of a financing deal between middlemen and farmers brings about contract farming where the parties have agreed on price and quantity of farm produce to be supplied prior to the production period. As a result, the middlemen provide some comfort to smallholder farmers due to the off-taker agreement leaving the farmer to focus on producing quality products to meet the market demand.

For facilitating marketing and financial intermediation between the farmer and market trader, the middlemen are entitled to a margin on the sale of farm produce. According to Quartey et al. (2012), gross market margins earned by middlemen vary from market to market and also from commodity to commodity. This could be explained based on transaction cost of marketing and/or production cost of marketing within specific geographical areas and market segmentation of the commodities. However, it is also clear that the middlemen exercise control over the farmers and as a result, they dictate or set the price to pay for the farm produce. This could end up affecting the profit margin earned by the farmer.

Table 5.4: Demographic & Socioeconomic Characteristics of AVCF & Non AVCF Farmers

		Maize		Groundnut		Soyabean		Rice	
		AVCF	**NON-AVCF**	**AVCF**	**NON-AVCF**	**AVCF**	**NON-AVCF**	**AVCF**	**NON-AVCF**
Variable	**Sub-Categories**								
Gender (Sex)	Male	67.58***	84.01	47.71***	68.20	60.62	68.18	76.15	85.19
Education Grade	No Formal Education	77.24	81.00	86.25**	80.08	78.60	86.36	75.23	66.67
Household Size	Household Size	12.92***	9.77	13.39***	9.49	13.21	11.87	14.33*	11.52
Marital Status	Married	92.26	94.58	91.55**	95.40	89.15	95.45	93.12	92.59
Years of Farming		16.35***	18.33	15.37	15.30	15.48	16.48	17.39	20.04
Farm Size (Ha)		2.67**	2.97	2.42***	2.88	2.91	3.22	3.45	4.77
Total No. Of Observations		**1,163**	**369**	**698**	**261**	**645**	**44**	**218**	**27**

Notes: We used Chi-Square (X^2) for categorical variables and t-test for continuous variables to test for similarities for the beneficiary and non-beneficiary groups. P-values *** p<0.01, ** p<0.05, * p<0.1 indicate the level of significance

Table 5.5: Distribution of Marketing Channels for Crops

Distribution of marketing channels for maize

Main Marketing Outlets	Frequency	Percent	Cumulative
Pre-harvest contractor	4	0.4	0.4
Farm gate buyer	66	6.66	7.06
Market trader	876	88.4	95.46
Consumer	38	3.83	99.29
State trading organization	1	0.1	99.39
Cooperatives	2	0.2	99.6
Processor	4	0.4	100

Distribution of marketing channels for groundnut

Main Marketing Outlets	Frequency	Percent	Cumulative
Pre-harvest contractor	9	1.08	1.08
Farm gate buyer	72	8.63	9.71
Market trader	721	86.45	96.16
Consumer	28	3.36	99.52
Processor	4	0.48	100

Distribution of marketing channels for soyabean

Main Marketing Outlets	Frequency	Percent	Cumulative
Pre-harvest contractor	8	1.31	1.31
Farm gate buyer	36	5.88	7.19
Market trader	521	85.13	92.32
Consumer	18	2.94	95.26
State trading organization	20	3.27	98.53
Cooperatives	6	0.98	99.51
Processor	3	0.49	100

Distribution of marketing channels for rice

Main Marketing Outlets	Frequency	Percent	Cumulative
Pre-harvest contractor	3	1.44	1.44
Farm gate buyer	25	12.02	13.46
Market trader	172	82.69	96.15
Consumer	7	3.37	99.52
Processor	1	0.48	100

Table 5.6: Summary Statistics of Variables in Double-Hurdle Models for Maize, Groundnut, Soyabean and Rice

	MAIZE			GROUNDNUT			SOYABEAN			RICE		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Market Access	1,532	0.64	0.48	959	0.87	0.34	689	0.88	0.32	245	0.84	0.37
Market Participation	1,532	0.35	0.32	959	0.64	0.31	689	0.74	0.33	245	0.59	0.32
AVCF Participants (Group)	1,532	0.76	0.43	959	0.73	0.45	689	0.94	0.24	245	0.89	0.31
Gender	1,532	0.72	0.45	959	0.53	0.50	689	0.61	0.49	245	0.77	0.42
Education Grade	1,532	0.20	0.40	959	0.15	0.36	689	0.21	0.41	245	0.26	0.44
Years of Farming	1,532	16.83	10.36	959	15.35	10.19	689	15.55	9.76	245	17.68	10.94
Household Size	1,532	12.17	7.47	959	12.33	7.33	689	13.12	8.19	245	14.02	8.35
Farm Size (Ha)	1,532	2.75	2.29	959	2.54	2.40	689	2.93	2.40	245	3.59	2.99
Radio	1,529	0.74	0.44	956	0.72	0.45	689	0.72	0.45	245	0.86	0.35
Mobile Phone	1,528	0.68	0.47	955	0.62	0.48	688	0.69	0.46	245	0.79	0.41
Motorbike	1,529	0.41	0.49	956	0.37	0.48	689	0.38	0.49	245	0.53	0.50
Access to Storage Facility	1,528	0.19	0.39	955	0.17	0.38	688	0.24	0.43	245	0.24	0.43
Access to Extension Officer	1,528	0.46	0.50	955	0.46	0.50	688	0.56	0.50	245	0.61	0.49
Expenditure on Transport	1,532	0.59	0.49	959	0.52	0.50	689	0.67	0.47	245	0.70	0.46
Finance (Production Credit)	1,532	0.10	0.30									
Finance (Savings)				957	0.14	0.35	689	0.16	0.37	245	0.21	0.41
Information on Commodity Prices	1,531	0.61	0.49	958	0.57	0.50	689	0.65	0.48	245	0.66	0.47
Information on Market Buyers	1,530	0.37	0.48	957	0.36	0.48	689	0.36	0.48	245	0.42	0.49
Distance to Nearest Market in Kilometres	1,528	8.46	7.18	955	9.02	7.59	688	7.37	5.96	245	6.05	4.81
Distance to Motorable Road in Kilometres	1,528	3.30	5.56	955	3.70	6.24	688	2.55	4.00	245	1.73	2.96

Given the dataset for analysis, Table 5.6 shows that on average 88 per cent of farmers have market access for the sale of soyabean as compared to 87 per cent of farmers who have market access for the sale of groundnut, 84 per cent of rice farmers have market access for the sale of rice, while 64 per cent of maize farmers have market access for the sale of maize. In the case of market participation, the trend is similar, indicating that the number of farmers who sell their farm produce is high for soyabean (74%), with groundnut at 64 per cent, rice at 59 per cent and maize at 35 per cent.

5.10. DISCUSSION OF RESULTS

The results of the factors influencing market access and market participation are presented in Table 5.7. Beginning with socioeconomic factors, we find that male maize farmers are less likely to participate in the maize market; however, being a male soyabean farmer increases access to the market. Education reduces market access for soyabean and rice farmers. Most smallholder farmers, especially in the northern parts of Ghana, have little or no education and hence the effect of education may be heavily biased downwards towards the majority (with less education). Thus, the result is reasonable within the context of the smallholder farmers in the Northern Region of Ghana. Experience reduces market access and market participation for maize farmers and equally reduces market access for groundnut and soyabean farmers. It, however, increases market participation for rice farmers. As noted in the literature review, experienced farmers may belong mostly to the traditional farmers who farm more for subsistence and hence this could explain the puzzling non-interest in market participation. The result is in line with the diminishing returns argument for the effect of experience. Household size only affects market access of rice farmers and it does so in a negative way.

With respect to transaction costs (market related) factors, we find that beneficiaries of AVCF have a higher probability of participation in the maize market but surprisingly sell less in the case of maize and soyabean farmers (reduced market participation). Ownership of a radio reduces market access for soyabean farmers but increases market participation of these farmers as well as that of rice farmers. Mobile-phone ownership increases access to market for soyabean farmers but reduces market participation for groundnut farmers. Although it is surprising that mobile phone ownership decreases market participation, it could be plausible that communication on market-related information is via physical meetings and discussions within farmer groups and networks and less so with mobile phones. Owning a motorbike also increases market access and market participation for maize farmers but reduces market access for soyabean farmers. Access to storage facilities increases market access of soyabean farmers and market participation for groundnut farmers. The expenditure on transport surprisingly increases the probability of market access for maize, groundnut and soyabean farmers and is insignificant in the market participation. A plausible reason for this puzzling effect could be that farmers make decisions to participate in the selling of maize at more distant markets mainly as a result of a search for larger returns that are gained in such markets relative to markets within or around their community. In that sense the expenditure on transport is indirectly a search for higher gains from more distant markets. Information on prices increases market participation for maize farmers but information on buyers reduces this market participation. Whilst distance to the nearest market reduces market participation for maize and soyabean farmers, distance to the nearest road increases market participation for maize and groundnut farmers. Although it is surprising that the longer the distance to the nearest road, the more farmers participate in market, a possible reason could be the nature of the terrain in Northern Ghana. Road density is low in this part of Ghana, particularly so for farming communities. Indeed, farmers (whether they participate actively in markets or not) are more likely to be located further away from road networks. They are therefore compelled to sell despite the poor road network in the region and the long travelling time spent to the nearest motorable road.

On the transaction cost (production related) factors, farm size increases access to market for maize and groundnut farmers and increases market participation for rice farmers. Access to extension officers reduces market access for maize and soyabean farmers but increases market participation for maize and groundnut farmers. Indeed, a justification for the result could be that, the immediate effect of extension officers (who concentrate on farm demonstrations on soil management and productivity) could delay attention to market access and hence reduce access to market initially, but with time and higher productivity this effect reverses and shows up in market participation. This effect would be more pronounced in farming major crops like maize. However, finance reduces market access for soyabean farmers but increases market participation for groundnut farmers.

Table 5.7: Estimation Results#: Determinants of Market Access and Market Participation

Factors	Maize		Groundnut		Soyabean		Rice	
	Market Access	Market Participation Truncated	Market Access	Market Participation Truncated	Market Access	Market Participation Truncated	Market Access	Market Participation Truncated
Socioeconomic factors								
Gender	-0.105	-0.082***	0.032	0.005	0.364**	0.032	0.252	0.030
Education Grade	-0.127	-0.003	-0.047	0.011	-0.328*	-0.013	-0.542**	0.040
Years of Farming	-0.023***	-0.002***	-0.017***	0.001	-0.018**	-0.002**	0.000	0.002*
Household Size	-0.002	-0.001	0.014	0.001	0.001	-0.001	-0.033***	-0.002
Transactions Cost-Market Related Factors								
AVCF Participants (Group)	0.308***	-0.109***	-0.046	0.014	-0.144	-0.059*	0.401	0.032
Radio	-0.088	-0.007	0.109	0.014	-0.308*	0.045**	0.119	0.105**
Mobile	0.073	0.006	0.035	-0.031**	0.313*	0.000	0.430	-0.056
Motorbike	0.215***	0.033**	-0.067	0.005	-0.275*	0.017	-0.266	0.014
Access to Storage Facility	-0.115	-0.003	0.015	0.040**	0.609***	0.012	0.410	0.000
Expenditure on Transport	0.324***	0.008	0.184*	-0.007	0.480***	-0.022	0.314	0.002
Info on Commodity Prices		0.030*		-0.011		0.024		-0.013
Information on Market Buyers		-0.033**		0.005		-0.011		0.011
Distance to Nearest Market		-0.005***		-0.002		-0.004***		-0.004
Distance to Nearest Road		0.006***		0.005***		0.001		-0.005
Transactions Cost-Production Related Factors								
Farm Size (Ha)	0.088***	0.002	0.090***	0.005	0.080	-0.002	0.038	0.010*
Access to Extension Officer	-0.188**	0.034**	-0.132	0.028*	-0.261*	0.019	0.215	0.010
Finance (Production Credit)	-0.031	-0.029	0.369*	0.001	-0.741***	-0.001	0.094	0.027
Finance (Savings)								
Constant	0.251**	0.725***	0.915***	0.676***	1.299***	0.906***	0.238	0.559***
Number of Observations	1528	973	955	831	688	608	245	205
Wald chi2(13)	117.10		31.450		56.340		21.410	
Wald chi2(17)		120.17		40.19		41.40		29.75
Prob > chi2	0.000	0.000	0.003	0.001	0.000		0.065	0.028
Likelihood ratio test stat (λ)		119.57*		162.18***		-2.59		60.21

*** p<0.01, ** p<0.05, * p<0.1. # Market access is determined by a probit model and the market participation is determined by a truncated model.

There are interesting detectable trends in our results. Apart from maize farming, where transportation cost (specifically ownership of a motorbike) affects market access and market participation in the same way, market access and market participation outcomes are affected differently. This pattern further justifies the use of our double-hurdle model approach, which is premised on separability. In addition, the effect of socioeconomic and transaction cost factors also differs across crop types. This could be explained by the fact that some crops such as soyabean and groundnut are mainly observed as cash crops whereas rice and maize are both cash and food crops. Transaction cost (market related) factors appear to be more influential in market access of maize and soyabean farmers and less so for groundnut farmers but insignificant in market access of rice farmers. A slightly similar pattern is observed in the case of transaction costs (production related), where it significantly affects market access and market participation more in maize, groundnut and soyabean farmers but is insignificant in its effect on market participation of rice farmers and market participation of soyabean farmers. Most of the factors hardly explain market access and market participation of rice farmers.

The determinants of market access and market participation as presented in Table 5.7 show that there are multiple factors that influence smallholder market access and the decision to participate in the market. Most importantly is also the evidence that these factors that predict market access and market participation of a smallholder farmer vary from crop to crop. It is also worthy of note that the majority of these farmers are farmers with more than one crop. Yet the factors for market access and market participation vary from crop to crop. According to Chamberlin and Jayne (2011), "market access has multiple dimensions that may be highly commodity-specific". In the light of this, the factors that predict market access and market participation could vary based on the crop type leading to the farmer adopting different marketing processes and strategies for different crops. This implies different methods of identifying marketing opportunities for different crops, different customer base, different price and different place for marketing different crops. These variations in marketing processes could have a direct impact on the transactions costs (market and production related costs) especially when some of these costs pertaining to a crop could either be fixed cost or variable cost or both. Clearly, Tables 5.1 and 5.2 provide evidence of the different prices for different crops at the national level. However, these market prices could further differ from one geographical location to the other implying that market prices of the various crops could be sensitive to a market place or location. The variation in growth period of a product is also a contributing to the factors that influence farmers' access to market and participation in the market. In short, using different marketing processes for different crops with each crop accounting for its transactions costs and the fact that a crop may be cash or food crop could account for the differences in the factors that predict market access and market participation.

For robustness, we also model the market access and market participation via the Heckman selection model and the results are shown in the appendix. We equally show Tobit versions of market participation model in the appendix.

5.11. CONCLUSION

By market access, we refer to the delivery of farm produce by a farmer (supplier) to a buyer at a location and at a price while market participation is the degree at which a farmer trades or sells the farm produce at the market. In this study, we applied the double-hurdle model to explain smallholder farmers' decision to market access and market participation in the Northern Region of Ghana. Our findings show significant differences in the effect of transaction costs (market and production related) and socioeconomic factors on market access and market participation. The differences show that except for some transportation cost factors for maize, there is separability between market access and market participation decisions of smallholder farmers. These differences in the market access and market participation are also seen across crop types, where some factors matter for some crops but not for others and some transport costs consistently influence market access alone in three out of the four crop farmers.

The contributions of this essay are also clear. We present new dimensions to the literature and show that there is substantial separability between the decision for market access and market participation by smallholder farmers. The decision to access the market and the market participation are therefore mostly two different ones for smallholder farmers. The factors which affect these decisions can affect them separately and in different directions. These differences in the factors influencing smallholder farmers' decision to access the market and participate also differ across crop types. The rationale for the differences in the factors affecting market access and market participation for the different crops could be explained on the account of the marketing process. That is to say, the crop type is sensitive to the market process and its strategies. This is because each crop has its separate market segmentation approach, different target market and therefore different positioning in terms of distribution channel and price for the product. The differences in the marketing processes therefore lead to differences in market related transaction costs and production related transaction costs. Thus, the factors influencing a smallholder farmer in the Northern Region of Ghana to access the maize market and participate in the market vary from the smallholder farmers' access to groundnut, soyabean and rice markets and their participation in those markets.

The evidence suggests that policies and strategies for increasing market access and market participation must not be the same for all smallholder farmers. It is also clear that these policies must be designed to suit crop typologies. Perhaps a more challenging issue is where a farmer farms more than one crop type and needs to balance the management of these factors to separately access markets for different crop types and also participate in the market of these crops. This requires substantial farmer training and skills enhancement in managing these market access and participation factors. Our policy recommendation is for investment into market-related factors that are geared towards reducing transaction costs in the form of transportation, search cost and access to storage facilities to improve market access and market participation.

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APPENDIX

Table 5.8: Estimation Results - Determinants of Market Participation and Intensity Using Tobit Model

Factors	Maize	Groundnut	Soyabean	Rice
Socioeconomic factors				
Gender	-0.096***	0.024	0.093***	0.084
Education Grade	-0.055*	-0.004	-0.056	-0.050
Years of Farming	-0.009***	-0.002*	-0.005***	0.002
Household Size	-0.001	0.003**	-0.001	-0.009***
Transactions Cost-Market Related Factors				
AVCF Participants (Group)	0.010	0.039	-0.129**	0.033
Radio	-0.029	0.036	-0.028	0.116*
Mobile	0.034	-0.018	0.050	0.033
Motorbike	0.089***	-0.007	-0.036	-0.039
Access to Storage Facility	-0.048	0.040	0.114***	0.054
Expenditure on Transport	0.120***	0.030	0.069**	0.057
Info on Commodity Prices	0.036	-0.009	0.074*	0.029
Information on Market Buyers	0.041	0.038	-0.050	0.022
Distance to the Nearest Market	-0.010***	-0.001	0.002	0.003
Distance to the Nearest Road	0.010***	0.009***	-0.009**	-0.015
Transactions Cost-Production Related Factors				
Farm Size (Ha)	0.026***	0.014***	0.013*	0.012
Access to Extension Officer	-0.050*	-0.004	-0.025	0.048
Finance (Production credit)	-0.031			
Finance (Savings)		0.048	-0.170***	0.034
Constant	0.344**	0.471***	0.787***	0.308**
Number of Observations	1528	955	688	245
Log pseudo likelihood	-1057.27	-450.06	-330.45	-122.65
Prob > F	0.000	0.000	0.000	
Pseudo R2	0.073	0.054	0.107	0.108

*** p<0.01, ** p<0.05, * p<0.1

Table 5.9: Estimation Results - Determinants of Market Participation and Intensity Using Heckman Selection Model

Factors	Maize		Groundnut		Soyabean		Rice	
	Market Participation	Intensity Truncated	Market Participation	Intensity Truncated	Market Participation	Intensity Truncated	Market Participation	Intensity Truncated
Socioeconomic factors								
Gender	-0.105	-0.060*	0.032	0.006	0.36**	0.03	0.25	0.03
Education Grade	-0.127	0.022	-0.047	0.011	-0.33*	-0.01	-0.54**	0.04
Years of Farming	-0.023***	0.003	-0.017***	0.001	-0.02**	0.00*	0.00	0.00
Household Size	-0.002	-0.001	0.014*	0.001	0.00	0.00	-0.03***	0.00
Transactions Cost-Market Related Factors								
AVCF Participants (Group)	0.308***	-0.167**	-0.046	0.014	-0.14	-0.06	0.40	0.03
Radio	-0.088	0.010	0.109	0.014	-0.31*	0.04*	0.12	0.11**
Mobile	0.073	-0.010	0.035	-0.030*	0.31*	0.00	0.43	-0.05
Motorbike	0.215***	-0.012	-0.067	0.005	-0.27*	0.02	-0.27	0.01
Access to Storage Facility	-0.115	0.018	0.015	0.040**	0.61***	0.01	0.41	0.00
Expenditure on Transport	0.324***	-0.060	0.184	-0.006	0.48***	-0.02	0.31	0.00
Info on Commodity Prices		0.029		-0.002		0.02		-0.01
Information on Market Buyers		-0.032		-0.011		-0.01		0.01
Distance to the Nearest Market		-0.005***		0.005		-0.00***		0.00
Distance to the Nearest Road		0.006***		0.005***		0.00		0.00
Transactions Cost-Production Related Factors								
Farm Size (Ha)	0.088***	-0.014	0.090**	0.006	0.08**	0.00	0.04	0.01
Access to Extension Officer	-0.188**	0.070	-0.132	0.027	-0.26*	0.02	0.21	0.01
Finance (Production Credit)	-0.031	-0.024	0.369**	0.002				
Finance (Savings)					-0.741***	-0.001	0.09	0.03
mills ratio (lambda)		-0.379		0.014		0.02		0.01
Constant	0.251**	0.969***	0.915***	0.672***	1.30***	0.90***	0.24	0.55***
Number of Observations	1,528	1,528	955	955	688	688	245	245
Wald chi2(17)		47.99		34.41		35.49		25.17
Prob > chi2		0.000		0.007		0.001		0.09

*** p<0.01, ** p<0.05, * p<0.1

CHAPTER 6

INTEGRATED SOIL FERTILITY MANAGEMENT (ISFM) AND PRODUCTIVITY OF SMALLHOLDER FARMERS

6.1. INTRODUCTION

Increasing the agricultural productivity of smallholder farmers has been a subject of concern among development partners, policy makers and stakeholders within the agricultural sector, mainly due to the growing demand for agricultural products (World Bank, 2008). Trends in agricultural growth in Africa over the years have shown some degree of instability. The average growth rate in Africa over a period of approximately five decades (1961–2012) was recorded at 3.3 per cent per year. A decomposition of the average growth rate shows that for the periods 1981–1990, 1991–2000 and 2001–2012 Africa's agricultural performance increased at 3.86 per cent, 3.53 per cent and 2.16 per cent respectively (Benin & Nin-Pratt, 2016). Although the agricultural growth rate in Africa remains low compared to that of the rest of the world, there are regional and country variations in Africa partially due to spatial and productive resource management factors that influence production (Fuglie & Rada, 2011; Aguilar, Carranza, Goldstein, Kilic & Oseni, 2014). For instance, Cameroon, Angola, Sierra Leone, Nigeria and Zambia are among the few countries with the fastest-growing agricultural economies at a minimum annual growth rate of approximately six per cent from 2001 to 2012 (Fuglie & Rada, 2011; Benin & Nin-Pratt, 2016).

According to Fuglie and Rada (2013), the observed changes in agricultural production and productivity are driven by several factors. These factors include the adoption of new technologies, investment into agricultural research, farmer education aimed at improving technical efficiency, expansion and provision of irrigation facilities as well as investments in land improvement and fertilizer use. While these productivity-enhancing factors are associated with intensive use of farm inputs and resources, several poor practices have been identified, leading to low agricultural productivity in Africa. For instance, from the perspective of fertilizer use, which is important in improving the nutrients of the soil, Morris et al. (2007) are of the view that the application of fertilizer in Africa is very low (8 kilograms per hectare), compared to the rest of the world (78 kilograms in Latin America, 96 kilograms in East and Southeast Asia and 101 kilograms in South Asia, all measured per hectare), thereby contributing to low agricultural productivity. The low production growth rate, according to Losch (2011), serves as a hindrance to the transformation of the agricultural sector of Sub-Saharan Africa. Thus, despite the number of policy interventions in the agricultural sector, it does not appear that productivity has increased much. Indeed, an obvious impediment is the absence of quality data and rigorous impact studies on agricultural interventions, especially at the project and micro levels. As a result, a yawning gap in the literature and policy is the lack of studies assessing the impact or effectiveness of agricultural interventions. The development of the Integrated Soil Fertility Management (ISFM), a recent trend in agricultural production and crop productivity, as noted by Fairhurst (2012), presents further opportunity to test the effectiveness of soil fertility management on productivity.

Ghana's agricultural sector plays a significant role in terms of its contributions towards growth and development (Zimmermann, Brüntrup, Kolavalli & Flaherty, 2009). Recognising the significance of agriculture, Ghana, has initiated many agricultural policy interventions or reforms aimed at increasing agricultural output over the years. Some of these policies have been directly focused on increasing farm size, more specifically cropping areas. Recent policy reforms have also been directed at modernisation and mechanisation of the agricultural sector. As is done in other countries in Africa, Ghana's modernisation drive includes rigorous and intensive use of farm inputs such as the adoption of improved seedlings, mechanised farming, and improved farm practices aimed at increasing farm-level productivity (Seini, 2002; Benin, Nin-Pratt, Wood & Guo, 2011). According to the Ministry of Food and Agriculture of Ghana (MoFA, 2007), increasing agricultural productivity is a step geared towards revitalising the agricultural sector, leading to the development of the FASDEP II that focused on the adoption of a value-chain approach towards agricultural development and increasing productivity. Thus, these policy reforms in Ghana's agricultural development make it relevant and interesting to study.

This paper evaluates the impact of the AVCF project on the productivity of smallholder farmers in Northern Ghana. More specifically, we provide evidence on the impact of the integrated soil fertility management (ISFM) practice on the productivity of smallholder farmers. AVCF was initiated and funded by the DANIDA, the aim of which is "to strengthen income and employment opportunities in rural areas of Northern Ghana through increased household agricultural productivity and value addition" (DANIDA, 2009). The project, which was implemented within the Northern Region in 2011–2015, was managed and coordinated by the AGRA. This project is like the numerous policy and project interventions in the agricultural sector of most African countries. The project offers a unique opportunity to evaluate the impact of agricultural interventions aimed at increasing productivity. We used survey data of beneficiary and non-beneficiary non-equivalent control groups to compare the mean productivity. The estimation is made possible using the PSM.

The rest of the paper is organised as follows: section 2 presents an overview of Ghana's agricultural sector and AVCF project. Section 3 reviews relevant literature. Methodology for data analysis is discussed in section 4 and the estimation of impact and the analysis of the survey data are presented in section 5. Section 6 presents a discussion of the results whilst section 7 captures the concluding remarks.

6.2. OVERVIEW OF GHANA'S AGRICULTURE SECTOR

One of the pillars or thematic areas for Ghana's economic transformation over the years is the development of the agricultural sector. The sector is sensitive to the growth and development of the economy due to the multiple purposes it serves in terms of providing food security, and improved nutrition, and improving the welfare of the rural population through job creation (Cheong, Jansen & Peters, 2013). To spur growth by increasing food production and improving productivity, Ghana has embarked on many agricultural sector development initiatives in the post-independence era to transform the sector from traditional farming methods towards commercialisation. This section highlights policies within the agricultural sector in Ghana covering the periods from 1970s to 2010s and presents stylised facts on the country's performance within the agricultural sector.

6.2.1. Overview of Agriculture Sector Policies

According to Nyanteng and Seini (2000) and Asante and Awo (2017), agricultural policies in the 1970s focused on increasing agricultural production, leading to the promulgation of OFY and Operation Feed Your Industries (OFYI) programs in 1972–1974. This era witnessed a paradigm shift from state-owned enterprises to private-sector engagement in agricultural production. The introduction of the ERP in 1983–1986 and SAP in 1987–1990 focused on stabilisation and structural transformation of the economy of Ghana. This was also a new era for the agricultural sector due to its significant role in Ghana's economy. During these periods, agricultural policies were skewed towards exporting cocoa because of increasing producer price and the removal of agricultural subsidies on fertilizer, agricultural chemicals, farm inputs and equipment while maintaining strategies for increasing productivity or yield (Nyanteng & Seini, 2000; Seini, 2002).

As part of Government of Ghana's commitment to the development of the agricultural sector, the MTADP was formulated in 1989 as the overarching framework to guide implementation of policies within the agricultural sector from 1991 to 2000 (Dzanku & Aidam, 2013; Asante & Awo, 2017). Within this framework and that of Ghana's Vision 2020 agenda, the focus of Ghana's agricultural policy centred on establishing a robust and diversified sector that ensures national food security. This was expected to be achieved by minimising the dependency on rainfall and adopting a shifting cultivation practice as a method of farming, increasing productivity through the development of skills and competencies of farmers and also adopting improved farming technologies. The expected result was to increase and sustain an agricultural growth rate of four per cent per annum (National Development Planning Commission [NDPC], 1994). Some of the major projects implemented during this period were the Agricultural Diversification Project (ADP) and the National Agricultural Extension Project (NAEP), (Asante & Awo, 2017).

Though some achievements were made under the above-mentioned policies, the growth in the agricultural sector remained low and unsustainable. This led to the introduction of the AAGDS in 2000 with the aim of increasing the annual agricultural growth from four per cent to six per cent between 2001–2010. This policy focused on increasing farm size under cultivation and irrigation as well as adopting intensive use of crop production systems, including improving access to technology (MoFA–FASDEP, 2002; Dzanku & Aidam, 2013). Meanwhile, 2002 saw the formulation and realisation of the FASDEP I, which was built on the thematic areas of AAGDS and further provided a policy framework for food and agricultural development in Ghana. The policy focused on modernisation of the agricultural sector in tandem with the use and application of small-scale technologies and adoption of efficient agronomic practices geared towards increasing agricultural productivity (MoFA–FASDEP I, 2002; NDPC, 2005).

Following the implementation of FASDEP I, FASDEP II was launched in 2007 to modernise agriculture through structural transformation of the economy as a result of food security (MoFA–METASIP 2011–2015, 2011). The distinction between FASDEP I and FASDEP II is that the latter adopts a value-chain approach towards agricultural development with the aim of enhancing productivity (MoFA–FASDEP II, 2007; Wolter, 2008). The implementation of this policy contributed to the introduction of several projects which, among others, include the creation of the Agricultural Mechanization and Service Centres

(AMSEC) to propel agricultural mechanisation and the promotion and development of higher-yielding seeds and higher-yielding crop varieties to accelerate productivity (NDPC, 2010).

Currently, Ghana's agricultural sector policies are enshrined in the GSGDA 2010–2013 and 2014–2017. These policy frameworks are consistent and interconnected with FASDEP II and regional agricultural development policies, namely, the Economic Community of West African States' Agricultural Policy (ECOWAP) and the CAADP. The objectives of these policies are modernisation and transformation of the agricultural sector and increasing the agricultural growth rate to a minimum of six per cent per annum. The implementation of these policies is currently guided by the METASIP, 2011–2015 (MoFA–FASDEP II, 2007; Dzanku & Aidam, 2013; Asante & Awo, 2017).

6.2.2. Agriculture Sector Performance

This section presents the performance of the agricultural sector in terms of the policy outcomes. It highlights the growth rates achieved for specific sub-sectors and the agricultural sector in general. This will be followed by the presentation and discussion of the impact of the various policies on major crops in Ghana in terms of their productivity.

From the viewpoint of the agricultural sector, Table 6.1 below shows that the expected annual growth rates across the various periods that the policies were implemented were not sustainable. The evidence shows that prior to ERP/SAP, Ghana recorded an average annual growth rate of negative 1.28 per cent from 1975–1982. However, during the period of economic transformation and structure adjustment (1983–1990), the average annual growth rate achieved was 1.57 per cent. The MTADP period (1991–2000) showed an improvement in the average annual growth rate to 3.32 per cent. However, this fell short of the minimum four per cent annual growth rate target set even though it was achieved in 1991 and 1996–1998. The expected minimum growth rate set for the agricultural sector from 2001 onwards under the various sets of policies was six per cent. The period from 2001–2010 recorded an average annual growth rate of 4.95 per cent. Meanwhile, some impressive growth rates were recorded in 2003–2004 as well as 2008–2009. The average annual growth rate then reduced from 4.95 per cent attained in the period 2001–2010 to 3.25 per cent over the average growth rate covering the period 2011–2015.

Table 6.1: Average Growth Rates in Agricultural Sub-Sectors (%)

	1975–1982	1983–1990	1991–2000	2001–2010	2011–2015
Crops	0.68	1.56	2.97	5.66	3.71
Cocoa	-5.74	1.49	5.40	9.34	0.71
Livestock	0.68	1.56	3.97	4.74	5.24
Forestry/Logging	-0.32	2.51	6.38	3.17	0.52
Fisheries	2.57	3.14	1.27	2.23	0.97
Agriculture	**-1.28**	**1.57**	**3.32**	**4.95**	**3.25**

Source: Ghana Statistical Service / Ministry of Food and Agriculture – Statistical, Research and Information Directorate.

Aside from the average annual agricultural growth rates, agricultural productivity of the major food crops in Ghana are presented in Table 6.2. According to Dzanku and Aidam (2013), attempts to enhance farm-level productivity of food crops by the Government of Ghana have been one of the key focus areas for policy initiatives. Clearly, Table 6.2 shows evidence of a progressive average increase in the productivity of the various crops across the implementation of the various policies discussed. For instance, the average productivity of maize increased from 1.14 metric tonnes per hectare (mt/ha) during the period 1985–1990 to 1.47 metric tonnes per hectare in 1991–2000 and subsequently to an average yield of 1.78 metric tonnes per hectare (mt/ha) from 2011–2015. Similarly, the average productivity of rice increased from 0.95 metric tonnes per hectare in 1985–1990 to 1.93 metric tonnes per hectare in 1991–2000 and 2.59 metric tonnes per hectare from 2011–2015.

For roots and tubers (cassava, cocoyam, yam and plantain), their productivity yields are far below their potential yields. The potential yield for cassava is 45 mt/ha; however, the average productivity for 1985 – 1990 was recorded at 7.73 mt/ha. This increased to an average productivity of 11.55 mt/ha for the period 1991 – 2000 representing a 49.42 per cent increase and subsequently increased by to 13.02 mt/ha and then to 17.68 mt/ha for the periods 2001 – 2010 and 2011 – 2015 respectively. Despite the marginal increase in the average productivity for cassava, there is still a huge yield gap. The average productivity of cocoyam for the periods 1985–1990 was 4.93 mt/ha. This increased by 39.76 per cent to the average of 6.89 mt/ha for the periods 1991–2000. However, the average productivity for cocoyam for the periods 2001 – 2010 and 2011 – 2015 declined to the average productivity rate of 6.56 mt/ha and 6.46 mt/ha respectively. These productivity rates are below the potential yield of 20 mt/ha. Like cassava, the average productivity of yam increased from 5.97 mt/ha in 1985 – 1990 and increased to the average productivity of 12.44 for the periods 1991 – 2000. The average productivity further increased to 13.49 mt/ha and

16.09 mt/ha for the periods 2001 – 2010 and 2011 – 2015. The potential yield for yam is 52 mt/ha. The productivity of plantain has also shown a continuous increase although the values are again far below the potential yield of 38 mt/ha. For instance, the average productivity of plantain was recorded at 5.66 mt/ha for the period 1985 – 1990. This increased to 7.74 mt/ha for the periods 1991 – 2000, 9.49 mt/ha for 2001 – 2010 and 10.75 mt/ha for 2011 – 2015. The low productivity observed could be attributed to the farming practice of the smallholder farmer, the weather or rainfall pattern as well as the farm inputs used.

Despite this progressive increase in yields, there are gaps between the actual and the potential crop yields. To attain the potential crop yield, a farmer needs to fully intensify in the use and application of effective and efficient agronomic and farm management practices. In other words, the implication of the low crop level of productivity as compared to the potential yield as shown in Table 6.2 is that, smallholder farmers are operating below their capacity resulting to low productivity. The existence of these gaps points to the numerous challenges or constraints confronting the agricultural sector. According to Nyanteng and Seini (2000) and Seini (2002), the low and unsustainable level of productivity observed is mainly due to the poor farming system that is practised. That is poor use and application of genotype, poor ecological and environmental factors affecting farming and poor farm management practices.

Table 6.2: Average Crop Productivity vs Yield Potential Measured in Metric Tonnes Per Hectare

Crops	1985–1990	1991–2000	2001–2010	2011–2015	Potential Yield
Maize	1.14	1.47	1.60	1.78	5.50
Rice (Paddy)	0.95	1.93	2.18	2.59	6.00
Millet	0.69	0.86	0.93	0.99	2.00
Sorghum	0.72	1.02	1.04	1.13	2.00
Cassava	7.73	11.55	13.02	17.68	45.00
Cocoyam	4.93	6.89	6.56	6.46	20.00
Yam	5.97	12.44	13.49	16.09	52.00
Plantain	5.66	7.74	9.49	10.75	38.00
Groundnuts	0.00	0.93	1.16	1.29	3.50
Cowpea	0.00	0.70	0.92	1.26	2.50
Soybean	0.00	0.00	1.21	1.72	3.00

Source: Ministry of Food and Agriculture – Statistical, Research & Information Dept (SRID) (2016).

6.3. CONCEPTUAL FRAMEWORK OF AGRICULTURAL PRODUCTIVITY

Increasing agricultural productivity is a complex phenomenon. It requires a multifaceted production approach that is relevant and sustainable to a particular system of farming. Beets (1990) classified the factors that drive agricultural productivity as physical, technological and human factors. The physical factors are the land area, the climate and the soil, among others. Martinussen (1999) identified soil fertility as the most important factor of agricultural production and further highlighted the significance of the climate by pointing out that unreliable and unstable climatic conditions adversely affect agricultural production. Similarly, Bot and Benites (2005) argued that a healthy soil produces and provides nutrients to crops and plants. It is also responsible for the supply of air and water, all of which contribute to maintaining and enhancing the soil structure and its fertility. Ultimately, this culminates in increased agricultural production, specifically improved crop productivity.

Technological factors entail the know-how, the practical knowledge required to expand agricultural production. Because of the multiple activities involved in farming, farmers require practical knowledge of the various farming practices to pursue a production growth agenda. The practical and technical knowledge is expected to vary, depending on the strategy employed; that is, the decision concerning what to perform and at what time is informed by the variation and seasonality of the implementation of these activities. Therefore, it is argued that the skills and competencies gained by farmers will contribute towards growth and ultimately increase productivity (Appleton & Balihuta, 1996; Zepeda, 2001; Dahms, 2003). On the other hand, production inputs also form part of the technological factors. Beets (1990), Reardon et al. (1997) and Hazell (2009) identified the inputs that contribute to increasing the productivity of smallholder farmers as improved seeds or high-yielding seeds, chemical (inorganic) fertilizers, and agricultural tools. They also include agricultural chemicals such as insecticides, pesticides, weedicides and herbicides as well as the provision of irrigation facilities. Altieri and Nicholls (2003) emphasise that inputs enhance the soil fertility and help to combat pests and diseases.

According to Beets (1990), the human factor involves the efficient combination of the physical and technological factors to achieve the highest result of increasing agricultural productivity. According to Philips (1994), the relationship or the effect of education (human capital development) on agricultural productivity has been well established. Bowman (1976) clearly indicated two stages or perspectives through which smallholder farmers' level of education impacts on productivity. These are the "formation of competences" and "transmission of information" stages. "The formation of competences" stage is associated with gaining basic competence or knowledge through literacy, numeracy and general cognitive skills that help to process information at a certain level of reasoning. The "transmission of information", which is also relevant to smallholder farmers, is the provision of information on prices, new seeds or techniques, irrigation methods, among others. This knowledge that Bowman (1976) referred to can be gained through agencies working closely with farmers such as the agricultural extension service as well as other relevant institutional and/or non-institutional frameworks. In effect, through education of smallholder farmers, agricultural productivity increases because of their efficient utilisation or application of farm inputs and their ability to adopt innovative farming techniques including the use of technology.

A recent trend in the agricultural production and crop productivity discourse is the development of the integrated soil fertility management (ISFM) practices that were introduced in the early 2000s (Fairhurst, 2012). ISFM is

> *the application of soil fertility management practices, and the knowledge to adapt these to local conditions, which maximize fertilizer and organic resource use efficiency and crop productivity. These practices necessarily include appropriate fertilizer and organic input management in combination with the utilization of improved germplasm* (Sanginga & Woomer, 2009).

ISFM encompasses the issue of physical, technological and human factors needed for agricultural productivity. The uniqueness of the ISFM practice is that it enables the farmer to acquire the right knowledge of the practices and to intensively and efficiently use them within a specific environment with the goal to ensure high crop productivity. ISFM is embedded in the concept of genotype environmental management (GEM) of the productivity of agriculture introduced by Chambers (1997).

According to Chambers (1997), in most instances the environment (E) needs to be modified or treated for it to accommodate the genotype (G). In other words, the hurdles associated with the environment must be surmounted to ensure that optimum agricultural productivity is attained. The principles of ISFM practices are structured on plant production ecology, which has to do with the degree at which plant or crop generation takes place within an ecological system. Production output thus depends on the permutation and the interplay of genotype (G), representing the seeds or plants used within farming units, and the environment (E), representing the soil and climate or the agro-ecological factors within a specified geographical area. Management (M) is also included in the model, which focused on skills and the capacity of a farmer in managing the farm (Fairhurst, 2012). The ISFM interventions are further explained in Figure 6.1 below.

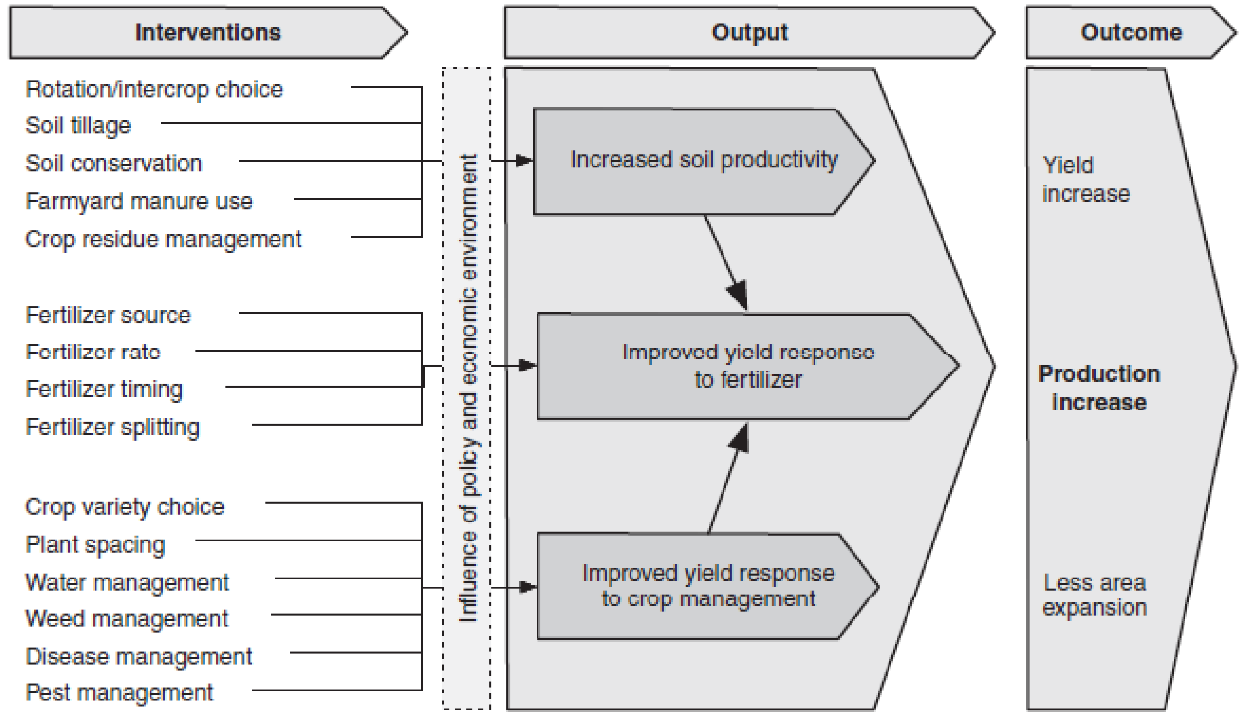

Figure 6.1: ISFM Interventions, Output and Outcomes
Source: Adapted from Fairhurst (2012).

Figure 6.1 explains the causal relationship between the set of ISFM interventions and their related outputs and outcomes. These interventions envelop the production inputs as well as farming and management practices. From an agronomic perspective, the ISFM model requires intensification of the use of fertilizer, which improves and replenishes the nutrients of the soil, leading to increased crop production. However, dependency on fertilizer alone is not enough to guarantee high crop productivity except for the additional use of seedlings and organic resources. Furthermore, the use and application of these farming practices, organic and mineral fertilizer inputs must be grounded in and adapted to the local environment. It is also clear that the use of fertilizer takes into consideration the source, the rate and the timing of its application and spread (Fairhurst, 2012). The ISFM is a mechanism that controls biological and physical factors, including crops.

Measuring agricultural productivity has been a subject of contention in respect of which method accurately captures the measurement of agricultural productivity. Coelli, Rao, O'Donnell & Battese (2005) identified two different approaches by which agricultural productivity is measured. One is the partial factor productivity (PFP) method, which seeks to measure productivity as a ratio of output to input. A typical example is the use of labour or land as a single input to generate a single output. The other method is to measure productivity using the total factor productivity (TFP). This takes a different approach as it captures productivity as the ratio of multiple inputs to outputs. TFP is therefore the relationship between the weighted output and the weighted input (Windle & Dresner, 1992; Block, 1994; Odhiambo & Nyangito, 2003).

6.4. EMPIRICAL LITERATURE

There is a growing body of empirical literature on factors impacting on agricultural productivity. However, the results of these studies are inconsistent; some have shown a positive and significant impact of agricultural interventions on productivity, whereas others have shown positive but insignificant results. This section reviews some of these empirical studies and presents their findings. The methods for the estimation of the results are also highlighted.

In Africa, Senkondo, Msangi, Xavery, Lazaro and Hatibu (2004) found a positive relationship between the application of a water harvesting system and the production of maize and paddy rice in Tanzania. The study, which focused on the profitability of rainwater harvesting for agricultural production, was estimated using the Gross Margin and Investment (Benefit cost) analysis. This study revealed that the production of maize using rainwater harvesting had a positive net present value (NPV) with benefit to cost (B:C) ratio of greater than one and internal rate of return (IRR) of 57 per cent. Paddy rice, on the other hand, also showed NPV with benefit to cost (B:C) ratio of greater than one and IRR of 31 per cent.

Tchale and Sauer (2006) also investigated the factors that influence agricultural productivity of maize among smallholder farmers in Malawi. By controlling several independent variables including rainfall, weeding and planting, the study revealed a positive relationship between ISFM and maize productivity. It showed that the productivity of maize increased by 4.2 per cent because of the use of ISFM as compared to the use of inorganic fertilizer only. The normalised translog yield response model was used for estimation. The data used for the analysis was drawn from 253 hybrid maize farm plots.

Tittonell, Shepherd, Vanlauwe and Giller (2008) carried out an empirical study by assessing the effect of soil fertility and crop management factors on the yield gap between maize farmers' yields and those of other potential yields in western Kenya using a field survey that was conducted in three districts in 2002. By adopting the Classification and Regression Tree (CART) method to explain the effect of the interaction of soil fertility management and crop management, Tittonell et al. (2008) found that, at the level of intensity of resource use in terms of the application of nutrient inputs and good planting density, the high average productivity of maize was 2.5 tonnes per hectare. On the other hand, the low average productivity of maize was also recorded at 1.2 tonnes per hectare under the circumstances where there is delay in planting coupled with low application of fertilizer.

In Burkina Faso, Smith, Hildreth and Savadago (2011) found that water harvesting (mulching) increased millet monocropping by 41 per cent and white sorghum monocropping by 121.6 per cent more than the output per hectare without water harvesting. The estimation of the result was carried out using a production technology with quadratic function – ordinary least squares estimation. A two-year (2001 and 2002) panel data from two villages was used for the analysis. Manzeke et al. (2012) also reported an increase in maize productivity following the combined or integrated application of organic and inorganic fertilizer as a soil fertility management strategy. The study, which was carried out in two districts from Zimbabwe, revealed that the average maize productivity recorded was 2.1 tonnes per hectare, compared to the average of 0.8 tonnes per hectare for farmers who did not apply any form of fertilizer. The analysis of variance (ANOVA) was deployed for the estimation.

Similarly, Kadyampakeni, Kazombo-Phiri, Mati and Fandika (2015) provided evidence of the performance or productivity of maize, wheat and rice crops under regulated surface irrigation (RSI) and unregulated surface irrigation (USI) in Malawi, using gross margin analysis for estimation. The study revealed a significant increase in productivity and net incomes for the crops cultivated under the RSI system compared to crops under USI system. Specifically, the findings of the study showed an increase in net incomes of maize, wheat and rice by US$322, US$162 and US$1,184 per hectare, respectively, thus higher for crops under the RSI system than for crops under USI system. In the same vein, the productivity of onion and tomato increased by 33.2 per cent and 37.6 per cent respectively, higher for farmers using the wetland irrigation system compared to the productivity of farmers using the upland cultivation system.

Studies in other geographical contexts, for instance Sharaiha and Hattar (1993), provided evidence of the effect of the combination of intercropping system and poultry manure (organic fertilizer) on the productivity of corn, soybean and watermelon. The study was carried out in Jordan Valley with the data collected on crops produced during the summer farming period in 1988 and 1989. The findings of the study indicated that the productivity of the crops was greater than one under the intercropping system as compared to the mono cropping system. In other words, the productivity levels of paired crops under the intercropping system were higher than the level of productivity gained under the sole cropping system.

The estimation method or technique used is the Duncan's Multiple Range Test (DMRT), while productivity was measured as the land equivalent ratio (LER). The study also revealed a significant increase in productivity because of the application of poultry manure on the farm.

Dai et al. (2010) provided evidence of the effect of fertilizer (macronutrients) on crop yield in China. The result of the study clearly indicated that the use of fertilizer stimulates an increase in rice and wheat productivity ranging from 3.7 tonnes to 3.8 tonnes per hectare for rice productivity and from 6.6 tonnes to 6.7 tonnes per hectare for wheat productivity compared to the control group who had no fertilizer input. Data for the study was drawn from 2005 and 2006 field experiment. The estimation of the result was carried out using analysis of variance (ANOVA).

A previous study by Ram, Singh and Sirari (2016) examined the effects of the application of integrated nutrient management (INM) on crop productivity and concluded that, during the period 2012–2013, the application of inorganic fertilizer and farmyard manure increased rice productivity by 4.95 tonnes per hectare and wheat productivity by 4.55 tonnes per hectare compared to the control group. However, the average productivity gains over the period 1972–2013 showed 125 per cent increase for rice and 227 per cent increase for wheat compared to the control group, that is, farmers who did not use fertilizer. The study, carried out in India (Tarai Region of Uttrakhand State), used experimental data covering 41 years from 1971/1972 to 2012/2013.

Rejesus et al. (2012) evaluated the impact of Farmer Field School (FFS) on farmers' knowledge of integrated pest management (IPM) and yield productivity and concluded that the FFS had a positive impact on farmers' knowledge in IPM. However, there is no evidence of its impact on crop productivity. The study, which used data from Vietnamese rice farmers, was estimated using the difference in differences (DID) technique. The FFS approach involves training in pest management, fertilizer application and cultural practices. Similarly, while controlling selection bias using the PSM, a study conducted in Philippines by Sanglestsawai, Rejesus and Yorobe (2015) revealed that the impact of IPM training on productivity of onion was not statistically significant. Data for the study was sourced from the IPM – FFS program implemented from 2004 to 2009.

Recent empirical studies show that integrated soil fertility management (ISFM) has a significant effect on productivity (Senkondo et al, 2004; Tchale and Sauer, 2006; Tittonell et al., 2008; Smith et al., 2011; Manzeke et al. 2012; Kadyampakeni et al., 2015) in Africa and in Asia (Sharaiha and Hattar, 1993; Dai et al., 2010; Ram et al., 2016; Rejesus et al., 2012; Sanglestsawai et al., 2015). However, the literature has clearly shown that, the application of ISFM practices is country or geographically specific due to ecological and the soil conditions factors in farming areas. In the light of this, the ISFM interventions in these studies vary across application of fertilizer (organic and inorganic), water harvesting (mulching), irrigation, intercropping, farm yard manure and pest management practices. Also emerging from these studies is failure to control for selection bias and endogeneity due to treatment variable ISFM which is binary. Except for studies by Rejesus et al. (2012) and Sanglestsawai et al. (2015) who deployed rigorous estimation techniques for their estimation, the absence of coherent econometric techniques in these studies generate results that are not consistent.

This paper contributes to the empirical literature on the effect of ISFM on farm level productivity of smallholder farmers. The contribution to this literature is two-fold. First, we implement a coherent and rigorous econometric technique to overcome the weakness in previous studies by controlling for selection bias and endogeneity or inverse causality. Second, the choice of using Ghana a country with numerous agricultural policies that seek to transform or improve the farming system from traditional methods towards increasing agricultural productivity and commercialization for our study is a contribution. The data used for this study is also drawn from an Agricultural Value Chain Facility (AVCF) project which is unique because of the focus of implementation of the project which is to increase the production and productivity of staple-food crops.

6.5. OVERVIEW OF AGRICULTURAL VALUE CHAIN FACILITY (AVCF) PROJECT

The AVCF was a project initiated by the DANIDA and forms part of the Danish Support to Private Sector Development – Phase II (SPSD II) programs. The implementation of AVCF was under the coordination and management of the AGRA. One of the objectives of the AVFC was the provision of mentorship and advisory services. The outcome of this objective is to "enhance capacity through mentorship and strengthened linkages among actors across the agricultural value chain" (AGRA, 2012). This objective had three broad (3) components under which a set of activities was carried out. These components are the productivity component, agro-dealer support component and small and medium enterprise (SME) support component (AVCMP, 2015).

The mentorship objective was targeted at training smallholder farmers in the Northern Region of Ghana. The region is known as the grain or bread basket of the country because of its contribution towards agriculture. According to Martey et al. (2014), the region has the potential of recording high crop production mainly within the segment of staple-food crops. Under the AGRA management structure, the provision of the mentorship and advisory services was implemented under two different sub-project names which carried out the same set of activities. These sub-projects are the Agriculture Value Chain Mentorship Project (AVCMP) and Integrated Agricultural Productivity Improvement and Marketing Project (INTAPIMP). The productivity component of the mentorship services focused on increasing productivity of staple crops such as maize, rice, soyabean and groundnut. The target number of smallholder farmers to benefit from the productivity component of the AVCF was 30,000 direct beneficiaries. The AVCF project was implemented over a five-year period from 2011 to 2015 (AGRA, 2014).

To achieve the objective of increasing agricultural productivity, participating farmers estimated at 27,856 received training on ISFM practices. The objective of the training was to enhance the skills and knowledge of smallholder farmers on effective agronomic practices while the learning outcome was to adapt and adopt the ISFM practices in the management of smallholder farms within a specific agro-ecological environment to increase productivity. Smallholder farmers received training on the following ISFM practices: ploughing across the slope, bundling, mulching cover cropping, row planting, proper plant spacing and minimum tillage. The rest are crop rotation, composting, organic fertilizer, organic manure, inorganic fertilizer, certified seeds, inoculum and dibbling.

6.6. DATA AND SAMPLING TECHNIQUES

This section discusses the sample design and the survey instrument used.

6.6.1. Sample Design

Two groups of farmers were sampled for identifying the impact of ISFM on farm-level productivity. The beneficiary group is the group that participated in the AVCF program and received the ISFM training and the non-beneficiary group is the group of farmers who did not participate in AVCF and so did not receive the ISFM training. Both groups consisted of farmers who were farming in either one or a combination of the following crops: maize, rice, soyabean and groundnut. This paper focuses on farm level analysis.

A three-stage sampling approach was used in the case of the beneficiary group. A combination of convenient, stratified and proportional sampling techniques was used. The rationale was to segment the entire population into different subgroups or strata, then randomly select the farmers proportionately from the different population groups or strata. In the first stage, we selected seven communities from each of the 22 districts used for this study in the Northern Region of Ghana. The selection of a community was influenced by the size of farmers who received ISFM training. That is, farmers were selected from communities with a large number of farmers who received ISFM training. The second stage was to randomly select a sample size of 1,700 farmers from a total number of 154 communities. After data editing and cleaning of outliers and various inconsistencies, we had a number of 1,608 farmers who either owned a maize farm or groundnut farm or soyabean farm or rice farm only or a farmer owning a combination of farms of different crops. The data shows a total number of 2,724 farms covering all the four crops. Of the total number of 2,724 farms, 1,163 were for maize farm plots only and 698 were for groundnut farm plots. In the third stage, we sampled 292 maize farms and 209 groundnut farms from the 1,163 maize farms and 698 groundnut farms respectively. The choice of maize and groundnut for analysis is due to the fact we did not have enough observations for soyabeans and rice for matching.

Data for the non-beneficiary group were also collected on farmers in selected communities within the Northern and Brong Ahafo (BA) regions with a total number of 295 farmers and 200 farmers respectively. The selected areas for this group are within the same agro-ecological zone as the beneficiary group. They share similar agricultural practices as well as community and socioeconomic characteristics. The selection of the areas or communities of these farmers is influenced by the fact that they are remote from communities where Government provides agricultural extension services to farmers and by the fact that NGOs are not there to provide agricultural services. After data cleaning and editing, the total number of smallholder farmers who did not benefit from the AVCF project intervention was recorded at 484. The total number of plot farms owned by the 484 smallholder farmers stands at 701 plot farms covering all the four crops. From the 701 plots farms, there are 369 maize plot farms and 261 groundnut plot farms only. The data was limited to maize plot farms and groundnut plot farms due to the limited observations for soyabeans and rice.

6.6.2. Survey Instrument

The survey was conducted within two months from July to August 2015. Detailed information was collected on key elements of socioeconomic characteristics of farmers by using a questionnaire. The questionnaire centred on farmer and farm plot characteristics. Data on production, farm size and market, among other characteristics of the survey, was limited to 2014/2015 farming season. The questionnaires were designed using the Ghana Statistical Service questionnaire on agricultural households as a guide. The field data was captured using Computer-Assisted Personal-Interview (CAPI) software.

6.7. DEMOGRAPHIC AND SOCIOECONOMIC CHARACTERISTICS OF BENEFICIARIES AND NON-BENEFICIARIES

The demographic and socioeconomic characteristics of maize and groundnut farmers who received training on ISFM practices (beneficiary group) and those who did not receive training in ISFM practices (non-beneficiary group) are shown in Table 6.3. From Table 6.3, the groups for maize farmers are similar except for slight differences in gender (sex), household size and number of years of farming. For groundnut farmers, the groups are also similar, except for slight differences in gender (sex), marital status and farm size.

Table 6.3: Demographic & Socioeconomic Characteristics of Beneficiaries and Non-Beneficiaries – Maize and Groundnut Farmers

		MAIZE FARMER		GROUNDNUT FARMER	
		Beneficiaries	**Non-Beneficiaries**	**Beneficiaries**	**Non-Beneficiaries**
Variable	**Sub-Categories**				
Gender	Male	67.81***	84.01	50.72***	68.20
Education Grade	No Formal education	81.51	77.24	86.12	80.08
Marital Status	Married	94.18	94.58	90.43**	95.40
Household size		12.30***	9.77	13.48***	9.49
Years of Farming		16.89*	18.32	16.13	15.30
Farm Size (ha)		2.67	2.97	2.37**	2.88
Total No. of Observations		**292**	**369**	**209**	**261**

Notes: We used Chi-Square (X^2) for categorical variables and t-test for continuous variables to test for differences between the beneficiary and non-beneficiary groups. P-values *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate the level of significance.

6.8. CHOICE OF VARIABLES

The choice of variables used to predict a farmer's participation in ISFM training is based on knowledge of the AVCF project and drawn from the conceptual framework of Adoption and Diffusion Outcome Prediction Tool (ADOPT), (Kuehne, Llewellyn, Pannell, Wilkinson, Dolling, Ouzman and Ewing, 2017). The concept of ADOPT strives on two key instruments being relative advantage and the effectiveness of the process of learning which strongly influences a farmer's participation in ISFM training. Kuehne et al., (2017) argue that by relative advantage, the focus is more on the decision to participate being influenced by the population of farmers and not that of an individual. This means that the decision to participate is based on the collective action of farmers resulting from a common objective. On the other hand, the process of learning is a predictor of the time lag before decision is made for a farmer to participate in ISFM training.

The instrument of relative advantage is a function of costs and risks that are associated with the ISFM training while the instrument of learning process which adds value through innovation is also a function of a farmer's access to services and awareness of the ISFM practice through observations. This means that these are some critical factors that influence a farmer's decision to participate in ISFM training. Each of these instruments (relative advantage and process of learning) is further categorized into characteristics that relate to the population of farmers and characteristics that relate to ISFM training. However, these characteristics are also likely to be interlinked (ibid).

The concept of ADOPT is therefore anchored on a broad set of characteristics that predict a farmer's participation in ISFM training. For this study, we choose characteristics of the farmer in addition to the ADOPT's model but specifically from the perspectives of relative advantage with characteristics that relate to ISFM training and process of learning with the characteristics that relate to the population of farmers.

Table 6.4: ADOPT Model and Variables

ADOPT MODEL	VARIABLES
Characteristics of farmer	Gender
	Education
	Years of farming
Relative advantage of ISFM training	Non-farm activity
	Expenditure on labour
	Expenditure on pesticides
	Distance to nearest market
	Owning mobile phone
	Owning radio
	Access to information about market buyers
Learning process – population specific factors	Distance to extension officer
	Distance to seed supplier
	Distance to fertilizer supplier

Source: Authors' compilation based on ADOPT model

Table 6.4 shows that based on the ADOPT model, we employ farmer characteristics as factors that influence a smallholder farmer's participation in ISFM training. The choice of variables under relative advantage to ISFM training denotes the fact that a farmer's participation in ISFM training is due to the farmer's motivation of earning profit or income through the effect of the ISFM training on farm management and economic activities within the year of practice and in the future. Additionally, with the ease and convenience of doing business, smallholder farmers are influenced to participate in ISFM training. Under the learning process with the characteristics that relate to the population of farmers such as access to advisory support and other farm inputs services, smallholder farmers are influenced to participate in ISFM training.

6.9. ESTIMATION OF IMPACT

According to Hacking (1988), Burtless (1995) and Loux (2015), randomisation (experimentation) is generally viewed as the most robust evaluation approach as it controls for selection bias. It is described as a highly reliable evaluation technique that helps to easily assign the difference in the average outcome of the treatment. However, the design of AVCF, which was the project of study, was not randomised. Meanwhile, the characteristics of the AVCF project offer the opportunity to use the PSM estimation model as the alternative approach for the estimation of the impact of ISFM on farm-level productivity. The choice of the PSM estimation therefore controls for selection bias. On that note, data was collected from both the beneficiary and the non-beneficiary and non-equivalent control groups who completed the same questionnaire for estimating the average treatment effect. Studies by Jalan and Ravallion (2003) used PSM to estimate "the benefit incidence of an antipoverty program in Argentina" and while Wendimu, Henningsen and Gibbon (2016) also adopted the PSM model for the estimation of "the effects of compulsory participation in sugarcane outgrowers schemes in Ethiopia".

PSM estimators are used for estimating a causal effect of a treatment in the absence of a randomised survey. According to Rosenbaum and Rubin (1983), a propensity score is "the conditional probability of assignment to a particular treatment given a vector of observed covariates". In other words, the propensity score is the probability of participating or receiving a treatment depending upon the pool of the observed characteristics. The conditional probability of receiving treatment or the propensity score is estimated using either the logit or probit regression model (Austin, 2008; Li, 2012). The propensity score is expressed in the equation below as:

$$e(x) = \Pr(Z = 1 \mid X) \qquad \text{Eq. (6.1)}$$

Equation (6.1) simply explains the propensity score denoted by $e(x)$ as the probability of participating or receiving treatment Z given X as the observed covariates. Given the propensity score, treatment Z and the observed covariates X are said to be conditionally independent, which is denoted as $X \perp Z \mid e(x)$ (Rosenbaum, 2010).

Abadie and Imbens (2009) and Gertler, Martinez, Premand, Rawlings and Vermeersch (2011) also note that propensity score eliminates "the curse of dimensionality" by constructing a single dimension. The construction of propensity score therefore addresses the problem of selection bias that unfolds because of selection on observable characteristics. Another form of selection bias is the selection of the counterfactuals that are used to construct a comparison group. The rationale is that the compared groups might contain some degree of "noise", with the argument that they might benefit from the treatment through spillover effects (Abate, Francesconi & Getnet, 2013). According to Cerulli (2015), selection bias exists when individuals are self-selected into the program and also because of the nature of the selection mechanism adopted by the project implementing agency.

After estimating propensity scores, one then matches the treatment (beneficiary) group with the control (non-beneficiary) group on the estimated propensity score. However, this is only made possible on the assumption that the common support condition is satisfied. In other words, the treated and the non-treated groups do not overlap (Khandker, Koolwal & Samad, 2010). Following Imai and Ratkovic (2014), the common support zone ranges from 0 and 1, which gives both the treated and the non-treated groups equal opportunity of participating in the project. This is denoted as:

$$0 < \Pr(Z_i = 1 | X_i) < 1 \qquad \text{Eq. (6.2)}$$

Propensity score is also known as the balancing score and Khandker et al. (2010), note that both the beneficiary group $(Z = 1)$ and non-beneficiary group $(Z = 0)$ must be balanced based on the propensity scores. This implies that the two independent groups must have the same or similar distribution, given the vector of covariates. This is denoted in equation (6.3) below:

$$\Pr\{X | Z = 1, e(x)\} = \Pr\{X | Z = 0, e(x)\} \qquad \text{Eq. (6.3)}$$

The causal effect, which is the average effect of a treatment, can now be estimated using the balancing score. The ATET is obtained by simply subtracting the outcome of average treatment effect of the non-beneficiary group from the outcome of the average treatment effect of the beneficiary group using the estimated propensity score (Li, 2012). This is expressed by equation (6.4) below:

$$ATET_{PSM} = E\{Y | Z = 1, e(x)\} - E\{Y | Z = 0, e(x)\} \qquad \text{Eq. (6.4)}$$

In brief, the causal effect of a treatment is estimated on the assumption that both the treatment (Z) and the potential outcome (Y) are conditionally independent of each other, given the covariates. The implication is that the potential outcome (Y) and treatment (Z) of each individual smallholder farmer remains independent and identically distributed. This further means that the potential outcome (Y) and treatment (Z) are neither correlated nor associated with the potential outcome and treatment of any other individual within the population.

6.9.1. Estimation of Treatment Effect

We estimate the impact of ISFM practices training on farm-level productivity of maize and groundnut by adopting two matching estimators for analysis. These are the propensity-score matching (PSM) and the nearest-neighbour matching (NNM)[19]. The matching methods simply match the beneficiary group to non-beneficiary group that correspond to a given distance based on the defined common support (Cerulli, 2015).

We assume the following steps for the estimation of the treatment-effect. First, we estimate the probability of farmers receiving or participating in ISFM training using a probit regression model. Secondly, we select the region of common support which is estimated on the propensity score to be followed by the estimation of the empirical result as the third step. Covariates balance as well as Rosenbaum sensitivity analysis are carried out in steps four and five respectively for post-estimation analysis.

6.10. PROBIT ESTIMATION OF PROPENSITY SCORE

We estimate the probability of a farmer participating in ISFM practices, given the observed covariates, using a probit regression model. The treatment variable (ISFM) represented Z is binary denoted as one (1) for a farmer who received ISFM training and zero (0) for a farmer who did not receive ISFM training. This is shown in the model below:

$$Z = \begin{cases} 1 \text{ if farmer } i \text{ received ISFM training (i.e., beneficiary group)} \\ \\ 0 \text{ if farmer } i \text{ did not receive ISFM training (i.e., non} - \text{beneficiary group)} \end{cases}$$

From Table 6.5 below, the results of the estimation of the propensity scores reveal that for a maize farmer's participation in ISFM training, the following factors: expenditure on labour and access to information about market buyers strongly drive a maize farmer's participation. On the other hand, gender (sex), owning mobile phone and distance to extension officer are the factors that are less likely to influence maize farmer's participation in ISFM training. Regarding a groundnut farmer's participation in ISFM training practices, we found that, except for gender (sex), number of years of farming and expenditure on pesticides that influence a groundnut farmer's participation, the remaining factors (basic

[19] We used *"teffects psmatch"* and *"teffects nnmatch"* STATA commands for estimation and *"tebalance sum"* for covariate balance analysis

education attained, tertiary education attained and distance to nearest market) are less likely to drive participation in ISFM training practices.

Table 6.5: Probit Regression Model for Maize & Groundnut Farmer's Participation in ISFM Training

Variables	MAIZE			GROUNDNUT		
	Coef.	**Robust Std. Err**	**P-Value**	**Coef.**	**Robust Std. Err**	**P-Value**
Gender (Sex)	-0.555***	0.141	0.000	0.573***	0.152	0.000
Formal Education Grade:						
Basic	-0.230	0.143	0.106	-0.359*	0.210	0.087
Secondary	-0.158	0.256	0.538	0.597	0.371	0.108
Tertiary	0.418	0.500	0.403	-1.167*	0.681	0.086
Number of Years of Farming	-0.005	0.005	0.329	0.015**	0.007	0.033
Non-Farm Activity	-0.035	0.116	0.759	0.113	0.145	0.436
Farm Size	0.003	0.045	0.945			
Labour Expenditure	0.219*	0.112	0.051			
Info about Market Buyers	0.480***	0.112	0.000			
Mobile Phone Ownership	-0.406***	0.117	0.001			
Radio Ownership	-0.065	0.125	0.603			
Distance to Extension Officer	-0.022***	0.007	0.001			
Pesticides Expenditure				0.707***	0.210	0.001
Distance to Seed Supplier				0.005	0.025	0.858
Distance to Fertilizer Supplier				0.029	0.028	0.289
Distance to nearest Market				-0.103***	0.019	0.000
Constant	1.036***	0.301	0.001	-0.564*	0.324	0.082
Observations		661			470	
Log likelihood		-415.499			117.31	
Pseudo R^2		0.084			0.210	

*** p<0.01, ** p<0.05, * p<0.1

6.11. DISTRIBUTION OF PROPENSITY SCORE ACROSS BENEFICIARY AND NON-BENEFICIARY GROUPS

Having developed the propensity score based on the covariates, we will now showcase a graphical view of the region of common support. Figures 6.2 and 6.3 below respectively show a graphical presentation of the distribution of maize and groundnut farmers who received training in ISFM practices (treated group) and the non-beneficiaries of ISFM training (non-treated group) depending upon the propensity score. The region of common support selected following the estimated propensity score for maize farmers' participation in ISFM training ranges between 0.098 and 0.939. For groundnut, the region of common support ranges from 0.008 and 0.989. The distribution shows that there is no overlap across the beneficiaries of ISFM training and the non-beneficiary group. A comparison of the distribution of crops (maize and groundnut) productivity as per the treatment (beneficiary of ISFM training) group and the control (non- beneficiary of ISFM training) group based on the propensity scores are shown in Figures 6.4 and 6.5 in Appendix A.

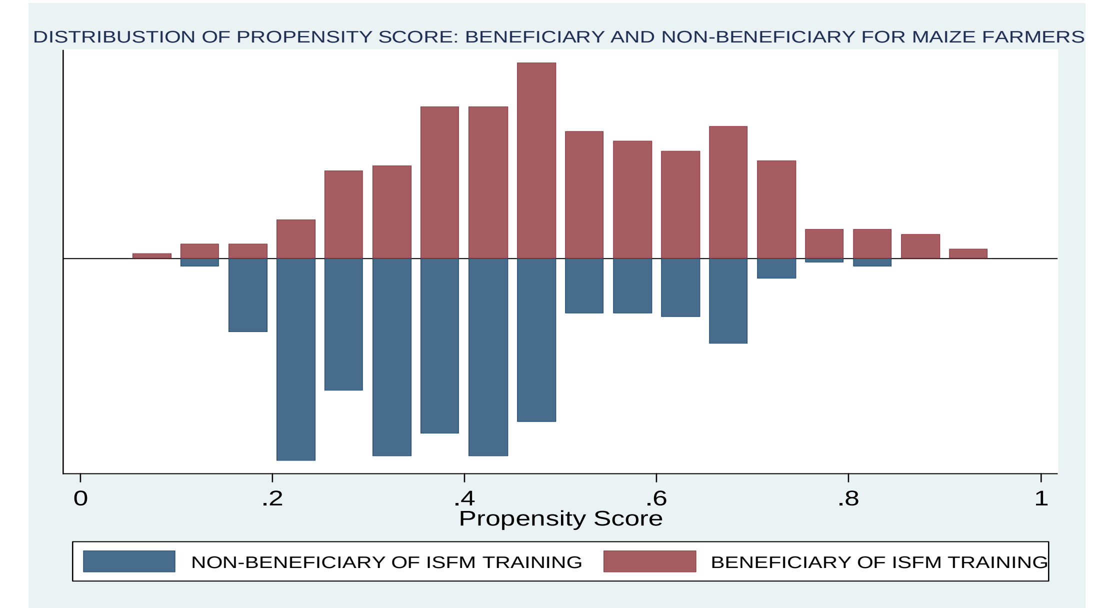

Figure 6.2: Distribution of Propensity Score across Treated and Non-treated Groups for Maize Farmer Participation in ISFM practices

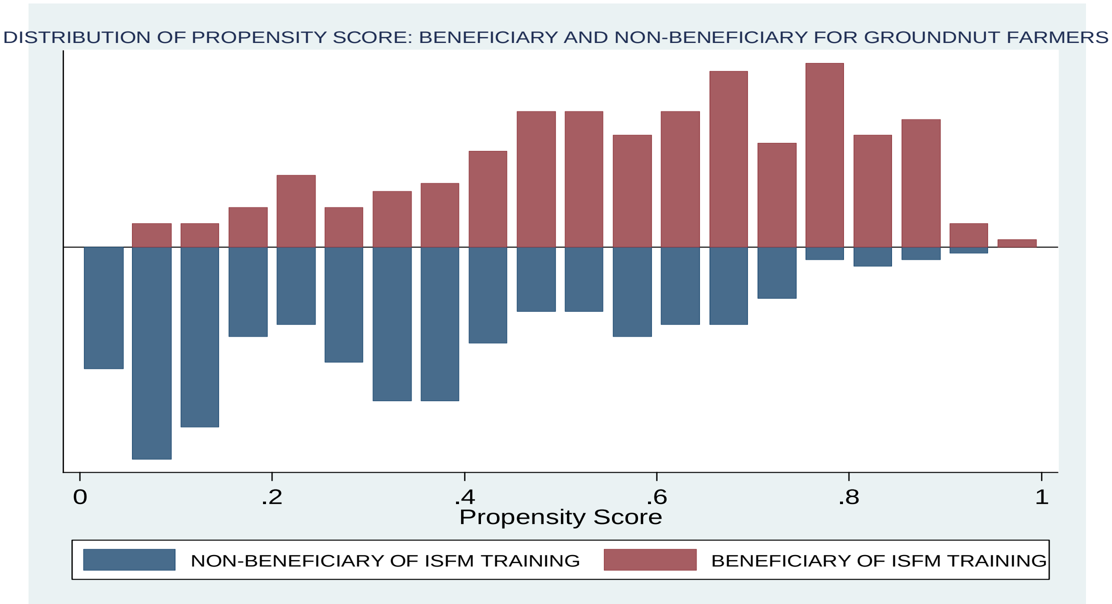

Figure 6.3: Distribution of Propensity Score across Treated and Non-treated Groups for Groundnut Farmer Participation in ISFM practices

6.12. DISCUSSION OF EMPIRICAL RESULTS

Our results reveal that integrated soil fertility management (ISFM) significantly increases productivity of smallholder farmers. The results show that by receiving training and adapting efficient agronomic practices that involve the application of genotype within a particular biophysical environment, coupled with improved knowledge and skills of smallholder farmers, have been proven to make a significant impact on the productivity of maize and groundnut in Northern Region of Ghana.

Our findings, as shown in Table 6.6, indicate that farmers who received training and adapt to ISFM practices increased their maize productivity by 0.283 metric tonnes per hectare higher than the non-beneficiary group while that of groundnut productivity also increased by 0.146 metric tonnes per hectare higher than the non-beneficiary group. This follows the use of propensity-score matching (PSM) estimator. Similarly, results of the nearest-neighbour matching (NNM) estimator shows that, a beneficiary of ISFM training increased the maize productivity by 0.205 metric tonnes per hectare more than maize farmers who did not receive ISFM training. Similarly, groundnut farmers who received ISFM training increased the productivity of groundnut by 0.145 metric tonnes per hectare higher than the groundnut farmer who did not receive training in ISFM practices. By controlling for selection bias, using robust and rigorous estimation techniques, this study confirms the results of similar studies in Nigeria by Kato, Nkonya and Place (2011), in Ethiopia by Agegnehu, Van Beek and Bird (2014) and Meresa, Mengistu and Bisetegn (2016) in Ethiopia.

The results also show the increase in productivity of maize is higher than that of groundnut. This can be explained on the basis that groundnut is a leguminous crop which adds nitrogen to the soil. For this reason, smallholder farmers in the Northern Region do not or hardly apply fertilizer to improve yield. Secondly, access to fertilizer (single super phosphate) used for groundnut is not readily available within the North. However, unlike groundnut, smallholder maize farmers apply fertilizer contributing to a higher productivity. This is also the case because although both maize and groundnut are significant crops in Ghana, to the farmer, maize serves as both food and cash crop whereas groundnut is only a cash crop.

Table 6.6: Treatment Effects Estimation (ATET) of ISFM on Maize & Groundnut Productivity

ESTIMATORS	MAIZE			GROUNDNUT		
	Coefficient	Standard Errors	P-value	Coefficient	Standard Errors	P-value
Propensity-score Matching	0.283***	0.054	0.000	0.146***	0.052	0.005
Nearest-neighbour Matching	0.205***	0.060	0.001	0.145***	0.050	0.004

Significance levels are based on AI Robust standard (errors in parentheses)
*** p<0.01, ** p<0.05, * p<0.1

6.13. POSTESTIMATION RESULTS

This section presents the covariate balance and conducts the test for hidden balance.

6.13.1. Covariates Balance

Post estimation results focus on checking the balancing of covariates using the standardised mean difference between the beneficiaries (treatment) and the non-beneficiaries (control) groups. This provides evidence of equal distribution of the matched (common support) and weighted samples of the propensity score. According to Austin (2009, 2011) and Austin and Stuart (2015), "standardized difference compares the difference in means in units of the pooled standard deviation". While they emphasise that no agreement had been reached on the value for standardised difference based on which one can draw conclusions on the balancing of the covariates of the beneficiaries and non-beneficiaries groups, they hold the view that standardised difference, which is also known as "effect size", with value exceeding 0.1 (10%) is an indication of imbalance of the covariates. Similarly, Hallahan and Rosenthal (1996) and Faul, Erdfelder, Lang and Buchner (2007) referred to the works of Cohen (1992) to state that a standardised difference with value of 0.2 (20%) has a small size effect. Meanwhile, Stuart, Lee and Leacy (2013) pointed out that a standardised difference with value of 0.1 to 0.25 is considered as a guide that is appropriate to establish a covariate balance of the treated and non-treated groups. In other words, a standardised difference greater than 0.25 (25%) is a recipe for significant imbalance of covariates. Following the above, we use a maximum standardised difference of 0.25 to reach a decision on balancing of covariates.

Table 6.7 below presents the result of the covariate balance of both the raw and weighted standardised differences. All covariates recorded a value of less than 0.25. We therefore conclude that there is equal distribution of the treated and non-treated groups. Hence, the covariates are balanced.

Table 6.7: Covariate Balance Summary

STANDARDIZED DIFFERENCE						
	MAIZE FARMER			GROUNDNUT FARMER		
VARIABLES		PSM	NNM		PSM	NNM
	Raw	Matched		Raw	Matched	
Gender (Sex)	-0.363	0.027	-0.137	0.361	0.074	0.090
Formal Education Grade:						
Basic	-0.085	0.022	0.008	-0.216	-0.100	-0.003
Secondary	0.006	-0.010	0.000	0.089	0.128	0.000
Tertiary	0.111	0.046	0.094	-0.037	0.050	0.050
Number of Years of Farming	-0.179	0.083	0.028	0.080	-0.087	0.055
Non-Farm Activity	0.008	0.099	0.108	0.115	-0.011	0.009
Farm Size	-0.015	-0.032	0.032			
Labour Expenditure	0.291	-0.037	-0.008			
Info about Market Buyers	0.333	-0.049	0.184			
Mobile Phone Ownership	-0.252	-0.037	0.037			
Radio Ownership	-0.013	-0.008	0.074			
Distance to Extension Officer	-0.222	-0.188	-0.122			
Pesticides Expenditure				0.430	-0.061	0.075
Distance to Seed Supplier				-0.774	-0.030	-0.102
Distance to Fertilizer Supplier				-0.752	0.004	-0.057
Distance to nearest Market				-0.956	-0.010	-0.225
Total Number of Observations	661	584	584	470	418	418
Treated Observations	292	292	292	209	209	209
Control Observations	369	292	292	261	209	209

6.13.2. Test for Hidden Bias

According to DiPete and Gangl (2004), matching on the propensity score does not solve all bias problems resulting from unobservable characteristics that affect the treatment variable or the outcome. Rosenbaum (2010) confirms that the propensity score balances only on the covariates observed. In other words, selection on observables do not provide the opportunity to factor in the unobservable variables for selection. Against this background, we carried out a sensitivity analysis to assess the effect of a hidden bias on the outcome. The relevance of the sensitivity analysis is that it is a further step taken to confirm the accuracy of the treatment effects in a way of attribution of the treatment to the outcome. We showcase this evidence by adopting the Rosenbaum bounds (rbounds) approach.

The sensitivity analysis, as shown in Table 6.8, explains a change in magnitude of gamma (Γ) as a result of 0.1 point movement. Specifically, this analysis provides strong evidence that the results of the impact of a smallholder farmer receiving training in ISFM practices on farm-level productivity of maize and groundnut are devoid of any hidden bias. The ISFM-maize productivity showed no evidence of the effect of hidden bias. For ISFM-groundnut productivity we found that, there is evidence of effect of hidden bias only after the magnitude Γ=1.5. This outcome of the Rosenbaum sensitivity analysis is a clear manifestation that knowledge gained by smallholder farmers because of their participation in ISFM training and the adaptation of the practices is the cause of the difference in the productivity gap between the beneficiary and non-beneficiary groups. The sensitivity analysis is reported for one-sided significance level (sig+) as shown below.

Table 6.8: Rosenbaum Sensitivity Analysis for Hidden Bias

Gamma (Γ)	**Maize**	**Groundnut**
	sig+	**sig+**
1	0.000	0.000
1.1	0.000	0.000
1.2	0.000	0.001
1.3	0.000	0.005
1.4	0.000	0.017
1.5	0.000	**0.043**
1.6	0.000	0.091
1.7	0.001	0.165
1.8	0.003	0.261
1.9	0.007	0.374
2	0.017	0.492

6.14. CONCLUSION

This paper provides the evidence by evaluating the impact of integrated soil fertility management (ISFM) on farm-level productivity of maize and groundnut. Data for the study was drawn from the Agricultural Value Chain Facility (AVCF) project implemented in the Northern Region of Ghana. To control for potential selection bias from observable characteristics, we use matching methods (propensity score and nearest neighbour matchings) for estimation. Since the matching method of estimation is limited in its control of endogeneity resulting from unobservable characteristics, we test for the effect of hidden bias on productivity.

We find compelling evidence that the crops (maize and groundnut) productivity of a beneficiary of ISFM training is significantly higher than that of a non-beneficiary of ISFM training. What this means is that by increasing the knowledge of a smallholder farmer in ISFM practices and its adaptation through training, the smallholder farmer is able to increase farm productivity. However, we also find that the result of ISFM impact on the productivity of maize is higher than the impact of ISFM on the productivity of groundnut. This is because the adaptation and practice of ISFM among maize farmers is higher as compared to groundnut farmers. That is, whereas maize farmers adopt fertilizer to improve the health of the soil leading to increase in productivity, groundnut farmers are constrained in using fertilizer and they therefore depend on the quality of the soil for its production. We find the results to be robust since it is free from the effect of hidden bias.

The result is therefore consistent with the theory on the link between knowledge and adaptation to ISFM practices and farm level production. The implication is that, through a more effective and efficient use of genotype (G) based on the ecological environment (E) within which farming takes place and coupled with effective farm management (M) practices, farm level productivity is expected to increase. The result, therefore, provides opportunities for smallholder farmers to embrace the use and application of ISFM practices as part of their farming system. This study, therefore, provides evidence on the effect of ISFM training on crop productivity of smallholder farmers using the case of Northern Region of Ghana.

In view of the results, policy direction should be focused on upgrading the skills and knowledge of smallholder farmers in ISFM practices towards boosting productivity. In this regard, development partners and State agencies responsible for developing the agricultural sector could consider introducing ISFM practices as the new farming system that needs to be adopted by smallholder farmers to increase productivity through its policy formulations. In addition, incentives should be given to key institutions and firms with interest in the development of the agricultural sector to engage in ISFM support services to crop farmers in order to boost productivity.

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APPENDIX A

Table 6.8: Definition and summary statistics of variables: Probit estimation and Econometric estimation of impact of ISFM training on Productivity of Maize

Variable	Obs	Mean	Std. Dev.	Min	Max	Label
Productivity of Maize	661	0.836	0.637	0.041	4.942	Productivity of maize measured in metric tonnes per hectare
Participating in ISFM	661	0.442	0.497	0	1	1 if Farmer participates in ISFM training or otherwise zero (0)
Gender (Sex)	661	0.773	0.419	0	1	1 if Farmer is a male or otherwise zero (0)
Formal Education Grade:						
Basic	661	0.165	0.371	0	1	1 if Farmer completes basic education or otherwise zero (0)
Secondary	661	0.044	0.205	0	1	1 if Farmer completes secondary education or otherwise zero (0)
Tertiary	661	0.011	0.102	0	1	1 if Farmer completes tertiary education or otherwise zero (0)
Number of Years of Farming	661	17.496	10.657	1	50	Number of years of farming
Non-Farm Activity	661	0.289	0.454	0	1	1 if Farmer is engaged in non-farm activity or otherwise zero (0)
Farm Size	661	1.413	1.235	0.405	16.997	Farm size of a farmer
Labour Expenditure	661	0.607	0.489	0	1	1 if Farmer spent cost on labour or otherwise zero (0)
Info about Market Buyers	661	0.315	0.465	0	1	1 if Farmer has information about market buyers or otherwise zero (0)
Mobile Phone Ownership	661	1.343	0.475	1	2	1 if Farmer owns mobile phone or otherwise zero (0)
Radio Ownership	661	1.274	0.446	1	2	1 if Farmer owns a radio set or otherwise zero (0)
Distance to Extension Officer	661	12.704	8.827	0	50	Distance to extension officer measured in kilometres

Table 6.9: Definition and summary statistics of variables: Probit estimation and Econometric estimation of impact of ISFM training on Productivity of Groundnut

Variable	Obs	Mean	Std. Dev.	Min	Max	Label
Productivity of Groundnut	470	0.720	0.522	0.076	4.052	Productivity of groundnut measured in metric tonnes per hectare
Participating in ISFM	470	0.445	0.497	0	1	1 if Farmer participates in ISFM training or otherwise zero (0)
Gender (Sex)	470	1.396	0.490	0	1	1 if Farmer is a male or otherwise zero (0)
Formal Education Attained:						
Basic	470	0.136	0.343	0	1	1 if Farmer completes basic education or otherwise zero (0)
Secondary	470	0.030	0.170	0	1	1 if Farmer completes secondary education or otherwise zero (0)
Tertiary	470	0.006	0.080	0	1	1 if Farmer completes tertiary education or otherwise zero (0)
Number of Years of Farming	470	15.670	10.440	1	50	Number of years of farming
Non-Farm Activity	470	0.291	0.455	0	1	1 if Farmer is engaged in non-farm activity or otherwise zero (0)
Pesticides Expenditure	470	0.130	0.336	0	1	1 if Farmer spends on pesticides or otherwise zero (0)
Distance to Seed Supplier	470	12.283	8.577	0	38	Distance to supplier of seeds measured in kilometres
Distance to Fertilizer Supplier	470	12.387	8.508	0	32	Distance to supplier of seeds fertilizer measured in kilometres
Distance to nearest Market	470	11.396	8.455	0	32	Distance to the nearest market measured in kilometres

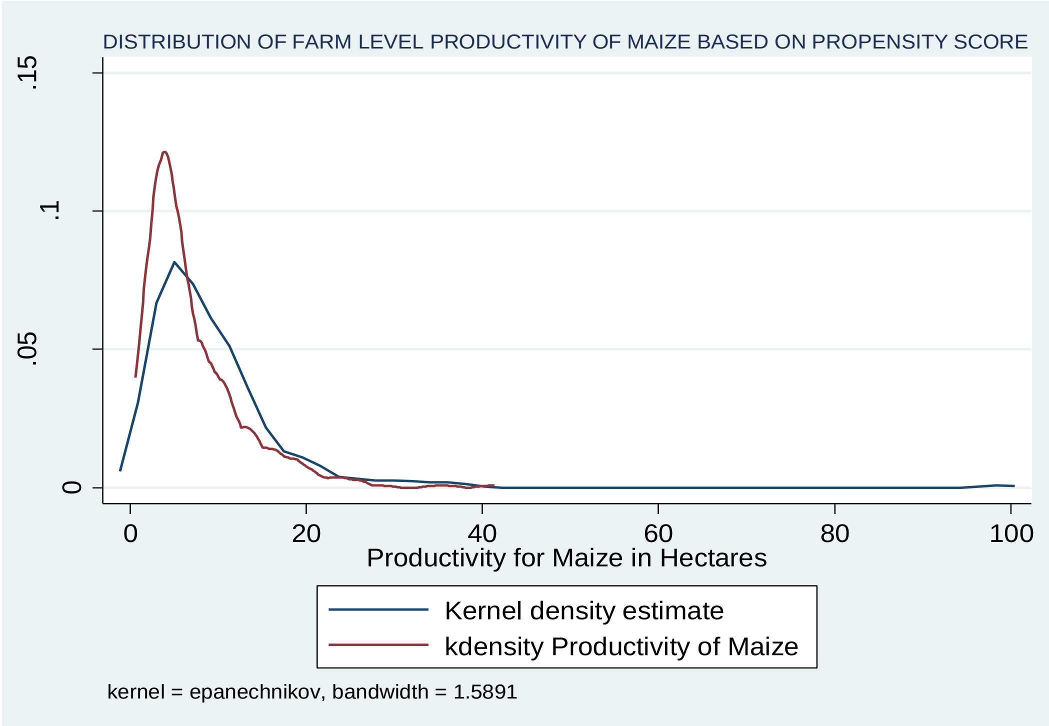

Figure 6.4: Distribution of productivity of maize per a beneficiary farmer (treated) compared to non-beneficiary farmer (non-treated). Samples matched by one-to-five nearest neighbour matching

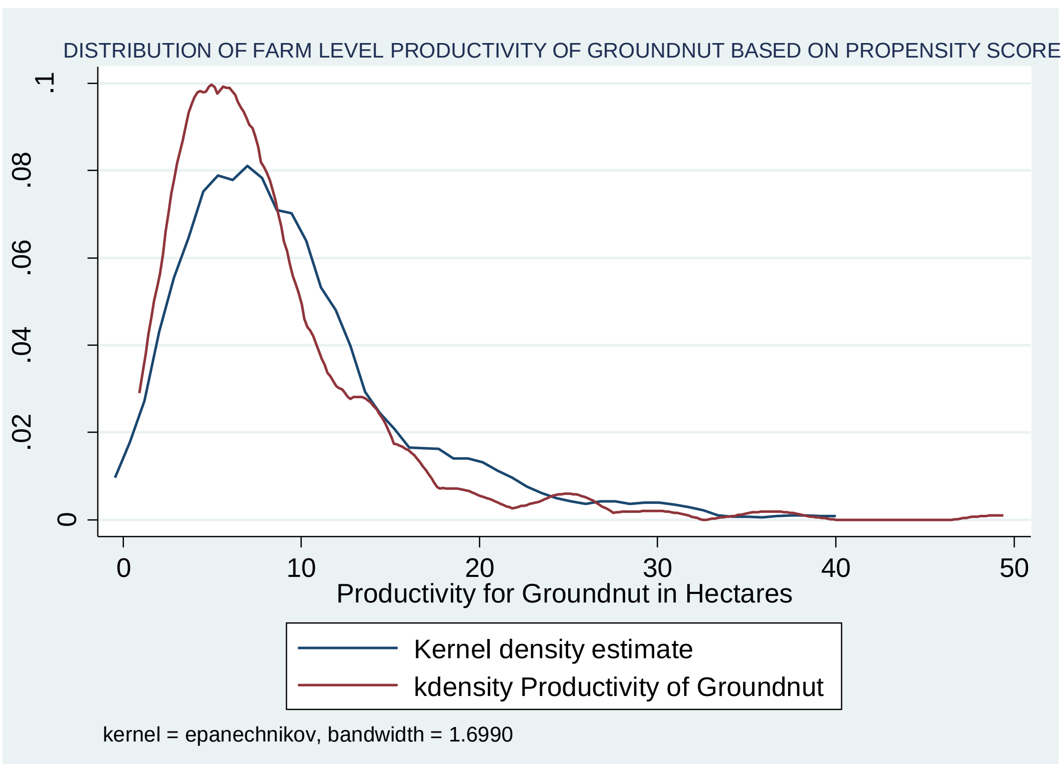

Figure 6.5: Distribution of productivity of groundnut per a beneficiary farmer (treated) compared to non-beneficiary farmer (non-treated). Samples matched by one-to-three nearest neighbour matching

Table 6.10: Growth Rates in Agricultural Sub-Sectors (%)

YEARS	Crops	Cocoa	Livestock	Forestry and Logging	Fisheries	AGRICULTURE
1975	-21.28	-26.08	-21.28	-1.74	7.45	**-19.93**
1976	-14.12	29.39	-14.12	3.51	-0.25	**-1.65**
1977	2.22	-21.06	2.22	-1.38	21.59	**-4.61**
1978	35.31	-11.25	35.31	2.94	-1.94	**18.04**
1979	8.23	-4.86	8.23	-3.50	-12.28	**3.77**
1980	0.09	9.50	0.09	2.02	9.13	**2.17**
1981	-0.78	-4.39	-0.78	-12.22	1.09	**-2.56**
1982	-4.23	-17.19	-4.23	7.81	-4.19	**-5.46**
1983	-8.01	-14.18	-8.01	7.42	3.37	**-6.99**
1984	15.45	-8.43	15.45	1.39	0.65	**9.71**
1985	-1.87	13.18	-1.87	0.10	11.97	**0.65**
1986	0.22	18.19	0.22	1.25	13.97	**3.31**
1987	-0.34	3.26	-0.34	1.55	-10.06	**0.03**
1988	6.00	-6.30	6.00	3.42	2.26	**3.58**
1989	5.14	3.19	5.14	1.17	0.55	**4.25**
1990	-4.13	2.98	-4.13	3.77	2.38	**-2.02**
1991	6.80	-1.95	6.80	2.09	1.43	**4.73**
1992	-1.94	2.10	-1.94	3.28	2.02	**-0.64**
1993	1.47	1.58	1.47	2.58	1.60	**2.84**
1994	1.68	12.21	4.76	1.76	1.18	**1.87**
1995	4.24	11.05	4.76	2.01	1.57	**3.74**
1996	6.00	2.90	4.76	2.68	3.05	**5.22**
1997	2.31	9.31	4.76	21.52	0.64	**4.30**
1998	4.81	11.09	4.76	10.04	1.79	**5.11**
1999	3.68	-0.48	4.76	6.78	1.00	**3.88**
2000	0.67	6.20	4.77	11.10	-1.60	**2.12**
2001	4.05	-1.00	4.76	4.80	2.00	**4.02**
2002	4.38	-0.51	4.75	5.01	2.81	**4.36**
2003	6.64	16.42	4.75	6.10	3.00	**6.07**
2004	7.91	29.90	4.82	4.20	6.20	**6.97**
2005	4.47	13.22	4.73	5.60	-1.20	**4.14**
2006	6.75	8.70	4.71	2.60	3.62	**5.74**
2007	-1.35	-8.20	4.73	-4.09	-7.25	**-1.72**
2008	8.60	3.22	5.10	-3.32	17.38	**7.40**
2009	10.21	5.00	4.37	0.72	-5.71	**7.23**
2010	5.00	26.60	4.65	10.07	1.49	**5.28**
2011	3.70	14.00	5.10	-14.00	-8.67	**0.85**
2012	0.77	-9.45	5.23	6.80	9.12	**2.30**
2013	5.88	2.65	5.28	4.59	5.67	**5.68**
2014	5.66	4.32	5.30	3.77	-5.57	**4.65**
2015	2.55	-7.96	5.27	1.44	4.30	**2.78**
2016	2.49	-7.02	5.33	2.52	5.68	**2.95**

Source: Ghana Statistical Service / Ministry of Food and Agriculture – Statistical, Research and Information Department.

Table 6.11: Crop Productivity (Yields) Measured in Metric Tonnes Per Hectare

CROP	Maize	Rice (Paddy)	Millet	Sorghum	Cassava	Cocoyam	Yam	Plantain	Groundnuts	Cowpea	Soybean
1985	0.98	0.92	0.54	0.74	8.64	4.50	5.05	5.00			
1986	1.18	0.91	0.70	0.73	7.43	4.87	5.85	5.70			
1987	1.09	1.12	0.74	0.76	7.00	5.15	5.80	5.71			
1988	1.20	0.90	0.84	0.73	7.43	4.48	5.91	5.69			
1989	1.20	0.90	0.74	0.73	7.44	4.82	5.88	5.70			
1990	1.19	0.92	0.60	0.63	8.42	5.75	7.34	6.19			
1991	1.53	1.59	0.54	0.92	10.66	6.39	11.58	6.79			
1992	1.20	1.65	0.64	0.97	10.26	6.14	10.40	6.89	0.78		
1993	1.51	2.04	0.97	1.06	11.23	7.07	12.37	8.04	1.01	0.67	
1994	1.43	1.83	0.93	1.05	11.58	6.42	11.03	8.06	1.03	0.67	
1995	1.55	2.22	1.08	1.08	11.99	6.89	12.07	7.71	0.89	0.68	
1996	1.52	2.05	1.02	1.12	12.04	7.26	12.78	7.97	0.87	0.68	
1997	1.55	1.69	0.84	1.03	12.11	7.42	12.85	8.21	0.88	0.75	
1998	1.46	2.16	0.90	1.07	11.39	7.24	12.81	7.78	1.10	0.72	
1999	1.51	1.93	0.89	0.94	12.00	7.58	15.66	8.06	0.88	0.74	
2000	1.46	2.16	0.81	0.97	12.28	6.48	12.88	7.85	0.96	0.70	
2001	1.31	2.03	0.70	0.85	12.34	6.35	12.34	7.47	1.13	0.62	
2002	1.49	2.28	0.80	0.94	12.25	6.51	13.31	8.17	1.36	0.80	
2003	1.63	2.08	0.85	0.97	12.68	6.45	12.42	8.15	0.92	0.76	1.16
2004	1.58	2.03	0.79	0.96	12.42	6.69	12.52	8.71	0.90	0.77	0.97
2005	1.58	1.97	1.00	1.00	12.76	6.61	13.08	9.63	0.93	0.80	0.86
2006	1.50	2.00	0.83	0.98	12.20	6.38	13.19	9.70	1.08	0.90	1.04
2007	1.54	1.70	0.69	0.74	12.76	6.56	13.52	10.59	0.88	0.86	1.06
2008	1.74	2.27	1.06	1.20	13.51	6.70	14.08	10.70	1.34	1.12	1.21
2009	1.70	2.41	1.31	1.31	13.81	6.70	15.26	10.96	1.44	1.26	1.46
2010	1.89	3.03	1.24	1.40	15.43	6.60	15.23	10.79	1.59	1.31	1.90
2011	1.65	2.35	1.03	1.18	16.01	6.36	14.50	10.76	1.30	1.30	1.92
2012	1.87	2.54	1.04	1.21	16.75	6.47	15.57	10.54	1.38	1.32	1.78
2013	1.72	2.64	0.97	1.14	18.27	6.50	16.78	10.81	1.24	1.24	1.64
2014	1.73	2.69	0.96	1.14	18.59	6.48	16.63	10.74	1.28	1.21	1.63
2015	1.92	2.75	0.97	1.00	18.78	6.49	16.96	10.90	1.24	1.25	1.65

Source: Ministry of Food and Agriculture – Statistical, Research and Information Department.

CHAPTER 7
CONCLUSION AND POLICY RECOMMENDATIONS

7.1. INTRODUCTION

This study examined the productivity, and welfare effects of finance and factors affecting market participation of small holder farmers as well as integrated soil fertility management of the small holder farmers in Ghana. This study was structured along four essays: first, it examined the link between access to finance and productivity; second, it assessed the impact of finance on welfare; third, it analysed factors influencing smallholder farmers' decision to access markets and to participate intensely in these markets; and finally, the thesis evaluated the impact of ISFM on the productivity of smallholder farmers.

Drawing data from the field on the DANIDA AVCF project on smallholder farmers in the Northern Region of Ghana, we use rigorous econometric estimation techniques such as the PSM, IPW and IV to examine the links between finance and productivity, finance and welfare and the impact of ISFM on the productivity of smallholder farmers. The rationale for the choice was to control for selection bias and the problem of endogeneity resulting from the non-randomisation of the project due to the design and its structure as well as non-randomisation of the treatment variables (integrated soil fertility management and access to finance) in each of the studies. For our estimations, we gathered data on non-equivalent control groups with similar characteristics to compare the mean outcomes of the beneficiaries and control groups. We also used the Cragg's double-hurdle model to assess the factors that influence market participation and its intensity. The results of these models provide a more robust, consistent and efficient estimation.

Generally, we have shown that, despite the introduction and implementation of policies, programs and projects aimed to improve agricultural productivity, Ghana has not yet been able to achieve and sustain its target annual agricultural growth rate of six per cent. Similarly, there is a wide gap between the levels of productivity attained and the expected levels of productivity or yield. From the empirical essays in this thesis we found that access to finance (production credit) has a significant impact on productivity of smallholder farmers when we compare beneficiaries to a more constrained Control group 2. With the access to finance, the smallholder farmer in the Northern Region of Ghana was efficient in allocating the required farm inputs, resulting in shifting the maize production frontier outwards and increasing productivity. The economic activity of most households in Africa is structured around agriculture and smallholder farming. However, very little is known about the impact of finance on smallholder farmers. Using household assets as a measure of welfare, we have shown that access to finance has a significant impact on the welfare of smallholder households in the Northern Region. We therefore conlude that the welfare of smallholder farmers can be greatly enhanced by access to finance but through economic generating activities such as investing in farm inputs. On factors influencing smallholder farmers' decision to access the market and participate in the market in the Northern Region of Ghana, our findings show that there are significant differences in the effect of transaction costs (market and production related) and socioeconomic factors on market access and the market participation. The differences show that apart from some transportation cost factors for maize there is separability between market access and market participation decisions of smallholder farmers. These differences in the market access and market participation are also seen across crop types. Finally, from our comparison of the beneficiaries of the ISFM training as against those who did not participate in the ISFM training we provide evidence that upgrading the knowledge of and adaptation of ISFM to local conditions is very significant, as it impacts on farm-level productivity of maize and groundnut in the Northern Region of Ghana.

7.2. CONTRIBUTIONS OF THE THESIS

This study makes unique contributions to the literature in several ways. First, we show that finance in the form of production credit is crucial for smallholder farmers. For these farmers a critical challenge to productivity is the ability to access short to medium-term credit on a regular basis to finance the cost of inputs, market access issues and other operational costs. This access helps to mitigate against the shocks and risks (real and perceived) associated with smallholder farming that make commercial banks shy away from lending in this area. We also show that the impact of finance on productivity becomes clearer when you control for a constrained smallholder farmer.

Second, we present evidence of the smallholder farmers' dimension of the effect of finance on the welfare of smallholder farmers' households using the case of Ghana. Although the literature on finance and welfare specifies a production channel via which finance affects welfare, it fails to show how this occurs with empirical evidence. Production activity in most households of developing countries is centered on smallholder farming. Therefore, to understand the link between finance and welfare better, it is important to empirically test this amongst smallholder finance.

Third, we present new dimensions to the literature which show that there is substantial separability between the decision to access the market and market participation by smallholder farmers. The decision to market access and of market participation are therefore mostly different for smallholder farmers and factors that affect these decisions can affect them separately and in different directions. These differences in decision and influencing factors also differ across crop types.

Finally, this thesis presents further evidence on the productivity impact of soil fertility and crop management by assessing the impact of a relatively new practice, namely ISFM. This evidence strengthens the argument for an integrated approach to crop management within particular ecological contexts.

7.3. CONCLUSION

The conclusion drawn from the evidence provided from the four empirical studies strongly reveals that access to finance is significant in enhancing agricultural productivity through investments in farm inputs or being able to finance their production needs. For this study, we deployed the instrumental variable (IV) estimation techniques using the Probit – 2SLS model for the estimations of the Average Treatment Effects (ATEs). We used two types of control groups: Control Group 1 (beneficiaries who did not have access to finance – a less constrained group) and Control group 2 (non-beneficiaries who were likely to be more constrained due to the absence of the AVCF benefits). The analysis of the treatment effect of access to finance on productivity of smallholder farmers using Control Group 1 showed a positive relationship between finance and productivity but had no significant effect. However, we find that the treatment effect (access to training and finance) had a significant impact on the productivity of smallholder farmers when we compared beneficiaries to a more constrained Control group 2. Thus, the treatment effect of access to finance on productivity is evident when we control for a constrained smallholder farmer. With access to finance, the smallholder farmers in the Northern Region of Ghana were efficient in allocating the required farm inputs, resulting in shifting the maize production frontier outwards and increasing productivity. Our result confirms the results of other studies in Nigeria by Awotide, Abdoulaye, Alene and Manyong (2015) and indirectly that of Martey et al. (2015). This paper makes a unique contribution to the literature by showing that finance in the form of production credit is crucial for smallholder farmers.

Similarly, there is evidence of an impact of finance on household welfare through increasing production, income generation and therefore improving household consumption. Using two non-beneficiary (control) groups for robustness checks, that is beneficiaries of AVCF project who are financially constrained (Control Group 1) and the non-beneficiaries of AVCF who are also financially constrained (Control Group 2), the results or the treatment-effects have shown a positive and statistically significant effect of access to finance on the welfare of a smallholder farm household. We can conclude that access to finance stimulates improvements in the welfare of smallholder farm households through smallholder farmers' income generation and entrepreneurial activities. In other words, through increasing agricultural productivity and market participation or commercialization of farm produce, smallholders earn income to meet consumption needs. However, we also observed that the combined treatment-effects of access to finance and training yield a higher impact. The result is therefore consistent with the theory on the link between finance and welfare. The study has also shown that the use of production credit which is a short to medium-term working capital is significant for smallholder farmers. Our results confirm the results of other studies in Pakistan by Khandker and Faruqee (2003), in Vietnam by Quach et al. (2005) and in Ethiopia by Geda, et al. (2006).

This study assessed the determinants of smallholder farmers' market access and market participation in the Northern Region of Ghana. We applied the double-hurdle model to explain smallholder farmers' decision. The empirical findings reveal that there are significant differences in the effect of market factors (transactions and transportation costs) and production factors on market access and market participation. In addition, we found that farmers with access to storage facilities are more likely to sell their farm produce in future for higher prices as against farmers without storage facilities who readily sell their products immediately after harvesting at relatively lower prices. These differences in the market access and market participation are also seen across crop types, where some factors matter for some crops but not for others and some transport costs consistently influence market access alone in three out of the four crop farmers. This is because each crop has its separate market segmentation approach, different target market and therefore different positioning in terms of distribution channel and price for the product. The differences in the marketing processes therefore lead to differences in market related transaction costs and production related transaction costs. Thus, the factors influencing a smallholder farmer in the Northern Region of Ghana to access the maize market and participate in the market vary from the smallholder farmer's access to groundnut, soyabean and rice markets and their participation in those markets.

Through increasing knowledge and adopting integrated soil fertility management (ISFM) practices, smallholder farmers increased their productivity through improvement in soil and the application of a more scientific and technological approach. We find compelling evidence that the crops (maize and groundnut) productivity of a beneficiary of ISFM training is significantly higher than that of a non-beneficiary of ISFM training. What this means is that by increasing the knowledge of a smallholder farmer in ISFM practices and its adaptation through training, a smallholder farmer increases farm productivity. However, we also find than the result of ISFM impact on the productivity of maize is higher than the impact of ISFM on the productivity of groundnut. This is because, the adaptation and practice of ISFM among maize farmers is higher as compared to groundnut farmers. That is, whereas maize farmers adopt fertilizer to improve the health of the soil leading to increasing productivity, groundnut farmers are constrained in using fertilizer and they therefore depend on the quality of the soil for its production. The result is therefore consistent with the theory on the link between knowledge and adaptation to ISFM practices and farm level production. The implication is that, through a more effective and efficient use of genotype (G) based on the ecological environment (E) within which farming takes place and coupled with effective farm management (M) practices, farm level productivity is expected to increase. This study confirms the results of similar studies in Nigeria by Kato, Nkonya and Place (2011), in Ethiopia by Agegnehu, Van Beek and Bird (2014) and Meresa, Mengistu and Bisetegn (2016) in Ethiopia.

7.4. RECOMMENDATIONS

The results offer some policy recommendations necessary for agricultural development in Ghana and the other Sub-Saharan African countries towards increasing productivity and improving household welfare of smallholder farmers.

Policy reforms on extending finance to smallholder farmers should be targeted and specific. For instance, smallholder farmers, a majority of whom are constrained, will need finance in the form of production credit to enable them to boost their farm production.

Financial sector policies must be focused not only on providing rural finance in general but also on unlocking the challenges of agricultural financing at all levels. To this end, developing a comprehensive agricultural value-chain finance policy will play a cardinal role towards improving access to finance and improving the welfare of smallholder farmers. Agricultural policies must have significant financing subcomponents aimed at financing the agricultural value chain.

Policies and strategies for increasing market access and market participation must not be the same for all smallholder farmers. It is clear that these policies must be designed to suit crop typologies. Perhaps a more challenging issue is where a farmer farms more than one crop type and needs to balance the management of these factors to separately access markets for different crop types and participate in the market of these crops. This requires substantial farmer training and skills enhancement in managing these market participation factors. Our policy recommendation is for investment into market related factors that are geared towards reducing transaction costs in the form of transportation, search cost and access to storage facilities to improve market access and its participation.

With regard to soil fertility and farm management, policy direction must be focused on enhancing intensive usage of ISFM practices towards boosting productivity. In addition, incentives should be given to key institutions and firms with interest in the development of the agricultural sector to engage in ISFM support services to crop farmers in order to boost productivity.

The ISFM practices offer remarkable benefits to farmers that are worth replicating. This innovative farming system that dwells on effective interplay or combination of farm inputs using the appropriate scale, timing of application of the inputs as well as effectively and efficiently managing other resources geared towards improving the nutrient of the soil should be promulgated.

In view of this, policy direction must be focused on enhancing intensive usage of ISFM practices towards boosting productivity. In addition, incentives should be given to key institutions and firms with interest in the development of the agricultural sector so that they can engage in ISFM support services to crop farmers to boost productivity. Government and development partners must invest in research and development to improve and sustain this innovation. This means that soil and crop scientists have a significant role to play in order to ensure effective communication between the scientists and agricultural extension officers (AEOs) for the dissemination of information to farmers and onward management of this farming system.

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