FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

GHANA FEED THE FUTURE AGRICULTURE POLICY SUPPORT PROJECT (APSP)

The Welfare Impact Of USAID-Advance Intervention Program: Evidence from ACDEP Facilitation In Northern Ghana

October,2017

USAID

FROM THE AMERICAN PEOPLE

GHANA FEED THE FUTURE AGRICULTURE POLICY SUPPORT PROJECT (APSP)

The Welfare Impact Of USAID-Advance Intervention Program: Evidence from ACDEP Facilitation In Northern Ghana

Contract No. 641-C-14-00001

PREPARED BY:

Dennis Sedem Ehiakpor

Contents

List of Acronyms/ Abbreviations

ACDEP	Association of Church-Based Development NGO
ADVANCE	Agriculture Development and Value-Chain Enhancement
FAO	Food and Agriculture Organization
GAP	Good Agricultural Practices
IFAD	International Fund for Agricultural Development
MoFA	Ministry of Food and Agriculture
MVP	Multivariate Probit Model
OD	Organizational Development
PSM	Propensity Score Matching
SSA	Sub-Saharan Africa
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

The quest to apply modern agricultural technologies as a critical avenue to increase productivity and income of smallholder farmers cannot be over-emphasized as cultivable land is getting exhausted. Nevertheless, smallholder farmers in Ghana are well known for their use of traditional and backward technologies. In response to the challenges of using traditional farming practices in order to boost smallholder productivity on sustainable basis, many civil organizations, NGOs and international donor agencies including USAID, Agriculture Development and Value-Chain Enhancement (ADVANCE) project, have initiated many intervention programs geared towards the development and dissemination of new production technologies. ADVANCE over the years has made a lot of investments in disseminating Good Agricultural Practices (GAPs) and marketing strategies to enhance productivity growth in selected agricultural crop sectors (maize, rice, and soybean) in the three northern regions of Ghana. However, there is a paucity of empirical evidence about the aggregated impact on farmers' productivity and economic wellbeing. The study aims to develop a better understanding of the adoption of some selected GAPs and marketing strategies disseminated by ADVANCE (facilitated by ACDEP-Association of Church-Based Development NGOs) and how these have impacted on the welfare of the beneficiaries. The study used cross-sectional farm-level data collected from 673 farm households in the three northern regions of Ghana. The study adopted Multivariate Probit Model to analyze the interdependency among the selected GAPs and marketing strategies, while Poison Data Count Regression was employed to identify the determinants of the intensity of adoption of GAPs. Propensity score matching technique was used to estimate the welfare impacts of the ADVANCE intervention program on the beneficiaries. The results of the study indicated that all the selected components of GAPs and marketing strategies were found to be complementary, and that the adoption of a particular GAP and marketing strategy is conditioned on the adoption of the other. Moreover, different socio-economic and institutional factors, such as educational level, the age of the farmer, visits to demonstration farms, and extension services, were found to influence different components of GAPs and marketing strategies significantly. The intensity of adoption was also influenced by some socioeconomic, farm-specific and institutional/policy variables. The study has also demonstrated that the ADVANCE project has contributed significantly to farm

household productivity and income of the beneficiaries. The interrelationship between the GAPs and the marketing strategies suggest that policies that affect a GAP strategy could have spillover effects on the others. Therefore, the study recommends that farm-level policies that support productive-enhancing technologies must continue to have a joint support for marketing strategies. For instance, the ongoing USAID/ADVANCE program that merged productivity-enhancing technologies with marketing strategies should be intensified and implemented to raise the living standard of northern Ghana. Finally, policies and development efforts focusing on increasing access to extension services, input and output market are crucial to improving adoption of GAPs, and subsequently, increase farm productivity and income.

***Key Words**: ACDEP/ADVANCE, Ghana, Multivariate Probit Model, Impact, welfare, Poisson regression, Propensity Score Matching.*

CHAPTER 1
INTRODUCTION

1 Background

The aim of every developing economy, particularly in Sub-Saharan Africa (SSA) is to reduce hunger and achieve food security under the menace of climate change. In Ghana, the main objective of agricultural development policies in recent times is modernization to achieve the goals of food security and economic development. These programs include improving access of smallholder farmers to improved productive technologies, irrigation, extension services, access to credit, and marketing. In recent times, however, governments, civil organisations and donor agencies have been making a shift from these disparate strategies of agricultural modernization to an all-encompassing value chain approach. With a value chain approach, there are interlinked relationships among all actors starting from the acquisition and supply of inputs through production to processing until the final product is made available to consumers. Thus, the value chain development approach to food security and improved livelihoods is more sustainable.

A value chain can be defined as a set of actors (private, public, and including service providers) and the sequence of value adding activities involved in bringing a product from production to the final consumer (Miller and Jones, 2010). The Food and Agriculture Organization (2010) defines value chain in agriculture as the set of actors and activities that bring a primary agricultural product from production in the field to final consumption, where at each stage, a value is added to the product. The agricultural value chain can also be thought of as "a farm to fork" set of process and flows (Miller and Da Silva, 2007). It includes input dealers supplying inputs, farmers involved in the production and other actors involved in transportation, processing, and marketing at the various stages of the chain.

Though all the key players are critical in the value chain, this study will focus on farmers as the foundation of the chain. Empowering smallholder farmers to improve productivity is a necessary first step to achieving the optimum potential of the agricultural sector on a sustainable basis. One of the primary goals of many civil organisations and Non-Governmental Organizations (NGOs) such as Association of Church-Based Development NGOs (ACDEP) and USAID-ADVANCE

which implemented the ACDI/VOCA value chain project, was to assist farmers to achieve high productivity and quality products that meet market standards. Matthias and Muzira (2009) argued that for business to stay in the market, their products and services need to meet changing market requirements continuously.

The Ghana Agricultural Development and Value Chain Enhancement Program (ADVANCE) is an eight-year farmer-to-farmer project with two phases (2009 – 2013 and 2014- 2018) designed by ACDI/VOCA and funded by the United States Agency for International Development (USAID). ACDI/VOCA is an economic development organization based in Washinton, D.C. whose primary goal is to raise living standards through its work in agribusiness, food security, enterprise development, agricultural financing and community development (ACDI/VOCA, 2013). In Ghana, one key aspect of the ACDI/ VOCA project is to boost farm productivity and enhance farmers' access to local and international markets.

The project undertaken by ADVANCE/ACDEP focused on three major crops (maize, rice, and soybean) mostly cultivated in northern Ghana due to their significant contribution to fighting food insecurity, providing employment to the rural folks and combat poverty in the three northern regions of Ghana. According to the Ghana Poverty and Inequality Report by Cooke *et al.,* (2016) the three northern regions continue to have the highest poverty rates in the country, albeit they secured the greatest reduction in poverty from 2006 to 2013. However, the Upper East region achieved a considerable progress with their level of poverty dropping from about 73% in 2006 to about 44% in 2013, and Upper West region dropping from about 89% to about 71% in the same period. Surprisingly, poverty levels in the Northern region fell marginally from 56% in 2006 to about 50% in 2013. These poverty indicators are of grave concern in particular for the Northern region, where about 1.3 million people are living in poverty which is the largest number of people in any of Ghana's ten regions (Ghana Poverty and Inequality Report, 2016)[1]. The prevalence of poverty ranges of 44% - 71% compared to about 34% and 28% in the Brong-Ahafo and Volta regions, respectively, and about 6% to 21% in the five southern regions (Ashanti, Central, Eastern, Western and Greater). These figures indicate a dramatic north-south gap, with poverty as well as food insecurity remaining widespread in the three northern regions (IFAD, 2012).

[1] This study was conducted by Cooke *et al.,* (2016).

The causes of poverty and food insecurity in the north of Ghana are numerous and quite complex. These include; socioeconomic issues (poor education and health care), inadequate economic opportunities and poor infrastructural development. Moreover, environmental issues such as soil infertility and land degradation, harsh and erratic climatic conditions are other challenges that deprive inhabitants' livelihoods through a reduction in agricultural production. Many studies have concluded that one of the surest ways to bring northern Ghana out of poverty is through improved agricultural production – where the livelihoods of over 70% of inhabitants in the north depend on agriculture (Wood, 2013). Hence, there is an urgent call on the primary agricultural stakeholders to reverse this situation.

The primary objective of USAID-ADVANCE project facilitated by ACDEP is to enhance the productivity of the three main crops (rice, maize, and soybean) cultivated in northern Ghana through improvement in farmers' technical skills on Good Agricultural Practices (GAPs) and linkage to output markets. It is worthy to note that the Northern, Upper East, and Upper West regions have suitable climatic and ecological conditions which favor the production of these crops. With the heavy dependence of smallholder farmers on these crops for food security and livelihoods, these crops have become strategic to the socio-economic development of rural farm households (which form the majority in the three regions) and northern Ghana as a whole.

1.2 Problem statement and justification

Despite the significant contributions of rice, maize and soya sectors, these crops are no exception to the challenges of agricultural production particularly in the northern part of the country. Agricultural production in the three northern regions of Ghana face numerous challenges. These include inadequate access to extension services and market information, poor farm management practices, poor infrastructural development, and unsuitable climatic conditions. As a result, the increase in the production of these crops has come as a result of an expansion in land under cultivation rather than an increase in productivity (MoFA, 2015). For instance, farmers in the rice, maize and soya sectors obtain an average of 2.20mt/ha, 2.29mt/ha and 2.7mt/ha, against potential yields of 5.5mt/ha, 4.5mt/ha and 4.5mt/ha, respectively. This suggests that any farm-level program oriented to reverse this trend by boosting the levels of productivity will consequently raise the

standard of living of the rural dwellers in northern Ghana. Over the years, there has been a great support of these sectors, particularly in northern Ghana where they are mostly concentrated.

Many civil organisations, non-governmental and other international funding agencies have taken a keen interest in boosting productivity levels of these crops through the value chain development approach. ACDEP is one of the key NGOs that implemented the ACDI/VOCA ADVANCE project, which is a value chain project seeking to improve the productivity of rice, maize and soya, thereby enhancing the well-being of main actors. ACDEP operates in the Northern, Upper East and Upper West and parts of Brong Ahafo Regions of Ghana

Key components of the value chain package have included capacity building in GAPs, and creating linkages among actors (farmers, input dealers, wholesalers/aggregators, transporters, financials institutions, procesors, etc.). Others include organizational development (OD) of the various segments of the chain (such as input dealers, processors, etc.) and value addition techniques/activities to enhance the quality of the produce/ product. Some of the GAPs components that farmers were introduced include the use of certified seeds, the conduct of germination tests, harrowing, row planting, and fertilizer application. The marketing strategies include grading, labelling, and collective marketing. Farmers are sensitized on the benefits of these practices or strategies and value addition techniques, and are stimulated to adopt them so as to improve their income and utimately their welfare.

Despite these massive investments in the three sectors, crop productivity is lower than expected and poverty is still pervasive in the three northern regions (MoFA, 2015; GSS, 2014). This situation raises significant issues regarding intervention efforts by governments, civil organizations and NGOs, including that of ADVANCE/ACDEP, to increase agricultural productivity and the well-being of farmers. Several reasons may explain this kind of situation. Some include the fact that there is partial adoption of programs/activities by key actors in the value chain, leading to lower than optimum impact on their livelihoods. Other reasons are that differences in socio-economic factors (such as age, educational attainment, sex, etc.) and resource endowment (such as farm size, capital, labour, etc.) influence farmers' aspiration and ability to adopt new practices to change the status quo. A search of the literature, however, shows a paucity of studies on the impact of intervention programs on the welfare of beneficiaries in value chain development. This

study, therefore, intends to fill this void by documenting farmers' adoption of the farm packages introduced to them using ADVANCE as a case study. Even though Abdul-Rahman and Donkor (2016) carried out some research on the ACDEP value chain development program in the northern region, the study failed to consider the impacts of ADVANCE intervention programs on the welfare of the farmers. Hence, this study intends to fill these gaps and contribute to the existing knowledge on intervention programs in northern Ghana by estimating the welfare impact of ADVANCE/ACDEP value chain development program. An understanding of the ADVANCE/ACDEP value chain program and its impacts on farmers' welfare could help in the design of future programs targeted at improving livelihoods through farm productivity.

1.3 Objective of the study

The aim of this study is to identify factors influencing the adoption of the value chain packages and their impact on welfare of beneficiaries in general and in the context of the ACDEP/ADVANCE value chain development program in northern Ghana in particular.

The specific objectives are to:

1. Document the adoption situation of the ACDEP/ADVANCE value chain package.
2. Identify factors influencing the adoption of the selected farm management and marketing practices.
3. Identify the determinants of intensity of adoption of Good Agricultural practices and market access programs.
4. Estimate the impact of the ACDEP/ADVANCE intervention program on the welfare of beneficiaries.

1.4 Scope of the study

The study covered ten districts in the three northern regions only. It examines value chain development program in general and focuses mostly on producers.

CHAPTER 2
METHODOLOGY

2.1 Study area

The study was conducted in Northern Ghana which is comprised of the Northern, Upper East, and Upper West Regions. These regions were selected due to their high level of rice, maize and soybean production and also because they are the catchment area of the ACDEP program for value chain (VC) development. Agriculture is the most important economic activity in these three Northern Regions. The majority of the farmers in the study area cultivate at least one of these crops: maize, rice and soybean.

2.2 Sampling and data collection techniques

The study used two main techniques to collect survey data: questionnaire administration and interview with key informants. This is to help triangulate the information gathered. Data for the study is completely primary data. The survey employed a multistage purposive and random sampling in selecting the districts in the region, communities from the districts and farm households from the communities. In the first stage, three agricultural districts from each region were purposively selected from a list districts that relatively largely share in the production of rice, maize and soybean in the three regions. The choice of the three districts was based on the combined production level of rice, maize and soybean of these districts. The purposive selection was done in consultation with the various district offices of MoFA and staff of ACDEP. In the second stage, stratified sampling was used to divide the districts into two (2) strata, one stratum making up ACDEP communities and the other stratum non-ACDEP communities. Four communities each for ACDEP operational areas/communities and non-ACDEP operational communities were randomly selected. Simple random sampling was employed to select six to ten respondents from each of these ACDEP communities and non-ACDEP community. In total, 673 were surveyed, comprising 394 ACDEP/ADVANCE farmers and 279 non-ACDEP farmers.

The data was collected through a household survey using semi-structured questionnaire aided by face to face interview of rice, maize and soybean farm households. The questionnaire was

designed to collect a range of data on levels of rice, maize and soybean production, household socioeconomic characteristics, family assets, farm-specific characteristics, social capital and policy and institutional variables likely to influence farming operations in the study areas. Research assistants from the Nyankpala Campus of the University for Development Studies were used as enumerators for the collection of data. These people have prior experience in survey work. Key informants such as some heads of departments of ACDEP and ADVANCE and community leaders were approached to discuss challenges and opportunities relating to the productivity of the three crops.

2.3 The concept of the study

This section seeks to illustrate the linkages between the VC program package implementation, farmers' adoption of the package, and the consequent impact of the VC program on the welfare of the beneficiary. Conceptually, it is expected that farmers who participated in the ADVANCE/ACDEP VC development would achieve higher output level and obtain greater impact than non-participants. It is theorized that individual or collective participation in any agricultural intervention program is largely a behavioral choice at a particular time and space. Thus, some farmers may decide to participate when they are aware of the program and its advantages over costs/disadvantages, whereas others may choose not to participate despite being aware of the program and its benefits over costs/disadvantages. In the agricultural literature, participation in an intervention program is hypothesized to be affected by socioeconomic characteristics, demographic, and institutional factors (Amare *et al.,* 2012; Shiferaw *et al.,* 2014; Awotide *et al.,* 2016). The schematic presentation of the conceptual framework is presented in figure 1.

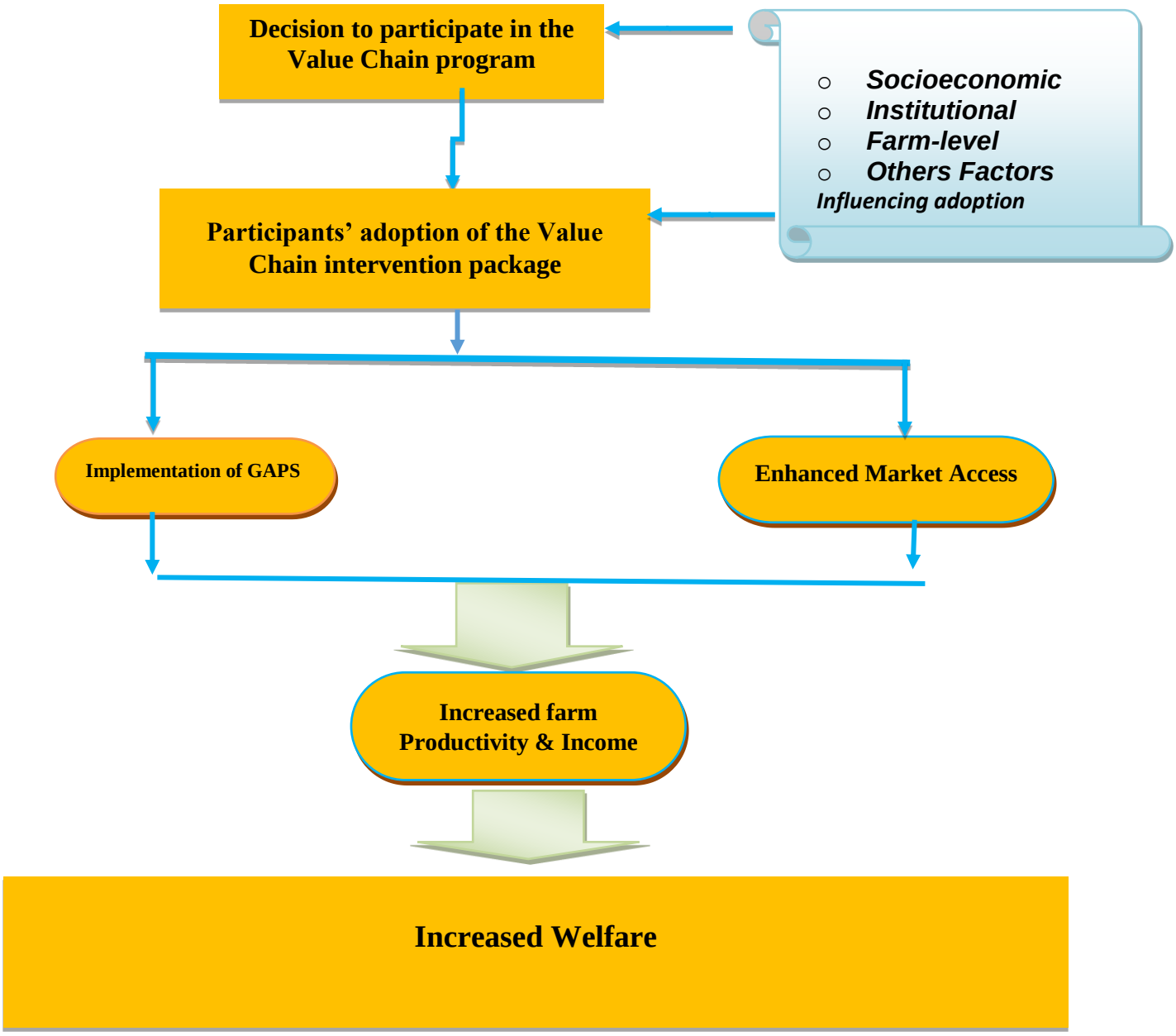

Figure 1: Conceptual Framework of Farmers' Participation in VC Program and Impact

Figure 1 above shows that farmers' decision to participate in the ADVANCE/ACDEP value chain development program depends on socioeconomic, institutional, and farm-level specific factors. Some of the socioeconomic factors include the age of the farmer, educational attainment, household size, and sex of the farmer. Farm-level characteristics include farm size, resources and

others, while institutional and policy variables may be comprised of access to credit, membership to farmer-based organizations, access to extension services, and market access. These factors are expected to play a significant role in influencing a farmers' decision to participate in the ADVANCE/ACDEP VC development program and hence to adopt the intervention package.

This study assumes a relationship between the probability of adoption and the extent of adoption of intervention packages through the decision of the farmer to participate in the VC program. Hence, the likelihood and the extent or intensity of ACDEP/ADVANCE value chain adoption are likely to be influenced by similar factors. The hypothesis is that the probability of participation and hence the extent/intensity of adoption of the ACDEP/ADVANCE VC intervention package are influenced by the set of socio- economic, farm level and institutional/ policy factors mentioned above.

The study classifies the ACDEP/ADVANCE VC intervention package into two main groups namely, GAPs and market access components. The GAPs components include planting in rows, use of certified seeds, and fertilizer application. Market access components include weighing, grading, labelling of bags and collective marketing. The concept of the study postulates that a farmer's participation in the ACDEP/ADVANCE VC intervention program and adoption of the GAPs and market access components will lead to improvement in the farmer's productivity and income earnings. These outcomes will, in turn, result in the farmer's welfare ceteris paribus. The study uses increased household consumption expenditures and consumption expenditures per capita as measures of household welfare (see figure 1).

2.4 Analytical framework and empirical models

The study used descriptive analytical techniques to quantify the extent of adoption of the two major components of the ACDEP/ADVANCE VC program. For inferential analysis, the study employs econometric techniques such as Multivariate Probit Model, Count Data Regression (Poisson Model), and Propensity Score Matching.

The theory of adoption of an agricultural intervention program or farm technology package has over the years provided the foundation for research work on farmer's attitudes towards joining

farm intervention programs (Rogers, 1983; Torborn, 2011). Farmers' who may decide to join the program may adopt some or all the components of the program. For instance, farmers who participate in the ACDEP/ADVANCE intervention program may adopt two of the GAPs components out of the package. The adoption decision may depend on farmers' demographic characteristics and institutional factors as indicated in the conceptual framework (Amare *et al.,* 2012; Shiferaw *et al.,* 2014; Awotide *et al.,* 2016). The rate of adoption is the relative speed with which farm technology is adopted by a farmer, whereas the intensity is the degree of use (Rogers, 1983). The rates and intensities of adoption of technological packages are influenced by the perception of farmers on the benefits of improved technology against alternatives (Torborn, 2011).

Following Khonje *et al.* (2015), Becerril and Abdulai (2010) and Crost *et al.* (2007), the observed outcome of adoption of improved farm technology can be modelled under the framework of a random utility function. Consider the *i*th farm household facing a decision on whether or not to participate in an intervention program or adopt a given technology. Let $P^{\bullet}$ denote the difference between the benefit the farm household derives from adopting ACDEP/ADVANCE GAP and market access packages (U_{iA}) and benefit from non-adoption of the package (U_{iO}). The farm household will adopt the package if $P^{\bullet} = U_{iA} - U_{io} > 0$ [1]

The net benefit $P^{\bullet}$ is unobservable and can be expressed as a function of observed characteristics (Z_i) and error term (ε_i) as follows;

$P_i^* = Z_i\beta + \varepsilon_i$; with $P_i = 1$ if $P_i^* > 0$ and $P_i^* = 0$, otherwise [2]

where P is a dummy variable representing the adoption of individual components of the package; $P = 1$ if VC is adopted and $P = 0$ if otherwise. Z_i is a vector denoting household and farm-specific characteristics, β is a vector of parameters to be estimated and ε_i is an error term.

The following sections give a brief description of the empirical models that were used in analysing the adoption of the various components of the GAPs and marketing strategies, intensity of adoption, and impact of the intervention program on the welfare of its intended beneficiaries.

2.4.1 Multivariate Probit model

Considering that farmers participating in the ACDEP/ADVANCE program may have more than two GAPs and market strategies components to adopt, the Multivariate Probit Model (MVP) is employed here to model the simultaneous adoption decisions of the GAPs and marketing strategies. The MVP is used when there is an assumption that the farmer's decision to adopt a component of a given package depends on the adoption of other components already adopted. For instance, in this study, we assume that farmers' decision to apply fertilizer may depend (though not necessarily) on the fact that they have adopted certified seeds or row planting. The MVP estimation technique uses a Probit Model to examine the relationship between each of the component of the VC package and farmers' socioeconomic, farm-specific and institutional factors. In this study, since we have six selected GAPs and marketing strategies, we have six adoption equations forming a system of equations. However, all these six are estimated simultaneously, hence, the name 'Multivariate Probit Model'. It also examines the correlation among the components of the VC package. The correlation may emanate from the same unobserved characteristics of farmers that have the probability of influencing adoption of different practices. The correlation is based on the principle that adoption of one GAP technology may depend on another complementary technology (positive correlation), or may be influenced by an available set of substitutes (negative correlation) Ahmed, 2015).

Following Ahmed (2015) and considering the selected components of GAPs and marketing strategies adopted by the farmers, each adoption equation can be specified as;

$$Y_{ik} = \beta_k X_{ik} + \varepsilon_i \qquad (k = A, B, C, D, E, F) \qquad [3]$$

where Y_{ik} is the latent dependent variable representing net benefits derived from the adoption, X_{ik} denotes the observed farmer household and farm-specific characteristics, as well as institutional and policy variables. Note that *A, B, C, D, E, F* represent the selected GAPs practices (certified seeds, row planting and fertilizer application) and the selected marketing practices (labelling, grading and collective marketing), respectively. In the second system of equations, the unobserved preferences in equation [3] translates into an observable dichotomous outcome which can be specified as;

$$Y_{ik} = \begin{cases} 1 \; if \;\; Y_{ik}^{*} > 0 \\ 0 \;\; otherwise \end{cases} \qquad (k = A, B, C, D, E, F) \qquad [4]$$

In the MVP framework, where several simultaneous adoption of GAPs and marketing strategies are allowed, the error terms jointly follow a multivariate normal distribution with zero conditional mean and variance normalized to unity. Where $(\mu_A, \mu_B, \mu_C, \mu_D, \mu_E, \mu_F) \approx MVN(0, \Omega)$ and the symmetric variance-covariance matrix Ω can be specified as;

$$\Omega = \begin{bmatrix} 1 & \rho AB & \rho AC & \rho AD & \rho AE & \rho AF \\ \rho BA & 1 & \rho BC & \rho BD & \rho BE & \rho BF \\ \rho CA & \rho CB & 1 & \rho CD & \rho CE & \rho CF \\ \rho DA & \rho DB & \rho DC & 1 & \rho DE & \rho DF \\ \rho EA & \rho EB & \rho EC & \rho ED & 1 & \rho EF \\ \rho FA & \rho FB & \rho FC & \rho FD & \rho FE & 1 \end{bmatrix} \pm \qquad [5]$$

Where $\rho(rho)$ represents the pairwise correlation coefficient between any two components of the package. For instance ρAB represents the correlation coefficient between certified seeds and row planting. A positive value of ρAB implies the certified seeds and row planting are complementary. In other words, they are used together. The reverse is true for a negative coefficient value. When the error terms are correlated, then the off-diagonal elements in the variance-covariance matrix (Ω) of the adoption equation formulate into a non-zero form and as such, equation [4] becomes the general MVP model.

Following from the foregoing and especially using equation [3], the empirical function/ model for the adoption of the GAP and marketing strategy components in the ACDEP/ADVANCE VC program can be formulated as;

Where, $\beta' s$ are parameters to be estimated; X_i denotes socio-economic characteristics of the farmer, farm-specific variables, institutional and policy factors.

$$Y_{ik} = \beta_0 + \sum_{k=1}^{K} \beta_{ik} X_{ik} + \varepsilon_i \qquad [6]$$

2.4.2 Count data regression – Poisson model

To analyze factors influencing the intensity of adoption of Good Agricultural practices (GAPs) and marketing strategies, the number of practices adopted by each individual farmer defines the dependent variable. As noted by Lorh and Park (2002) and Sharma *et al.* (2010), the number of technologies adopted by an individual farmer is interpreted as a measure of intensity or diversity of adoption. Following Cameron and Trivedi (1990) and as discussed by Greene (2008), the number of GAPs and marketing strategies a farmer adopts could be modelled under the framework of Poisson regression analysis. This is because the dependent variable (intensity of adoption) is a numerical count by its nature. Given that there is a random occurrence of the number of components in the package used by the farmer, the appropriate probability distribution is the Poisson distribution. The count data model has been used in numerous studies to explain the intensity of adoption of various technologies (e.g., Nkegbe and Shankar 2014; Sharma *et al.* 2011; Isgin *et al.* 2008, Rahelizatovo and Gillespie 2004, Lohr and Park 2002).

The probability of adopting a number of components in the package at any given period, Y_i, subject to farmer characteristics, X_i, can be modelled using the Poisson count data model (Cameron and Trivedi 2010, Greene 2008, Winkelman 2008) as;

$$P(Y_i = j / X_i) = \frac{\lambda_i^j \ell^{-\lambda_i}}{j!}, \qquad j = 0,1,2,3..... \qquad [7]$$

From equation [7] above, the parameter $\lambda_i = E(Y_i / X_i) = Var(Y_i / X_i)$ and $\lambda_i > 0$. The mean is defined as $\lambda_i = \exp(X_i^{/}, \beta)$ where $X_i^{/}$ is a vector of household characteristics and β a vector of unknown parameter to be estimated. The marginal effect in the Poisson model is specified as;

$$\lambda_i \beta = \frac{\partial E(Y_i / X_i^{/})}{\partial X_i} \qquad [8]$$

The marginal effect is interpreted as a unit change in the intensity of adoption (number of technologies used) resulting from a change in the independent variable (Cameron and Trivedi, 1998).

2.4.3 Propensity Score Matching

Participation in any farm intervention program is hypothesized to increase productivity, household incomes, and thus help to improve welfare. The study adopts the propensity score matching (PSM) technique to quantitatively estimate the impact of ACDEP/ADVANCE intervention program on the welfare of the beneficiaries. In this case, we use sampled non-ACDEP beneficiaries as a control group and the ACDEP beneficiaries as the treatment group. The PSM technique matches the ACDEP beneficiaries and non-ACDEP beneficiaries based on their observed socioeconomic characteristics such as age, level of education, marital status, farm sizes, etc. This is done to minimize or eliminate any biases that emanate from observed socioeconomic characteristics. PSM has been previously used to study observational data (Rosenbaum and Rubin, 1983).

The PSM framework outlined by Rubin (1974) and described by Angrist and Imbens (1991) was used. Following Heckman and Vytlacil (2007), the value of the outcome/impact variable welfare is stipulated as Y_1 when the household is subjected to treatment (ACDEP/ADVANCE participation, $P=1$) and Y_0 when the household does not participate (non-participants group, $P=0$). The observed welfare is specified as;

$Y = Y_1 P + (1-P)Y_0$ for a random sample of farm households. [9]

If ($P=1$), Y_1 is observed and if ($P=0$), Y_0 is observed. Variables Y_1 and Y_0 represent potential welfare of a farm household that participates and that does not participate, respectively, in the ACDEP/ADVANCE VC program.

The average treatment effects on the treated *(ATT),* which computes the mean difference in the outcome of the treatment group (participants) with or without the program, can be specified as;

$$ATT = E[(Y_i(1) - Y_i(0) / P_i = 1] = E[Y_i(1) / P_i = 1] - E[Y_i(0) / P_i = 1] \quad [10]$$

Where P is an indicator for participation in the ACDEP/ADVANCE intervention program which takes the value of one (1) for the participants (treated group) and zero (0) for the non-participants (control group). $Y_i(1)$ and $Y_i(0)$ are the outcomes (in our case, welfare indicator which is proxied by consumption expenditure per capita, household income and farm income per acre) for the treated and control group, respectively.

The PSM estimation technique is a two-step procedure. First, a probability model (logit or probit) of participation in the ACDEP/ADVANCE was estimated to calculate the propensity score for each household. In the second stage, each participant is matched with non-participants with similar propensity score value in order to estimate *ATT* (Abadie and Imbens, 2006). In estimating the true impact of the intervention program on the welfare of the participants with PSM, we used two different PSM algorithms known as matching on propensity score. These techniques are Nearest Neighbour Matching (NNM) and Kernel Based Matching (KBM) which are frequently used in analysing impact of an intervention program on farm household welfare (see Gebrehiwot, 2015, Ali *et al.* 2016). The two techniques are used to serve as a robustness check. After matching the participants and non-participants on the propensity score, *ATT* is calculated as the weighted difference between the treated and matched control group. *ATT* measures the impact of the ACDEP/ADVANCE intervention program on the welfare of the farm households participating in the program. This can be calculated as;

$$ATT = E(Y^P - Y^{NP} / P = 1) = \frac{1}{N_P}\left[\sum_{i \in P} Y_i^P - \sum_{j \in NP} \omega(i, j) Y_i^{NP}\right] \qquad [11]$$

Where Y_i^P and Y_i^{NP} are the outcome (welfare) of the participants and non-participants, respectively. N^P is the number of participants in the sample, and $\omega(i, j)$ is the weight factor used in the matching. We then estimate the *ATT* using propensity score matching for all the three dependent variables of interest used to defined farm household welfare. This PSM technique has been used extensively in the literature to estimate the treatment effects of such intervention programs on outcome variable of interest (Shiferaw *et al.* 2014, Abate *et al.* 2016, Rutherford *et al.* 2016).

CHAPTER 3
RESULTS AND DISCUSSIONS - DESCRIPTIVES

3. Descriptive analysis of the survey

This section of the study discusses the descriptive statistics of the sampled respondents. In all, 673 farm households (394 ACDEP/ADVANCE beneficiaries and 279 non-beneficiaries) were interviewed across the three northern regions. The descriptive statistics comprise the demographic characteristics of both the ACDEP/ADVANCE beneficiaries and non-beneficiaries. This is to understand the demographic features of the respondents in its entirety and also to examine whether significant differences exist between ACDEP/ADVANCE beneficiaries and non-beneficiaries regarding their observed characteristics. The study also made a comparison between ACDEP/ADVANCE beneficiaries and non-beneficiaries regarding their productive activities. Finally, we concentrate on the ACDEP/ADVANCE beneficiaries (since they are the group of interest), and perform some comparative analysis across the three northern regions according to crop type.

3.1 Demographic characteristics of the sampled farm households

The demographic characteristics of the sampled respondents are presented in Table 1. About 60% (40%) of the respondents in the intervention program are male (female) while about 75% (25%) of the non-participants are male (female). This suggests that the intervention program consciously incorporated gender equity into the program. This is because in a normal Ghanaian society, particularly, in the Northern part of the country, women usually pull out and allow the men to participate in such programs. About 40% of women participation in an intervention program is a good indication of women empowerment in the northern part of the country. About 81% of the participants are married while 79% of the non-participants are married. The average household size of the participants and non-participants are about 10 and 12 persons per household, respectively. ACDEP/ADVANCE members on the average have spent about 22 years in crop production while non-ACDEP/ADVANCE members have about 24 years of experience in crop farming

Table 1: Distribution of household characteristics by participation in the ACDEP/ADVANCE program

Description of variables	*ADVANCE/ ACDEP participants*	*Non-ADVANCE /ACDEP participants*	*Mean difference*
Household Characteristics			
Proportion of male in the sample	0.599	0.746	-0.148[a]
Proportion of married farmers in the sample	0.81	0.79	0.02
Household Size (# of persons)	9.824	11.777	-1.952
Number of years in Crop Farming	21.571	23.502	-1.93[b]
Number of Years in Formal Education	5.58	5.769	-0.188
Number of Household in School (persons)	4.096	3.659	0.437
Household Assets			
Farm Size (acres)	8.237	7.691	0.545
Off-farm income activities (dummy, yes = 1)	0.677	0.358	0.32[a]
Ownership of Donkey (dummy, yes = 1)	0.653	0.616	0.04
Ownership of Motor bike (dummy, yes = 1)	0.953	0.916	0.04
Ownership of Tricycle (dummy, yes = 1)	0.784	0.549	0.235[a]
Ownership of TV/or Radio (dummy, yes = 1)	0.806	0.802	0.004
Institutional/Policy Variables			
Workshop Attendance (dummy, yes = 1)	0.477	0.158	0.319[a]
Visit to demonstration Farms (count)	2.85	1.95	0.90[a]
Other Agricultural training received (dummy, yes =1)	0.449	0.157	0.292[a]
Membership of Social group (dummy, yes =1)	0.406	0.262	0.144[a]
Access to market information (dummy, yes = 1)	0.763	0.576	0.187[b]
Access to storage facilities (dummy, yes = 1)	0.594	0.487	0.106
Received Gov't extension services (dummy, yes = 1)	0.297	0.369	-0.07[c]
Location Variables			
Distance to the nearest Output Market (minutes)	35.696	38.612	2.916
Upper East Region (dummy, yes = 1)	0.292	0.311	-0.019
Upper West Region (dummy, yes = 1)	0.322	0.331	-0.009

Also, the number of years spent in formal education was about 6 for both participants and non-participants. Both ACDEP/ADVANCE and non-ACDEP/ADVANCE members cultivate an average farm plot of about 8 acres (thus rice, maize and soyabean). Moreover, about 68% of the ACDEP/ADVANCE members are engaged in off-farm income compared with 35% of the non-ACDEP/ADVANCE members. About 78% of the ACDEP/ADVANCE members owns tricycle (locally known as "motorking"), compared with 55% of the non-ACDEP/ADVANCE members.

Workshops are usually organized by program facilitators to train farmers on farm financial management, such as crop budgeting, business planning, and basic cost-benefit analysis to complement the technical knowledge on agricultural production farmers received from demonstration plots. The results indicate that a higher proportion of ACDEP/ADVANCE members have visited farm workshops and have had training from demonstration plots than non-ACDEP/ADVANCE members. Also, more ACDEP/ADVANCE members have received other agricultural trainings, access to market information, and access to storage facilities than non-ACDEP/ADVANCE members. However, only a few (about 30%) of the ACDEP/ADVANCE members have received extension services from the government.

3.2 Adoption of GAPs and marketing strategies by ACDEP/ADVANCE beneficiaries and non-beneficiaries.

The selected GAPs and marketing strategies supposed to be adopted as a package are certified seeds, row planting, fertilizer application, labelling of products, grading of produce and collective marketing. The intensity of adoption[2] of these GAPs and marketing strategies by ACDEP/ADVANCE members are compared with sampled non-ACDEP/ADVANCE farmers from non-ACDEP/ADVANCE catchment districts. This comparison is necessary so that the non-ACDEP/ADVANCE members can serve as control group upon which performance of ACDEP/ADVANCE members can be assessed. The results are presented in Table 2. Table 2 indicates that 54%, 75.6%, and 92.8%, of the farmers in ACDEP/ADVANCE program adopted certified seeds, row planting and fertilizer on their plots respectively as against 28.7%, 65% and 86.3% of the non-ACDEP/ADVANCE participants adopting the same set of technologies. Further,

[2] Intensity of adoption here refers to the proportion of farmers adopting a particular component of GAPs and marketing strategy.

48%, 12.4% and 11.1% of the ACDEP/ADVANCE members had adopted labelling, grading and collective marketing as compared with 63.8%, 11.8% and 9.4% respectively for non-ACDEP/ADVANCE members.

Table 2: Distribution of GAPs and marketing strategies between ACDEP/ADVANCE and non-ACDEP/ADVANCE beneficiaries

GAPs/Marketing Strategies	*ACDEP beneficiaries*	*Non-ACDEP beneficiaries*	*Difference*
Adoption (dummy, 1 = yes)			
Use of certified seeds	0.537	0.287	0.250[a]
Row planting	0.756	0.65	0.107[a]
Fertilizer application	0.928[3]	0.863	0.065[a]
Labelling	0.480	0.638	-0.158[a]
Grading (weighing and sorting)	0.130	0.118	0.012
Collective marketing	0.116	0.094	0.022

[a] *denote significant at 1% level*

3.3 Farm performance indicators by crop and participation in ACDEP/ADVANCE program

Table 3 reports a comparative analysis of performance indicators by crop between ACDEP/ADVANCE participants and non-participants. These performance indicators are used to assess the productive use of land for each crop and its effects on farm income. The results indicate that ACDEP/ADAVNCE participants had larger farm areas allocated to maize and soybean production than non-ACDEP/ADVANCE members, whereas non-ACDEP/ADVANCE members allocate more farm lands to rice production than ACDEP/ADVANCE members. Similarly, ACDEP/ADVANCE farmers outperformed the non-ACDEP/ADVANCE farmers in maize production as indicated by the maize farm output of 9025kg and 950kg/acre for ACDEP members,

[3] This figure refers to the proportion of farmers applying fertilizer on their rice and maize field only. It does not include fertilizer application on soybean fields. Generally, farmers do not generally apply fertilizer on their soybean field. The study found only a fraction of them as indicated in Table 5. Hence, its exclusion.

as against 7480kg and 880kg/acre for non-ACDEP members. Regarding rice, although non-participants allocated larger farm plots to the production of rice, ACDEP/ADVANCE members had better farm output and yield than the non-ACDEP/ADVANCE members.

Table 3: Distribution of performance indicators by crop and beneficiaries and non-beneficiaries of ACDEP/ADVANCE

	Participants			***Non-Participants***		
	Maize	Rice	***Soybean***	***Maize***	***Rice***	***Soybean***
Farm size (acreage)	9.5	8	6.5	8.5	8.5	6
Farm Output (kg)	9,025	8,400	3,900	7,480	7,225	4,800
Output/acre (kg/acre)	950	1050	600	880	850	800
Farm Income (GH¢)	5,866	6,349	4,786	4,462	5,461	5,890
Farm Income/acre (GH¢)	618	794	736	572	642	982.

Note: The price range for maize and rice was GH¢60 – 70 and that of soybean was GH¢135. The study, therefore, used the average price of GH¢65 for both rice and maize, and GH¢135 for soybean.

However, non-members performed better in soybean production than members of ACDEP/ADVANCE as indicated by the yield of 800kg/acre versus 600kg/acre. The results further showed that farm productivity measured by output per acre had a significant effect on farm income. For instance, although participants on the average operated relatively small farm lands regarding rice production, output per acre was larger, and that translated into greater farm income and farm income per acre.

3.4 Plot size and crop yield of ACDEP/ADVANCE members by crop and region

Since ACDEP/ADVANCE members are the focus of this study, we now concentrate only on participants to understand how productive they are by crop-specifics across the three regions. Table 4 shows the distribution of plot size by crop, while figure 2 indicates the productive performance of the members across the three regions.

Table 4: Distribution of plot size of ACDEP/ADVANCE participants by crop and region

Plot Range (acres)	*Northern*	*Upper East*	*Upper West*	*Total*
		Maize		
1 - 5	52.16	68.23	73.5	54. 60
5.5 -10	28. 80	23.15	20.05	27.5
10.5 - 15	13.14	7.12	5.65	14.75
> 15	5.9	1.5	0.8	3.15
Total	100	100	100	100
Mean	11	9.5	7.5	
		Rice		
1 - 5	88.5	90.65	87. 45	89.25
5.1 -10	7.5	8.5	10.52	8.75
10.5 - 15	4	0.85	1.5	1.85
> 15	0	0	0.53	0.15
Total	100	100	100	100
Mean	9	8.5	6.5	
		Soybean		
1 - 5	65.87	92.88	95.05	78.65
5.1 -10	24.6	5.55	4.95	16.56
10.5 - 15	7.25	1.57	0	3.32
> 15	2.28	0	0	1.47
Total	100	100	100	100
Mean	7.5	6.5	5	

Table 4 shows that while about 68% and 74% of farmers in Upper East and Upper West operate on small maize farmland ranging between 1 – 5 acres, and about 52% of farmers from the northern region farm on the same range of maize plot size. Only a fraction of farmers across from all the

three regions had maize farmland greater than 15 acres. Similarly, the majority of the farmers across the regions farm less than 5 acres of rice farm. Likewise, in the case of soybean production, nearly all the farmers in Upper East and Upper West operate farm plots between 1 – 5 acres. However, about 34% of farmers in the northern region farmed more than 5 acres of soybean.

Further, figure 2 compares crop-specific yields of farmers across the three northern regions. It is observed that while the average yield of maize, rice, and soybean for the Upper West region were 950kg/acre, 1050kg/acre and 550kg/acre, respectively, for the Northern region were 800kg/acre, 850kg/acre and 450kg/acre for maize, rice, and soybean respectively[4]. Interestingly, the Upper East region outperformed the other two regions in all the crops, with reported yield of 1100kg/acre, 1250kg/acre and 780kg/acre for maize, rice and soybean, respectively.

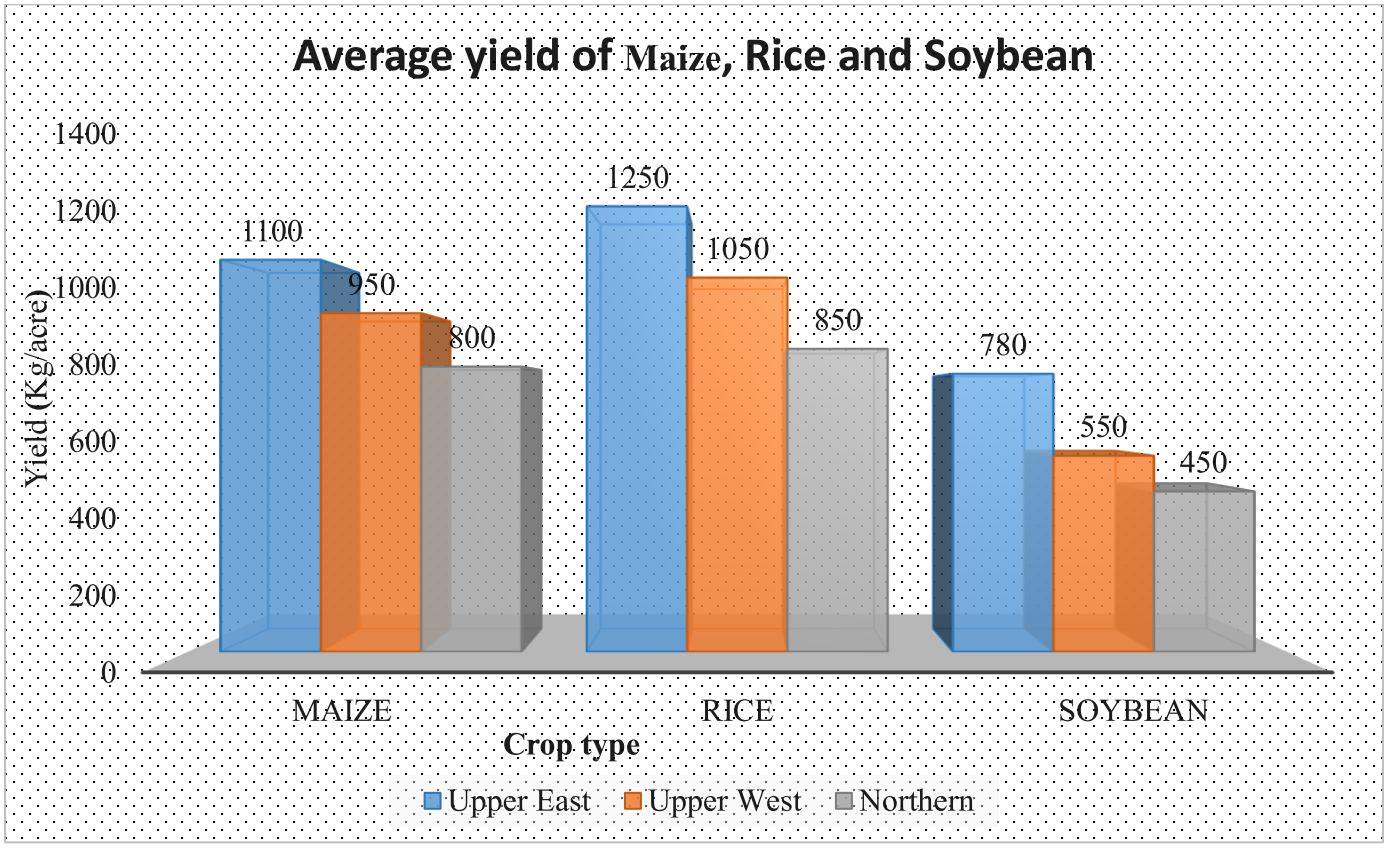

Figure 2: Average yield of maize, rice and soybean by crop and region for ACDEP beneficiaries

[4] 1 acre = 0.4047 hectares

3.5 Adoption distribution of GAPs and marketing strategies by crop and region – ACDEP/ADVANCE members.

Table 5 presents the adoption of GAPs and marketing strategies adopted by ACDEP/ADVANCE sampled farmers across the three northern regions. The results indicate that farmers across the three regions have high fertilizer adoption intensity for both maize and rice production.

Table 5: Adoption distribution of ACDEP/ADVANCE members by GAPs/Marketing Strategies and regions

GAPs/Marketing Strategies	*Northern*	*Upper East*	*Upper West*	*Mean*
Maize				
Certified seeds	0.72	0.78	0.70	0.73
Row Planting	0.82	0.82	0.70	0.78
Fertilizer application	0.92	0.95	0.91	0.93
Labelling	0.56	0.47	0.35	0.46
Grading (weighing and sorting)	0.23	0.15	0.08	0.15
Collective Marketing	0.16	0.16	0	0.11
Rice				
Certified seeds	0.68	0.74	0.68	0.70
Row Planting	0.71	0.76	0.72	0.73
Fertilizer application	0.90	0.96	0.89	0.92
Labelling	0.49	0.46	0.30	0.42
Grading (weighing and sorting)	0.16	0.12	0.07	0.12
Collective Marketing	0.13	0.18	0.05	0.12
Soybean				
Certified seeds	0.21	0.19	0.15	0.18
Row Planting	0.76	0.84	0.68	0.76
Fertilizer application	0.02	0.05	0.03	0.033
Labelling	0.55	0.58	0.52	0.55
Grading (weighing and sorting)	0.14	0.13	0.1	0.12
Collective Marketing	0.18	0.12	0.05	0.12

Thus, at least 89% of the farmers in all the regions applied fertilizer in their maize and rice farms. However, only a fraction (3.3%) of farmers across the three regions applied fertilizer on their soybean fields. Adoption of certified seeds of maize and rice in all the three regions was quite high. Adoption of certified seeds of soybean was very low in all the regions as the maximum intensity of adoption was 21% achieved by the farmers in the Northern region. Moreover, adoption of row planting is relatively high among farmers in all the regions.

Regarding marketing strategies, product labelling recorded the highest use in all the crops across all the three regions, though adoption is still below expectation. Similarly, farmers across all the regions seem not to be interested in grading and collective marketing irrespective of the product.

CHAPTER 4
RESULTS AND DISCUSSIONS - EMPIRICS

4.1 MVP regression results on adoption decisions

The results from the MVP analysis in equations [5] and [6] are presented in Table 6 and 7. Table 6 presents the nature of the relationships (equation [5]) amongst the various GAPs and marketing strategies adopted by the smallholder farmers in the study area, whereas Table 7 reports on the determinants of the adoption decisions (equation [6]).

4.1.1 Nature of the relationship between the technologies

The correlation matrix among the various components of the GAPs and marketing strategies generated from the MVP using equation [5] is presented in Table 6. From the matrix, each of the components of the VC package is paired generating a pair-wise correlation. The likelihood ratio (LR) test measures the overall correlation among the components of the package. It tests the null hypothesis that there is no correlation among the components of the package. Since the value of the LR is significant ([χ^2 (15) = 190.971; p = 0.000], the null hypothesis that there is no correlation among the various components is rejected. Thus, there is an overall correlation among the various components of the VC package. Hence, the use of the MVP is appropriate to analyze the mutual interdependence among the multiple GAPs and marketing strategies. This result is supported by most of the pair-wise correlations in the Table. A positive correlation coefficient (e.g., a correlation of 0.466 between row planting and certified seeds) indicates that the two components are complements. Thus, farmers who plant in row couple it with the use of certified seeds. The reverse applies to a negative correlation coefficient. The entire set of correlation coefficients is positive, indicating that there is a positive (complementarity) correlation between the different GAPs and marketing strategies. This suggests that the adoption of a given farm technology or marketing strategy is based on whether another farm or marketing practice in the subset has been adopted. For instance, a farmer's decision to use fertilizer depends on whether or not a certified seed or row planting was adopted. The highest correlation is between labelling and collective marketing (51%) followed by row planting and grading (48%) and then certified

seeds and row planting (47%). The smallest correlation is between fertilizer application and labelling (1%).

Table 6: Correlation Matrix of the Technologies from the Multivariate Probit Model

	Row Planting	***Fertilizer Application***	***Grading***	***Labelling***	***Collective Marketing***
Certified seed	0.466(0.063)[a]	0.231(0.099)[b]	0.303(0.648)[a]	0.227(0.080)[a]	0.030(0.087)[a]
Row Planting		0.135(0.871)	0.478(0.056)[a]	0.184(0.081)[b]	0.312(0.087)[a]
Fertilizer application			0.198(0.831)[b]	0.012(0.102)	0.215(0.111)[c]
Grading				0.331(0.072)[a]	0.325(0.079)[a]
Labelling					0.514(0.748)[a]
Likelihood ratio test $[\chi^2 (15) = 190.97]$					
Joint probability (success)	0.140				
Joint probability (Failure)	0.037				
Linear predictions					
Certified seed	0.394				
Row planting	0.771				
Fertilizer Applications	0.681				
Grading (S&W)	0.129				
Labelling	0.286				
Collective marketing	0.457				

a, b and c represent 1%, 5% and 10% level of significance, respectively. Figures in parentheses are standard errors.

The results further indicate that the joint probability of adopting all the technologies was 14% and the joint probability of failure to adopt all the technologies was 3.7%. The linear prediction as indicated in the Table measures the probability of farmers adopting each of the GAPs and marketing strategies. From Table 6, the linear predictions show that the probability of households adopting certified seeds, row planting fertilizer, grading, labelling and collective marketing are 39%, 77%, 68%, 13%, 29%, and 46% respectively.

4.1.2 Determinants of farmers' choice of farm and marketing strategies

The factors influencing adoption of the various components of the VC package using the MVP in equation [6] are presented in Table 7. The Table presents the adoption equation for each of the GAPs and marketing strategies. Hence, we have six results. A positive coefficient in relation to a

variable implies that as the variable increases, the probability of adoption of the component also increases. The reverse goes for a negative coefficient concerning a variable.

Table 7: Estimates from the Multivariate Probit Model

	Certified seeds		*ROW*		*FZ*		*Labelling*		*Grading*		*CMKT*	
Variable	***Coeff***	***S.E***	***Coeff***	***S.E***	***Coeff***	***S.E***	***Coeff***	***S.E***	***Coeff***	***S.E***	***Coeff***	***S.E***
Household Characteristics												
Sex	0.194	0.13	0.336	0.136[b]	-0.001	0.197	-0.032	0.161	0.206	0.125[c]	-0.312	0.173[c]
Household Size	0.019	0.01[b]	0.001	0.009	0.024	0.129[c]	0.035	0.01[a]	0.016	0.009[c]	0.024	0.011[b]
Number of years in Crop Farming	-0.004	0.01	0.139	0.006[b]	0.018	0.008[b]	0.013	0.007[c]	0.145	0.006[b]	-0.004	0.006
Number of Years in Education	0.271	0.13[b]	0.67	0.238[a]	0.296	0.024	0.047	0.027[c]	0.381	0.22[c]	0.001	0.019
Household Assets												
Farm Size	0.766	0.37[b]	0.217	0.106[b]	0.062	0.33[c]	-0.011	0.111	0.004	0.006	0.029	0.017[c]
Off-farm Income	0.48	0.15[a]	-0.26	0.158	0.911	0.199[a]	0.459	0.168[a]	-0.03	0.143	0.467	0.275[c]
Own Donkey	0.634	0.26[b]	0.324	0.221	0.594	0.322[c]	-0.131	0.276	0.293	0.221	-0.239	0.273
Own Tricycle	-0.04	0.17	0.183	0.167	0.442	0.201[b]	0.196	0.203	-0.04	0.165	0.578	0.263[b]
Own TV/or Radio	0.036	0.16	0.598	0.162[a]	0.835	0.215[a]	0.083	0.203	-0.04	0.154	0.027	0.213
Institutional/Policy Variables												
Workshop Attendance	0.557	0.14[a]	-0.2	0.161	0.237	0.217	0.01	0.177	0.405	0.14[a]	-0.05	0.179
Demonstration Farms Visit	0.531	0.14[a]	0.509	0.153[a]	-0.547	0.212	0.283	0.168[c]	-0.16	0.132	-0.451	0.169[a]
Other Agricultural training received	-0.13	0.15	0.545	0.16[a]	-0.341	0.214	0.343	0.167[b]	0.376	0.144[a]	-0.402	0.188[b]
Membership of Social group	0.443	0.13[a]	0.292	0.145[b]	0.59	0.215[a]	0.071	0.165	0.407	0.13[a]	0.289	0.171[c]
Access to market information	520	0.12[a]	-0.24	0.134	0.063	0.184	0.459	0.168[a]	-0.06	0.126	0.408	0.185[b]
Access to storage facilities	0.164	0.12	0.459	0.131[a]	0.028	0.18	-0.233	0.147	0.534	0.118[a]	-0.087	0.160
Received Gov't extension services	0.298	0.14[b]	0.24	0.159	0.412	0.219[c]	-0.124	0.184	0.012	0.147	0.231	0.193
Location Variables												
Distance to the nearest Output Market	-0.001	0.002	0.001	0.002	0.852	0.196[a]	0.001	0.002	0.001	0.002	0.05	0.299[c]
Upper East	0.276	0.17[c]	0.279	0.165	1.619	0.26[a]	-0.124	0.479	0.479	0.156[a]	-0.313	0.207
Upper West	0.52	0.19[b]	2.151	0.401[a]	1.645	0.423[a]	-0.678	0.26[a]	1.121	0.192[a]	-0.676	0.282[b]
Constant	-1.64	0.40	-0.20	0.374	-0.839	0.522	-1.788	0.455	-0.81	0.363	-1.514	0.495

a, b and c indicate significance level at 1%, 5% and 10% level of significance respectively. ROW, FZ and CMKT denote row planting, fertilizer application and collective marketing, respectively.

The estimates related to household characteristics indicates that male farmers are more likely to adopt row planting, more likely to have their produce graded before selling and have greater propensity to engage in collective marketing. The household size variable is key in explaining the adoption of certified seeds, fertilizer application, labelling, grading and collective marketing. Families with large members serve as farm labour to combat the challenging labour intensive nature of agricultural technologies and marketing strategies. The positive correlation between household size and the use of fertilizer is contrary to a result obtained by Ahmed (2015) who established a negative relationship between large family size and fertilizer application. Farmers' level of experience measured by the number of years in crop farming is positively related to row planting, fertilizer application, labelling and engagement in collective marketing. Higher educational status increases farmers' awareness about the benefits of farm technology and marketing strategies. From the results, education was found to have a positive relationship with the use of certified seeds, row planting, labelling and engagement in collective marketing. The relationship between education and certified seeds is consistent with Shiferaw *et al.* (2014).

Household assets have been established to influence farmers' decisions on farm technology adoptions (Kassie *et al.* 2013, Holden 2014). Contrary to the study of Kassie et al. (2015), the study found a positive relationship between certified seeds and farm size which is consistent with Shiferaw *et al.* (2014). Similarly, farm size has a positive relationship with row planting and fertilizer application. Off-farm activities also exhibit positive correlation with the use of certified seeds, row planting, fertilizer application and collective marketing. This is plausible, as farmers often generate income from off-farm activities to support their farming activities in terms of purchasing inputs. Farmers' engagement in off-farm activities generates extra income that can be used to support the farm household in case of productivity failure or where farm products are not sold at the right time. Further, the results indicate that ownership of donkey increases the probability of certified seeds and fertilizer adoption. This result is consistent with previous studies on the use of farm technology (e.g. Priscilla *et al.* 2014, Marenya and Barret 2007). These studies reported that ownership of animals especially donkeys that are used for farm work significantly influence farmers' choice of technology. Similarly, ownership of tricycle and TV/or radio also do influence farmers' adoption of some components of ACDEP/ADVANCE VC package.

From the results presented in Table 7, workshop attendance, visits to demonstration farms and other agricultural related trainings received have a significant influence on smallholder farmer's choice of production technologies and marketing strategies. Di Falcao and Bulte (2013) and Kassie *et al.* (2013) reported that social capital and network variables are important in explaining households' adoption decisions. This is because attending farm workshops and visits to demonstration farms help increase farmers' knowledge and understanding of productive technologies and agricultural marketing strategies. Hence, farmers who are knowledgeable about productive technologies are more likely to adopt than those who do not know (Zhang *et al.* 2002). Likewise, membership of farmers' group may increase access to information on productivity-enhancing technologies and marketing strategies (Olwande and Mathenge 2012). Hence, membership of farmers group is expected to increase adoption.

Similarly, access to information on input costs and output prices shape farmers' decision making, likewise, access to storage facilities. Extension service is an important variable that provides technical information to farmers. The extension service variable has a positive correlation with the use of certified seeds and fertilizer application. This finding is in line with Sissay *et al.* (2015) and Mmbando and Baiyeghunhi (2016), who found a positive relationship between a number of extension contacts and adoption of improved maize variety. Consistent with Shiferaw *et al.* (2014), location of smallholder farmers influences the adoption of agricultural technologies.

4.2 Determinants of intensity of adoption

Table 8 reports the determinants of the intensity of adoption of GAPs and marketing strategies from the Poisson regression analysis. The dependent variable is the number of GAPs and marketing strategies used by the farm households. Since the coefficient estimates do not provide any meaningful interpretations, the estimated coefficients were transformed into marginal effects and are presented in the Table. The marginal effects give the magnitude of the change in a given number of GAPs and marketing strategies used by the farm households when an independent variable changes by one unit.

Table 8: Intensity of adoption from the Poison regression analysis

Variable	*Marginal Effects*	*Standard Errors*
Household Characteristics		
Sex	0.074	0.045
Age	-0.007	0.002[a]
Number of years in Education	0.022	0.01[b]
Number of Years in crop farming	0.001	0.004
Number of household in school	-0.745	0.133[b]
Household Assets		
Farm Size	0.027	0.007[a]
Off-farm Income	-0.111	0.056[b]
Ownership of Tricycle	0.274	0.068[a]
Ownership of motorbike	0.051	0.048
Institutional Variables		
Workshop Attendance	0.111	0.067[c]
Visit to demonstration Farms	0.067	0.039[c]
Access to market information	0.062	0.042
Received Gov't extension services	0.379	0.084[a]
Location Variables		
Upper East Region	0.269	0.06[a]
Upper West Region	0.351	0.06[a]
Constant	0.779	0.10[a]
Wald Chi^2 (15)	128.08	
Prob > Chi^2	0	
Observation	673	

a, b and c denote significant levels at 1%, 5% and 10%.

The results from Table 8 indicate a negative relationship between age and the likelihood to adopt more of the given set of technologies. This is possible because farmers are usually reluctant to try new ways of doing things as they grow old, whereas the young ones are more willing to take the risk associated with innovations. The marginal effects imply that a percentage or a year increase in the age of the head of a farm household is expected to reduce the intensity of adoption by

0.007 units. The positive and significant education variable suggests that as farmers become more educated, they increase the intensity of adoption of a given farm management strategy and marketing technologies. This is because educated farmers are more likely to access, comprehend and absorb information given to them by the agents of the intervention programs or extension service personnel. This finding is consistent with that of Ehiakpor *et al.* (2016). With regard to farm size and farm management practices, the study's findings indicate that farmers with large farm size adopt more of the GAPs and marketing strategies than farmers with smaller farm size. This is because the coefficient of the farm size variable and farm management practices is positive and significant at 1%. This result is consistent with previous adoption and farm marketing studies (e.g; Ahmed 2015, Teklewood *et al.* 2013, Kassie *et al.* 2013). Off-farm income is negatively signed and significant at the 5% level. The negative sign of the off-farm income suggests that as farmers take more time off their farming activities, the number of farm management practices used declines. However, ownership of tricycle increases the intensity of adoption.

The positive and significant effect of workshop attendance suggests that exposing farmers to workshop activities where they learn and share ideas about farm activities will help increase adoption of more farm management and marketing strategies to boost production and farm income. Likewise, visits to demonstration farms where farmers get the opportunity to observe and practice farm management technologies increase their knowledge about such technologies, hence, increases the intensity of adoption. Another important result is the positive and significant effect of extension services on the number of farm and marketing practices adopted and hence the intensity of adoption. Location variables are positive and significant suggesting the farmers located in the Upper East and Upper West regions, where rice and maize respectively are dominant, adopt more of the farm management practices and marketing strategies than those from the Northern region.

4.3 Impact of ACDEP/ADVANCE intervention program on beneficiaries' welfare

Before turning to the impacts of participating in the ACDEP/ADVANCE program, the study first discusses the quality of the matching process. After estimating the propensity scores for ACDEP/ADVANCE participants and non-participants, each of the participants was matched to

one or several non-participants according to their socioeconomic characteristics such as age, educational status, etc. This is done to eliminate any significant differences between participants and non-participants based on their characteristics, so that the only difference between them is the effect of participation in ACDEP/ADVANCE program. In this case, we say the participants and non-participants are subjected to the condition of common support or confined in the region of common support. However, those that do not get their match are considered to be off-support. Figure 3 gives a density distribution of the propensity scores and the region of common support. The green colour indicates a group of participants (ACDEP) who did not get their match from the control group (non-participants). The maroon and the blue indicate the treated and the control farmers who were perfectly matched. It is clear from Figure 3 that there is a considerable overlap of distribution of the propensity scores for both the participants and non-participants of the ACDEP/ADVANCE program.

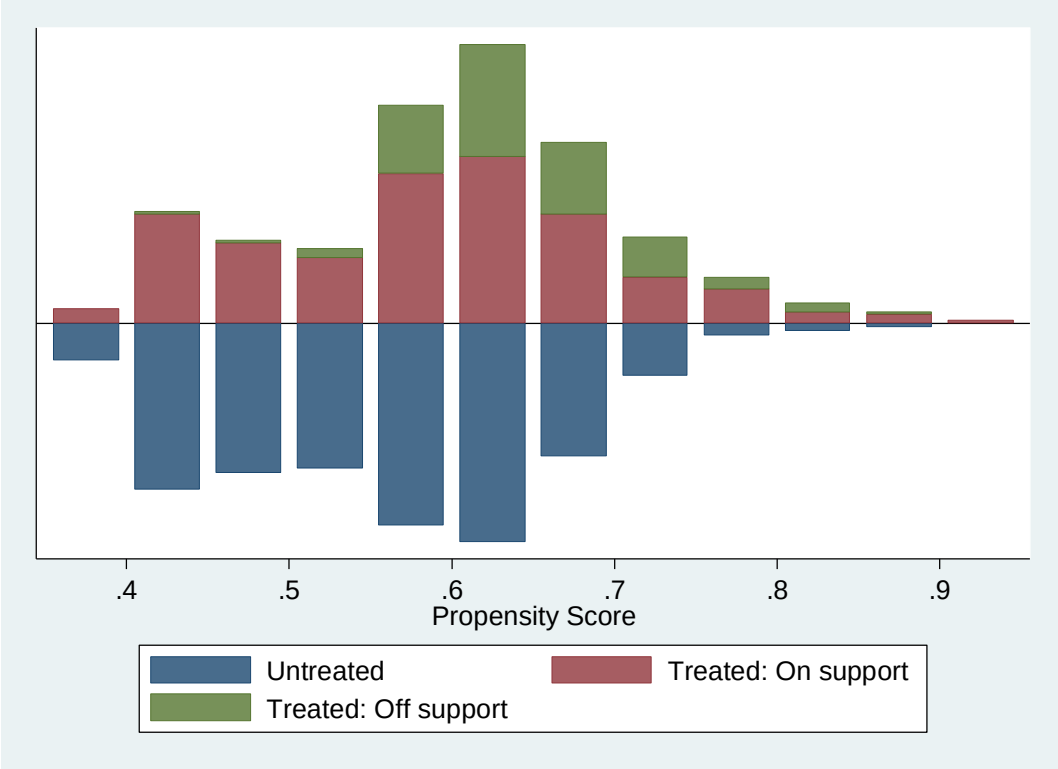

Figure 3: Propensity score matching between treated (ACDEP/ADAVANCE members) and untreated (non-ACDEP/ADVANCE members).

Thus, the common support assumption is satisfied with a loss of only 16 (4.06%) from the treated group. The bottom half of the graph represents the distribution of the estimated propensity scores for the non-participants and the upper half refers to the participants. The estimated densities of the scores are on the *y-axis.*

A major aim of the propensity score is to balance the distribution of the variables between ACDEP participants and non-participants. Table 6 presents the results of the matching quality from the covariates balancing test between participants and non-participants. The table indicates that, the standardized mean difference used in propensity (about 21% before matching) dropped considerably to 4.8% - 5.7% after matching leading to a substantial reduction in the total bias, in the range of 73% - 78%. The p-values of the likelihood ratio tests indicates that the joint significance of the covariates was not rejected before matching, but was rejected after matching in all the matching technique.

Table 6: PSM quality indicators before and after matching

Matching Algorithm	Pseudo R^2 before matching	Pseudo R^2 after matching	LR χ^2 (p-value) before matching	LR χ^2 (p-value) after matching	Mean standardized bias before matching	Mean standardized bias after matching	Total % Ibiasl reduction
NNM	0.331	0.031	30.33 (0.000)	1.36 (0.986)	21.1	5.7	72.98%
KBM	0.331	0.029	30.33(0.000)	1.16 (0.891)	21.1	4.8	77.25%
RBM	0.331	0.022	30.33 (0.000)	1.27 (0.811)	21.1	5.1	75.83%

NNN = Five nearest neighbor matching with replacement and common support

KBM = Kernel matching based matching with band width 0.05 and common support

RKB = Radius Matching with a radius of 0.001 and common support

The Pseudo R^2 also reduced significantly from 0.33 before matching to about 0.022-0.031. The low Pseudo R^2, low mean standardized bias, high total bias reduction and the insignificant value of the likelihood ratio tests suggests a fair balancing of the distribution of the covariates between ACDEP participants and non-participants. Thus, both groups have the same distribution in covariates after matching (Mmbando *et al.,* 2015). The results, therefore, suggests that the

proposed specification is fairly successful and can therefore be used to estimate the impact of ACDEP programme among households with similar characteristics.

4.3.1 The average impacts of ACDEP/ADVANCE programme on the participants - ATT

The estimated average impact of ACDEP/ADVANCE program participation on household welfare is presented in Table 9. The study used farm income per acre, household income and consumption expenditure per capita as welfare indicators. Both the Nearest Neighbor and the Kernel Matching techniques were used to test the robustness of the results. The PSM estimates in the Table show that smallholder farmers who participated in the ACDEP/ADVANCE program had increased their farm and household income and consumption per capita.

Table 9 Impact of ACDEP/ADVANCE Program on Farm Income per acre, Household Income, and Consumption Expenditure per Capita

Outcome Variable	*Matching algorithm*	*Mean Outcome Variables based on Matched Observations*		
		Participants	*Non-participants*	*Difference (ATT)*
Farm Income per acre	NNM	924.325	551.244	375 (3.13)[a]
	KBM	958.330	550.179	408 (3.73)[a]
Household Income	NNM	8,603.212	4179.085	4,424 (5.85)[a]
	KBM	8,501.986	4150.208	4,351 (6.22)[a]
Consumption Expenditure per capita	NNM	893.926	463.869	430.057 (4.51)[a]
	KBM	870.197	454.989	415.209 (4.72)[a]

1: Figures are in Ghana Cedis (GH¢) 2: 1US$ = 4.08 (average rate for 2016) 3: a represents significant level at 1%.

The increase in farm income per acre ranged from GH¢375 ($91.91) to GH¢ 408 ($100). Similarly, participation in ACDEP/ADVANCE program increased average household income in the range of GH¢4,351($1,066.42) and GH¢4,424 ($1,084.31). The results further indicate that farmers' expenditure per capita increased in the range of GH¢415 ($101.72) to GH¢430 ($105.39) through

participation in the ACDEP/ADVANCE program. Thus, the ACDEP/ADVANCE program has had a substantial effect on the welfare of the participating smallholder farmers.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The study has analyzed adoption and intensity of GAPs and marketing strategies by smallholder farmers in the three northern regions of Ghana using plot-level data of 673 farm households. It has also assessed the impact of ACDEP/ADVANCE intervention program on the welfare of the beneficiaries using farm income per acre, household income, and consumption expenditure per capita as welfare indicators. The study revealed that about 54%, 76% and 93% of ACDEP/ADVANCE farmers across the three northern regions had adopted certified seeds, row planting, and fertilizer, respectively. However, these adoption rates are generally higher among ACDEP/ADVANCE farmers in the Upper East region, particularly in maize and rice fields, than their counterparts in the Northern and Upper West regions. Adoption of certified seeds of soybean is relatively low across all the regions, whereas only 3.3% ACDEP/ADVANCE farmer applied fertilizer in his or her soybean field. The adoption of marketing strategies was also low to very low in all the three crops across the three regions. The average adoption rates of product labelling, grading, and collective marketing for ACDEP/ADVANCE members across the three regions are 48%, 13%, and 12%, respectively. The descriptive statistics further indicate that the ACDEP/ADVANCE farmers in the Upper East region perform better than the other two regions in terms of productivity (yield per acre) in all the three crops. The least productivity-performing region in all the three crops is Northern region. Also, the reported performance indicators show that ACDEP/ADVANCE members had higher output and output per acre than non-members of ACDEP. This translates into higher farm income per acre.

The results from the MVP analysis of the study indicated that all the selected components of GAPs and marketing strategies were found to be complementary and that the adoption of a particular GAP is conditioned on the adoption of the other GAPs. Moreover, different socio-economic factors (sex, household size, the number of years in crop farming, educational attainment) and household assets (off-farm income, ownership of donkeys, tricycle/motor bike and TV/radio) were found to have significant influence on different components of GAPs and marketing strategies.

More importantly, institutional factors (demonstration farm visits, access to market information, access to storage facilities and extension services) and social capital and networking (e.g. Farmer Based Organizations-FBOs) have positive significant effects on adoption of different components of GAPs and marketing strategies. The study also revealed that adoption intensity (number of GAPs and marketing strategies adopted by individual farm household) is also positively influenced by factors such as farmers' educational level, ownership of tricycle, workshop attendance, demonstration farm visits and farmers' contact with extension services.

Finally, the results from the impact analysis show that participating in the ACDEP/ADVANCE intervention program has a significantly positive effect, both statistically and economically, on farm income per acre, household income and consumption expenditure per capita. Thus, participation in the intervention programs such as ACDEP/ADVANCE is pro-poor in nature, with participants having better welfare than non-participants.

5.2 Recommendations

Some key lessons have emerged from this study for government and other stakeholders in the Ghanaian agricultural sector. First of all, the yields were relatively low particularly for maize and rice compared to yields of other countries such as Brazil who is setting the vision to become a global agricultural powerhouse. The yields of rice and maize in Brazil has been estimated to be about 4,704kg/ha and 4,706kg/ha, respectively. This offers a milieu for a holistic approach to increasing productivity in a sustainable manner to improve the livelihoods of the farmers in these sectors. To achieve a sustained gain from investment in interventions programs and uplift the living standards of the rural farm households, it is imperative to think holistically about socioeconomic development in a more comprehensive way. For instance, the study revealed that educated farmers adopt more of the GAPs and marketing strategies than the non-educated farmers. We believe that long-term investment in education can serve as a vehicle for increasing agricultural productivity in a more sustainable way. We envisaged education in two perspectives. First, formal education of young people through an aggressive infrastructural and human investment requisite where young people are encouraged to go into agriculture. Secondly, formal adult education where at least numeracy is taught could be integrated into intervention programs

or strengthen where it already exists. This would shape the decision-making and choice frameworks. We believe that these efforts will have direct positive effects on farm income, help young people to journey their way out of poverty, and improve the decision-making process of the adults, especially in the study area where poverty is pervasive.

Also, from the study, farmers with access to market and storage facilities adopt more GAPs and marketing strategies than those farmers who don't. This simply suggests that focusing solely on productivity-enhancing technology transfer with little long-term development in agricultural infrastructure such as storage facilities will produce less than expected results from the huge investments in intervention programs. Long-term infrastructural developments such as storage facilities are particularly important to assure farmers that if they experienced market surpluses, produce could be stored in safer places for the next marketing seasons. To this end, strategies of buffer stocks or warehousing receipt system being implemented should be intensified. Since farmers with access to market information are likely to increase their adoption and adoption intensity of GAPs and marketing strategies suggest that a well-coordinated market system in the agricultural value chains be strengthened within programs/projects. This will enhance productivity and thus, increase farmers' income.

Also, the promotion and facilitation of farmers' group/association will help increase the use of GAPs and marketing strategies as this helps reinforce farmer-to-farmer extension services. The nucleus-outgrower farmer scheme where a nucleus farmer serves as an aggregator for smallholder farmers is commendable. Further, on-farm trials or demonstrations farms as a way of enhancing famers' technical skills should also be intensified across all agricultural sectors. Farmers who participate in demonstration farms get sufficient information on farm technologies as they learn more by practicing, and hence, boost their farm productivity. The study also revealed the importance of extension services in the use of farm and marketing strategies. Therefore, government and other stakeholder extension delivery services should be strengthened through recruitment, incentives and regular training of the extension agents. Nucleus farmers with large acreage of farms should be encouraged to employ extension officers who would in turn assist their out growers.

Overall, this study argues for a comprehensive and a broader approach to improving the welfare of the rural livelihoods in the study area through infrastructural, agricultural technology transfer,

and agricultural marketing strategy developments. There is also the need to earmark an organization or establish one overseeing and streamlining activities of projects/programs in northern Ghana to avoid overlap and duplication of interventions, and enhance the judicious and efficient use of resources. Donors could equally take measures to avoid multiple allocation of resources to same activities. It is also recommended that organizations such as ACDEP/ADVANCE implementing farm intervention programs extend their coverage areas to capture more farmers, since the empirical evidence presented in this study shows that such programs lead to improved welfare of farmers.

References

Abadie, A., Imbens, G.W. 2006. Large Sample Properties of Matching Estimators for Average Treatment Effects. Econometrica 74(1), 235–267.

Abate, G.T., Rashid, S., Borzaga, C. and Getnet, K. 2016. Rural finance and agricultural technology adoption in Ethiopia: Does the Institutional design of lending organizations matter? *World Development,* 84: 235 – 253.

Abdul-Rahman, F.A. and Donkoh S.A. 2015. Analysis of the Maize Value Chain Development in the Northern Region, the case of the Association of Church Development Programme (ACDEP). *Ghana Journal of Science, Technology and Development,* 3(1): 47 – 62.

ACDI/VOCA. 2013. Our story. http://www.acdivoca.org/site/ID/OurStory.

Ahmed, M.H. 2015. Adoption of multiple agricultural technologies in maize production of the cental rift valley of Ethiopia. *Studies in Agricultural Economics,* 117.

Ali, A., Rahut, D.B., and Behera, B. 2016. Factors influencing farmers' adoption of energy-based water pumps and impacts on crop productivity and household income in Pakistan. *Renewable and Sustainable Energy Reviews,* 54: 48 – 57.

Amare, M., Asfaw, S., Shiferaw, B. 2012. Welfare impacts of maize– pigeonpea intensification in Tanzania. *Agricultural Economics* 43(1), 27–43.

Angrist J.D., Imbens G.W., 1991. Identification and estimation of local average treatment effects. Technical Working Paper No. 118.

Awotide, B.A., Aziz, A.K. and Diagne, A. 2016. Agricultural technology adoption, commercialization and smallholder rice farmers' welfare in rural Nigeria. *Agricultural and food economics* 4 (3).

Becerril, J., Abdulai, A., 2010. The impact of improved maize varieties on poverty in Mexico: A propensity score-matching approach. *World Development* 38(7), 1024–1035.

Cameron, A.C. and Trivedi, P.K. (1990). Regression-based tests for over-dispersion in the in the Poisson model. *Journal of Econometrics* 46(3): 347-364.

Cameron, A.C. and Trivedi, P.K. 1998. *Regression Analysis of Count Data*. Cambridge Cambridge University Press.

Cooke, E., Hague, S. and Mckay, A. 2016. The Ghana poverty and inequality report, using the 6th Ghana Living Standards Survey.

Crost, B., Shankar, B., Bennett, R., Morse, S., 2007. Bias from farmer self-selection in genetically modified crop productivity estimates: Evidence from Indian data. *Journal of Agricultural Economics* 58(1), 24–36.

De Janvry, A., Fafchamps, M. and Sadoulet, E. 1991. Peasant household behavior with missing markets: some paradoxes explained. *The Economic Journal* 101: 1400–1417.

Di Falco, S. and Bulte, E. 2013. A dark side of social capital? Kinship, consumption, and savings.*Journal of Development Studies,* 47: 1128–1151.

Ehiakpor, D.S., Danso-Abbeam, G., Zutah, J., and Hamdiyah, A. 2016. Adoption of farm management practices by smallholder cocoa farmers in Prestea Huni-Valley District, Ghana. *Russian Journal of Agriculture and Socioeconomic Sciences,* 5(53): 117 – 124.

FAO (Food and Agriculture Organization of the United Nations). 2010. Nutrition country profiles Ghana. Agriculture and Consumer Protection Department. http://www.fao.org/ag/agn/nutrition/gha_en.stm.

Gebrehiwot, K.G. 2015. The Impact of Agricultural Extension on Households' Welfare in Ethiopia. *International Journal of Social Economics* 42 (8):733 - 748.

GSS (Ghana Statistical Service) 2014. Annual Gross Domestic Product (GDP) report. Accra, Ghana.

Greene, W.H. 2007. *Functional Form and Heterogeneity in Models for Count Data.* Foundations and Trends in Econometrics Publishers Inc.

Greene, W.H. 2008. *Econometric Analysis*, 6th editon. New Jersey: Prentice Hall.

Hechman, J., 1979. Sample selection bias as specification error. *Econometrica* 47,153-161

Heckman, J., and E. Vytlacil. 2007. "*Handbook of Econometrics.*" *Econometric Evaluation of Social Programs, Part 2 of Using the Marginal Treatment Effect to Organize Alternative Economic Estimators to Evaluate Social Programs and to Forecast Their Effects in New Environments. In J. Heckman, & E. Leamer (Eds.)*. Amsterdam: Elsevier Science.

Holden, S.T., 2014. Agricultural household models for Malawi: household heterogeneity, market characteristics, agricultural productivity, input subsidies, and price shocks. A baseline report. In: CLTS Working Paper No. 5/2014.

Holden, S.T., Shiferaw, B., Pender, J., 2001. Market imperfections and land productivity in the Ethiopian highland. *Journal of Agricultural Economics*, 52(3): 53–70.

IFAD (International Fund for Agricultural Development). 2012. Ghana: country programme evaluation. IFAD Publ. No. 84.

Isgin, T., Bilgic, A., Forster, D.L. and Batte, M.T. 2008. Using count data models to determine the factors affecting farmers' quantity decisions of precision farming technology adoption. *Computers and Electronics in Agriculture* 62(2): 231-242.

Khanna, M. 2001. Sequential adoption of site-specific technologies and its implications for nitrogen productivity: A double selectivity model. *American Journal of Agricultural Economics* 83:35 - 51.

Kassie, M., Jaleta, M., Shiferaw, B., Mmbando, F. and Mekuria, M. 2013. Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania. *Technological Forecasting and Social Change,* 80: 525–540.

Kassie, M., Teklewold, H., Jaleta, M., Marenya, P. and Erenstein, O. 2015. Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. *Land Use Policy* 42: 400-411.

Kassie, M., Teklewold, H., Marenya, P., Jaleta, M. and Erenstein, O. 2014. Production risks and food security under alternative technology choices in Malawi: Application of a multinomial endogenous switching regression. *Journal of Agricultural Economics,* (DOI: 10.1111/1477-9552.12099.

Khonje, M., Manda, J., Alene, A.D., Kassie M., 2015. Analysis of Adoption and Impact of Improved maize Variety in Eastern Zambia. *World Development* 66, 695-706

Lohr, L. and Park, T.A. 2002. Choice of insect management portfolios by organic farmers: lessons and comparative analysis. *Ecological Economics* 43(1): 87-99.

Marenya, P.P. and Barrett, C.B. 2007. Household-level determinants of adoption of improved natural resources management practices among smallholder farmers in western Kenya. *Food Policy* 32: 515–536.

Matthias L. and Muzira, T.J. 2009. International Labour Organization: Value chain Development for Decent Work –A practical and conceptual guide, EMP/ENTERPRISE publications, International Labour Office, Geneva.

Miller, C. and Jones, L. 2010. Agricultural value chain finance: Tools and lessons. Food and Agriculture Organization (FAO), Practical Action Publishing, FAO.

Miller, C. and da Silva, C. 2007. Value chain financing in agriculture: Enterprise Development and Microfinance 13(2/3), Practical Action Publishing, Rugby.

Mmbando, F.E., and Baiyegunhi, L.J.S. 2016. Socio-Economic and Institutional Factors Influencing Adoption of Improved Maize Varieties in Hai District, Tanzania. *Journal of Human Ecology* 53 (1):49-56.

Mmbando, F.E, Wale, E.Z and Baiyegunhi, L.J.S. 2015. Welfare impacts of smallholder farmers' participation in maize and pigeonpea markets in Tanzania. *Food Security,* 7(6): 1211 – 1224.

MoFA (Ministry of Food and Agriculture) (2015). Annual Report. Statistical, Research and Information Directorate, Ministry of Food and Agriculture, Accra, Ghana.

Nkegbe, P.K. and Shankar, B. 2014. Adoption intensity of soil and water conservation practices by smallholders: evidence from Northern Ghana. *Bio-based and Applied Economics* 3(2): 159-174, 2014

Olwande, J. and Mathenge M 2012. Market Participation among Poor Rural Households in Kenya. *Paper presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference*, Foz do Iguaçu, Brazil, 18-24 August, 2012.

Poisson model. *Journal of Econometrics* 46(3): 347-364.

Priscilla, W., Songporne, T. and Matin, Q. 2014. Improved Seeds, Fertilizer or Natural Resource Management? Evidence from Kenya's Smallholder Maize Farmers. *Paper presented at the EAAE 2014 Congress 'Agri-Food and Rural Innovations for Healthier Societies',* Ljubljana, Slovenia, 26-29 August 2014.

Rahelizatovo, N.C. and Gillespie, J.M. 2004. The adoption of best-management practices by Louisiana dairy producers. *Journal of Agricultural and Applied Economics,* 36(1): 229-240.

Ramirez, O.A. and Shultz, S.D. (2000). Poisson count models to explain the adoption of agricultural and natural resource management technologies by small farmers in Central American countries. *Journal of Agricultural and Applied Economics* 32(1): 21 – 33.

Rogers, E. M., 1983. Diffusion of Innovation (Second ed.). New York: Free Press.

Rosenbaum, P. R., and Rubin, D.B (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika* 70:41 - 55.

Rubin, D.B., 1974. Estimating causal effects of treatments in randomized and nonrandomized studies. *Journal of Education and Psychology* 66, 688-701.

Rutherford, D.D., Burke, H.M., Cheung, K.K. and Field, S.H. 2016. Impact of an agricultural value chain project on smallholder farmers, households, and children in Liberia. *World Development,* 83: 70 – 83.

Sharma, A., Bailey, A. and Fraser, I. 2010. Technology adoption and pest control strategies among UK cereal farmers: Evidence from parametric and nonparametric count data models. *Journal of Agricultural Economics*, doi: 10.1111/j.1477-9552.2010.00272.x

Sharma, A., Bailey, A. and Fraser, I. 2011. Technology adoption and pest control strategies among UK cereal farmers: evidence from parametric and non-parametric count data models. *Journal of Agricultural Economics* 62(1), 73-92.

Shiferaw, B., Kassie, M., Jaleta, M. and Yirga, C. 2014. Adoption of improved wheat varieties and impacts on household food security in Ethiopia. *Food Policy*, 44: 272–284.

Sisay D, Jema H, Degye G. and Abdi-Khalil, E. 2015. Speed of improved maize seed adoption by smallholder farmers in Southwestern Ethiopia: Analysis using the count data models. *Journal of Agricultural Economics, Extension and Rural Development,* 3(5): 276-282.

Soule, M. J., Tegene, A. and Wiebe, K. D. 2000.Land tenure and the adoption of conservation practices. *American Journal of Agricultural Economics*, 82: 993–1005.

Springer-Verlag.

Teklewold, H., Kassie, M. and Shiferaw, B. 2013. Adoption of multiple sustainable agricultural practices in rural Ethiopia. *Journal of Agricultural Economics*, 64: 597–623.

University Press.

Toborn, J., 2011. Adoption of Agricultural innovations, converging narratives and the role of Swedish Agricultural Research for development. Draft Discussion Paper, version 2011-01-28.

Winkelmann, R. 2008. *Econometric Analysis of Count Data*, 5th ed. Berlin Heidelberg: Springer-Verlag.

Wood, T.N. 2013. Agricultural development in the northern Ghana. Doctoral documents from the Doctor of Plant Health Programme, University of Nebraska, Lincoln.

Zhang, X, Fan, S. and Cai, X. 2002. The path of technology diffusion: Which neighbours to learn from? *Contemporary Economic Policy*, 20(1): 470-478.