IMPACT OF RURAL AND COMMUNITY BANK CREDIT ACCESS ON TECHNICAL EFFICIENCY OF SMALLHOLDER CASSAVA FARMERS IN FANTEAKWA DISTRICT OF GHANA

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DECLARATION

Declaration

This thesis is my original work and has not been presented for an award in any other academic institution.

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DEDICATION

To my Father

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LIST OF ABBREVIATIONS AND ACRONYMS

ADB	Agricultural Development Bank
ARB	Association of Rural Banks
BoG	Bank of Ghana
ESR	Endogenous Switching Regression
FAO	Food and Agriculture Organization of the United Nations
FBOs	Farmer-based Organizations
GoG	Government of Ghana
IFAD	International Fund for Agricultural Development
MoFA	Ministry of Food and Agriculture
RCBs	Rural and Community Banks
SDGs	Sustainable Development Goals
SFA	Stochastic Frontier Analysis
SFM	Stochastic Frontier Model

ABSTRACT

Cassava is an important staple food in Ghana, both in terms of quantity produced and quantity consumed. Increases in the output of the crop, in recent years, have been attributed to increases in land size rather than intensification. This situation has been blamed partially on the low use of improved inputs among smallholder farmers who dominate the country's agriculture. The low use of improved inputs has been attributed to the persistent lack or limited access to credit among smallholder farmers. Rural and Community Banks (RCB) were established with the sole aim of enhancing rural entrepreneurs' access to financial services, and particularly credit. It was envisaged this would improve farm productivity. However, there is little knowledge on what impact cassava farmers' access to RCB credit has on their technical efficiency. The study sought to fill this gap in knowledge.

A multistage sampling technique was employed in the selection of 300 smallholder cassava farm households in the Fanteakwa District in the Eastern Region of Ghana. A semi-structured questionnaire was used to collect primary data on farm level and socioeconomic characteristics of the farmers. Descriptive statistics and binary probit regression were employed to ascertain the factors influencing farmers' awareness of credit facilities provided by RCBs in the district. A stochastic frontier model was used to estimate cassava farmers' technical efficiency while the endogenous switching regression model evaluated the impact of farmers' RCB credit access on their technical efficiency.

The results show that half of smallholder cassava farmers in the district were aware of RCB credit facilities. Access to extension services, membership in farmer-based groups, land ownership, and saving with the bank were major determinants of farmer's awareness of RCB credit programmes. Although the cassava farmers exhibited increasing returns-to-scale, they were technically inefficient operating 28.1 percent away from the efficient frontier. Gender, extension access, membership in farmer-based groups, reduces farmers' technical inefficiency. The first stage of the endogenous switching regression revealed that gender, extension access, land ownership and off-farm income positively influenced farmers' decision to access RCB credit. Overall, RCB credit access had a positive and significant impact on farmers' technical efficiency among those who accessed it.

The study recommends that RCBs in Ghana vamps up their efforts to make their programmes widely known to farmers in their catchment areas to enhance credit access. In addition, Ghana's Ministry of Food and Agriculture should enhance the scope and mode of extension service delivery to increase farmers' technical efficiency.

CHAPTER ONE

INTRODUCTION

1.1 Background

Ghana experienced unprecedented economic growth between 2005 and 2012, achieving the coveted middle-income country status with US$1858 income per capita in 2013 (McKay & Aryeetey, 2004). Accordingly, there were also improvements in human development as indicated by the change in the human development index (HDI) from 0.588 in 2016 to 0.592 in 2017 (UNDP, 2018). Although this growth arose largely from the oil exploration as well as the services sector, agriculture remains a significant player. In 2018, agriculture accounted for about 21 percent of the country's Gross Domestic Product (GDP), thereby remaining a key contributor to the country's economic growth (Ghana Statistical Service, GSS, 2019).

The crop's importance as a global food crop is evidenced in its global production. For instance, in 2013, approximately 276 million metric tonnes (MT) was recorded out of which Africa produced approximately 158 million MT which is approximately 57 percent of the world's cassava production in 2013. The continent's production grew at an average rate of 6 percent per annum between 2009 and 2013 as compared to 2 percent growth in production by Asia over the same period (Koyama *et al.*, 2015).

At the turn of the Millennium, the FAO recognized cassava as the fourth most important food crop in developing countries. In Sub-Sahara Africa, the crop is grown mainly by smallholder farmers and is a source of livelihood for at least 300 million people (Naziri *et al.*, 2014). It is consumed mainly as a staple food, and provides calories for approximately 500 million people and constitutes approximately 37 percent of the population's daily energy requirements (Bamgboye & Kosemani, 2015). It is estimated that the annual per capita consumption of cassava is 80 kilograms (kg), compared to a global average of 17 kg (Tonukari *et al*., 2015).

Globally, Ghana is the seventh largest and Africa's fourth largest producer of cassava, with production at 16 million MT in 2013 (FAO, 2014). An estimated 70 percent of all farmers in the country are involved in cultivation of cassava. It is cultivated and consumed in all the sixteen regions of the country making it an important food security crop. The crop is only second to maize in terms of area planted. Approximately 50 percent of all root and tuber production is accounted for by cassava and has been registered as the most preferred crop among smallholder, resource-poor farmers (Senkoro *et al*., 2018; Enete *et al.*, 2009).

Ghana's agricultural sector, particularly the cassava production subsector, is traditional, rainfed, and dominated by smallholder farmers. The smallholder farmers constitute approximately 90 percent of agricultural farms in the country and produce about 80 percent of the total agricultural production (Peprah *et al.*, 2016). Another challenge is a persistent lack of and/or limited access to agricultural credit. This phenomenon impedes their access to productive resources and hinders the adoption of new technologies. According to Kudadze *et al*. (2016), high transaction cost, information barriers, and lack of collateral are the principal constraints to access to credit amongst smallholder farmers. Lack of collateral arises due to insecure property rights and weak land tenure systems. For decades, smallholder farmers in Ghana have been side-lined by the mainstream commercial banks in the country due to the nature of their production activities.

Since independence in 1957, the Government of Ghana (GoG), has introduced several policies aimed at enhancing smallholder farmers' access to credit and therefore improve resource use for agricultural productivity. For instance, to make the financial sector more friendly and favourable to smallholders in the country, the Central Bank of Ghana (BoG) directed all commercial banks in the country to set aside not less than 20 percent of their loan portfolio to the agricultural sector (Nair & Fissha, 2010). This however, did not succeed as the commercial banks lent mainly to the already well-established agricultural firms, thereby side-lining smallholder farmers owing to the perceived high risks associated with their production (Awunyo-Vitor, 2012).

In another policy, the Agricultural Development Bank (ADB) was established in the 1960s; to help boost agriculture in Ghana (Sebe-Yeboah *et al*., 2014). Accordingly, the GoG set up several branches of the ADB across the country; with rural branches used as payment centers for cocoa farmers (Afful *et al*., 2015). In addition, these branches were used to collect deposits from rural farmers for lending in urban areas. According to reports by ADB, it accounts for 85 percent of all institutional credits to the agricultural sector currently (ADB, n.d). However, studies show that smallholder rural farmers receive only 15 percent of the total agricultural credit advanced by the ADB (Afful *et al*., 2015).

In 1976, the GoG established rural and community banks (RCBs) to increase credit access to productive rural enterprises as a means of promoting rural development (Nair & Fissha, 2010). As stated by the Association of Rural Banks (1992), they were set up with three main objectives. The first one was to encourage banking habits amongst rural dwellers; the second was to mobilize resources into the banking systems in order to accelerate rural development, and, third was to identify viable industries in respective catchment areas for investment and development (*ibid*.). The Central Bank of Ghana (BoG), in pursuant to the three objectives, identified agriculture as an important sector, in Ghana's economic development given that it is the mainstay for majority of rural dwellers. Therefore, the BoG, directed that agricultural loans would constitute at least 50 percent of rural banks' loan portfolio at any point in time (Essel & Newsome, 2000). As at the end of the year 2017, there were about 140 rural and community banks with close to 1000 branches scattered all over the country. As at 2010, RCBs were the largest network of formal financial service providers in rural areas (Nair & Fissha, 2010).

The Fanteakwa district is one of the leading cassava-producing districts in the Eastern region of Ghana. It is predominantly rural with majority of households engaged primarily in farming and rain-fed agriculture is a major characteristic, which makes the activity very vulnerable. The district has four RCBs and two microfinance institutions (Fanteakwa district assembly, 2013).

The sources of credit and the constraints faced by smallholder farmers in accessing them have been extensively studied. There is also, a vast body of empirical studies on how credit access affects smallholder farmer-productivity. Accordingly, the conclusion that is mainly drawn from those studies is that timely access to adequate credit is critical in enhancing smallholder farmers' production, thereby helping them out of poverty through increased incomes. Nonetheless, most of those studies fail to consider the farmer efficiency in the allocation and use of their farm resources. Moreover, most of the studies take a broad view of farmers' sources of credit, considering that there are seemingly numerous sources in developing countries, most of which are informal. Thus, the empirical literature is not clear on how specific sources of credit, particularly those that are government interventions like the RCBs in Ghana, influence farming activities and the respective indices. The utilization of the scarce resource, credit is not yet explored.

1.2 Statement of the Problem

In Ghana, cassava production is dominated by smallholders with most of the farmers cultivating for subsistence. The yields are generally low leading to inefficient sourcing of raw materials to industries in the country given that a high volume of cassava roots is required by the industries. Studies have however shown that yields can likely be increased if improved inputs are used and better agronomic practices are adhered to (Koyama *et al*., 2015).

To achieve gains in production, farmers must invest in improving yields, which is estimated to cost an additional $200 per hectare for improved cassava stem cuttings, fertilizer, pesticides and labour costs (Koyama *et al.*, 2015). However, access to credit continues to remain a major issue facing the smallholder farmers. A study by Abor and Biekpe (2006) on small business financing schemes in Ghana, found that more than 50 percent of small firms (which also includes smallholder farmers) in Ghana were unaware of the financing schemes available to them. This raises questions about whether the smallholder farmers in the country are aware of RCBs and their credit programmes considering that currently, there are about 140 RCBs with close to 1000 branches scattered all over the country.

A lot of empirical discussions has been done on staple foods such as maize and rice in Ghana, largely in the area of productivity and efficiency of farmers (Kudadze *et al*., 2016; Addai *et al*., 2014; Bempomaa & Acquah., 2014; Abdulai *et al*., 2013; Kuwornu *et al*., 2013). However, not much can be said empirically about technical efficiency in the utilization of the scarce resources, credit especially, in most valued crop like cassava. Considering the role cassava cultivation plays in terms of employment and food security, there is the need for empirical investigations focusing on their technical efficiencies can be improved and hence lead to increased cassava production in Ghana. Smallholder farmers are claimed to be efficient but poor (Lundhal, 1987), but this efficiency has not been calibrated where credit is used to mitigate poverty. There is the need to identify how technically efficient smallholder cassava farmers in Ghana are, and how access to credit from RCBs help to improve it.

Empirical studies on the relationship between access to RCB credit and technical efficiency of rural farmers, particularly of smallholder cassava farmers, is scanty. Most of the previous studies in Ghana (Dadze *et al*., 2012; Anang *et al*., 2016; Aidoo-Acquah, 2015; Addo *et al*., 2018) only examine the determinants of demand and supply of institutional credit. The few studies that have assessed the relationship between credit sources and farmer productivity mostly focused on cereals (Owusu, 2017; Kudadze *et al*., 2016). Accordingly, there is little empirical evidence on the impact of RCB credit access on the technical efficiency of cassava producers in Ghana.

1.3 Objectives of the Study

The study aimed to examine the impact of access to credit from rural and community banks on the smallholder cassava farmers' technical efficiency in Fanteakwa district of Ghana.

The specific objectives were to:

1. Assess factors influencing smallholder farmers' awareness of RCB credit programmes Fanteakwa district of Ghana.
2. Estimate the technical efficiency of smallholder cassava farmers in Fanteakwa district of Ghana.
3. Assess the impact of RCB credit access on the technical efficiency of smallholder cassava farmers in Fanteakwa district of Ghana.

1.4 Hypotheses

Based on the objectives stated above, the underlying hypotheses for the study were

1. Smallholder cassava farmers' sociodemographic characteristics do not have any effect on their awareness of RCB credit programmes in Fanteakwa district of Ghana.
2. Smallholder cassava farmers in Fanteakwa district of Ghana are not technically efficient.
3. Smallholder cassava farmers' access to RCB credit has no impact on their technical efficiency.

1.5 Justification

Interventions in the agricultural sector are usually aimed at increasing yields of the farmers, thereby leading to a rise in their income levels and hence significant poverty reduction and food security. Several studies have been done in that regard in order for food security and nutrition to be enhanced in Ghana. Cassava ranks as the second most popular food crop in the country after maize. It is cultivated and consumed in all the sixteen regions of Ghana making it a very important food security crop. It is therefore important to assess the performance of policies aimed at achieving improvements in the production of the crop.

The contribution of cassava to the growth of the sector depends on technological change, the increased use of improved inputs, and technical efficiency of the farmers (Abdallah, 2016). Technological change comes through efforts in research and development. Technical efficiency on the other hand, is influenced by better infrastructure, farmer's managerial abilities and the timely decision making by the farmer as well as the flow of information. The implementation of such decisions to a large extent depend on the resources that are available to the farmer (Abdallah, 2016).

The availability of funds makes it possible for the farmer to acquire the needed resources at the right time as well as in the right quantities. A farmer who is credit constrained has a higher probability of investing in technologies that are less risky rather than technologies that are riskier but productive, thereby limiting their technical efficiency which impedes their ability to attain the maximum possible output (Dercon & Christiaensen, 2011). The findings of this study are of relevance to policy makers including the Ministry of Food and Agriculture (MoFA) and development partners such as the RCBs. The study is aligned with Ghana's Vision 2030 and sustainable development goals one and two.

Ascertaining farmers' awareness of credit programmes provided by RCBs will inform the RCBs in the study area on how well they can improve their awareness campaign and strategies in order to increase uptake amongst the target groups. The assessment of factors influencing farmer participation in the rural bank credit programme will guide officials of RCBs, researchers as well as other stakeholders in designing appropriate credit programmes that will meet the needs of the smallholder farmers. This will further contribute towards achievement of sustainable development goals (SDGs) regarding poverty, hunger and food security. Knowledge of smallholder cassava farmer efficiency will enable policy makers maintain status quo or address inefficiencies among farmers. It will also enable farmers gain knowledge about their input choices as well as their input allocation decisions.

The findings of this study will also contribute to the existing literature on credit access and technical efficiency nexus using the endogenous switching regression model (henceforth ESR) since no substantive study has been conducted on the subject matter in Ghana.

1.6 Description of the Study Area

The study area was the Fanteakwa District. The district is located at the center of the Eastern region at longitudes 0° 10 East and latitudes 6° 15’ North and 6° 40’ North. It is about 58km from the capital city of Ghana, Accra. It shares borders to the north with the Volta Lake, North-West by the Kwahu-South District, to the East by the Manya Krobo district and to the South-West by the East-Akim District. Also, on the South-east border of the district is the Yilo-Krobo district, to the south is the Fanteakwa South district. The district covers a land area of about 1,150 square kilometres and has a population of about 121, 714 people according to the 2010 Population and Housing Census (GSS, 2013).

The region's vegetation consists of the savanna scrub and wet-semi deciduous rain forest. Another climatic feature of the region is a bimodal rainfall pattern with the significant rains starting from March to early August (Asante *et al.*, 2017). The minor rains occur from late August to November. The average rainfall is between 1500mm and 2000mm annually. The climatic condition of the area makes it conducive and suitable for the cultivation of industrial and food crops. For that, a greater percentage of the population is engaged in agriculture particularly, crop production. Cassava is cultivated almost throughout the district (MoFa, 2017).

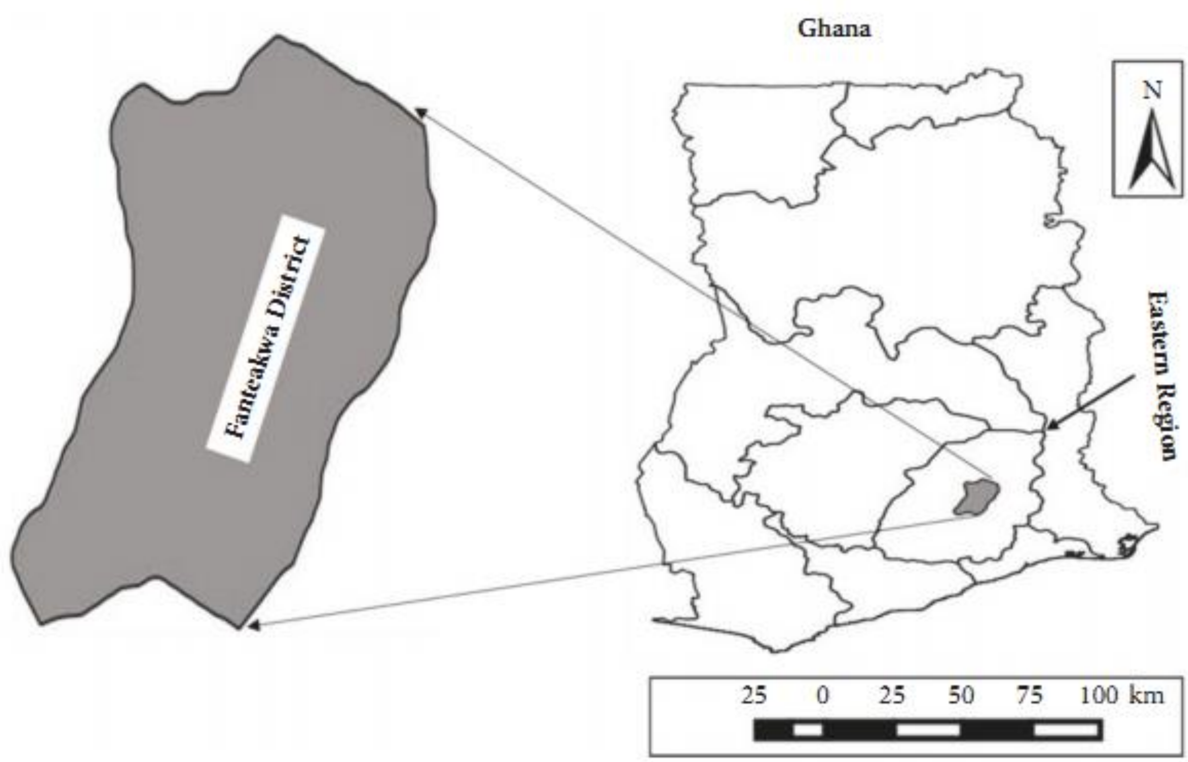

Figure 1: A map of Ghana depicting Fanteakwa district located in the Eastern Region

Source: Kyei-Mensah *et al.* (2019)

1.7 Organization of the Thesis

This thesis is made up of five chapters. The first chapter features the background of the study, statement of the problem, objectives, justification, and description of the study area. Chapter two covers the review of the literature. The third chapter contains the conceptual framework, the theoretical framework, sampling procedure, data collection method, and frameworks for empirical data analysis. Chapter four presents the discussion of the results after data analysis while chapter five provides the conclusions of the findings and policy recommendations thereto.

CHAPTER TWO

LITERATURE REVIEW

2.1 Rural Banking in Ghana

Rural banks were first introduced in Ghana in the 1970s to respond to smallholder farmers and other rural entrepreneurs' demand for credit to improve their production and incomes as well as the general development of the rural areas (Owusu-Frimpong, 2008). Rural banks provide two kinds of credit facilities to smallholder farmers and rural entrepreneurs; loans and/or overdrafts (Nair & Fissha, 2010). The loans are provided to individuals and groups. Individual loans are given where an individual, a company or an association is the borrower while group loans are granted in the case where the borrower belongs to a group, usually an informal group, and the loan is guaranteed by the other members of the group. With regard to overdrafts, the amount needed by the borrower for the stated purpose is estimated by the borrower and is approved by the rural bank (Owusu-Frimpong, 2008).

Another classification of rural bank credit is in terms of the duration of the loan. Thus, there are short loans and overdrafts. This class of credit is usually granted for the period of not more than 18months. There are also medium-term loans and overdrafts; the duration for this class of credit is between 18months and 5years. The third class is the long-term loans and overdrafts which are granted for periods beyond 5years. In recent years, outreach of the bank has increased steadily. For instance, total number of borrowers grew from 139000 in the year 2000, to 680000 borrowers in 2008 which presents an annual growth of 27 percent for borrowers (Nair & Fissha, 2010).

2.2 Theoretical Review

2.2.1 Production Frontier

A production frontier measures the optimum output that can be derived from a given set of inputs, and so sets out the upper boundary of the feasible output. Thus, given a set of inputs, measuring the technical efficiency of a firm involves the measurement of the distance between the actual output of the firm and the production frontier. The distance can be measured using two techniques namely: the distance functions and, revenue, profit or cost functions (Farnsworth, 2015)

2.2.2 The Concept of Efficiency

An investigation by Farrell (1957) into the structure of productive efficiency showed that, efficiency is a product of allocative (price) and technical efficiency. The concept is used to characterize resource utilization. Therefore, efficiency is a relative concept such that an economic agent's performance must be juxtaposed with a yardstick (Førsund & Hjalmarsson, 1974).

2.2.3 Measures of Efficiency

2.2.3.1 Typologies of Efficiency

Farrell (1957) grouped efficiency measures into two groups namely allocative efficiency (AE) (cost efficiency) and technical efficiency (TE). Multiplying the two efficiency measures produces economic efficiency. Technical efficiency explains ability of a firm to achieve maximum output from a set of inputs and the technology available, while AE measures the ability of a firm to achieve a given level of output from an optimal combination inputs at the least cost (Chavas & Aliber, 1993). Economic efficiency, therefore, is the firm's ability to produce the maximum level of output, using inputs in such a way that minimizes cost, given the available technology (Farrell, 1957; Bravo-Ureta & Pinheiro, 1997).

2.2.3.2 Approaches for Estimating Economic Efficiency

The methods to estimating efficiency can be grouped into two, namely; the frontier and the non-frontier approaches (Worthington, 2010). The frontier methods include the parametric and non-parametric techniques. The parametric methods require the construction of a fully–efficient frontier against which the individual measurements are estimated, and also allows the investigation into the role of in the overall performance of the firm. It is further categorized into deterministic and stochastic frontier approaches (Worthington, 2010). The non-frontier approach makes use of a production or profit function for its estimations and is unable to factor in inefficiencies in the firm's overall performance because it assumes the firm is technically efficient (Aigner *et al.*, 1977). The non-parametric frontier approach evaluates the efficiency of a firm in relation to that of other firms in the same industry. One method which is commonly used is the Data Envelopment Analysis (DEA) developed by Charnes *et al.* (1978). DEA employs linear programming to calculate the efficiency of a given firm in relation to other firms' performance in a given sample (Worthington, 2010).

The non-parametric approach however fails to capture statistical noise and other factors that are outside the firm's control as it assumes that any deviation from the frontier is due mainly as a result of the inefficiencies of the firm (Worthington, 2010). One limitation of this approach, therefore, is that it fails to observe the contribution of technical inefficiency in the performance of the firm because it assumes the firm to be technically efficient (Atkinson & Cornwell, 1998). This study hypothesized that smallholder cassava farmers area is not technically efficient, therefore, the parametric approach is the most suitable since it is able to assess the role of technical inefficiency in the firm's performance. Two types of production frontiers under the parametric approach are the deterministic and stochastic frontier.

2.2.3.3 The Deterministic Frontier

In the deterministic approach, any deviation from the firm's potential output is due solely to the inefficiencies of the firm and therefore disregards any factor that is outside the control of the firm (Ali & Chaudhry, 1990). The firm's frontier is thus expressed as:

$$Y_i = f(X_i; \beta) exp(-U_i), \quad U_i \geq 0 \quad i = 1, 2, .. N \tag{2.1}$$

where Y_i represents the maximum possible output level of the ith firm; $f(X_i; \beta)$ is an appropriate production function ; X_i is a vector of inputs used by the ith firm, β is a vector of unknown parameters to be estimated and; U_i is a non-negative term that represents inefficiency associated with the firm's inability to optimize (Oh *et al*., 2014). The firm's technical efficiency is given by $exp(-U_i)$, and ranges between zero and one representing the ratio of the firm's actual output to the firm's potential output (Oh *et al*., 2014).

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{f(X_i;\beta) exp(-U_i)}{f(X_i;\beta)} = \exp(-U_i) \tag{2.2}$$

2.2.3.4 The Stochastic Frontier

Adding deviations from the highest possible output due to random statistical noise, e.g., rain failure, market shocks and policy shifts to equation (2.2) gives rise to a stochastic frontier (Aigner *et al.*, 1977; Meeusen & Van den Broeck 1977). Representing inefficiency due to random statistical noise is V_i and combining it with inefficiency due to producers' inability to optimize production,

$-U_i$, gives rise to a composite error term $(V_i - U_i)$. The firm's production frontier therefore becomes (Aigner *et al.*, 1977):

$$Y_i = f(X_i; \beta) exp(V_i - U_i) \qquad (2.3)$$

where Y_i measures the ith firm's output, X_i denotes the vector of inputs, β is a vector of unknown parameters to be estimated. V_i is assumed to be independently and identically distributed (*iid*) and normally distributed random variable with zero mean and a constant variance, $V_i \sim iid\ N(0, \sigma_V^2)$, while U_i is assumed to be *iid* normal variable with either half normal distribution, $U_i \backsim iidN^+(0, \sigma_v^2)$, truncated normal distribution, $U_i \backsim iidN^+(\mu, \sigma_v^2)$, an exponential distribution, $U_i \backsim iidG(\lambda, 0)$, or gamma distribution, $U_i \backsim iidG(\lambda, m)$. V_i and U_i are also assumed to be distributed independently of each other and of the regressors (Jondrow *et al.*, 1982). The choice of which distribution to use depends on the functional form (Eling & Luhnen, 2008).

Given these assumptions, and a sample size I, the log-likelihood function is given by (Aigner *et al.*, 1977):

$$ln\, L = K - I\, ln\, \sigma + \sum_i ln\, \omega\, (\frac{\varepsilon_i \gamma}{\sigma}) - \frac{1}{2\sigma^2} \sum_i \varepsilon_i^2 \qquad (2.4)$$

where $\varepsilon_i = U_i + V_i$, $\sigma^2 = (\sigma_U^2 + \sigma_V^2)$, $\gamma = \sigma_U^2/(\sigma_U^2 + \sigma_V^2)$, and ω is the standard normal distribution function. This function (equation 2.4) is estimated using a maximum likelihood estimator which yields more efficient βs (than OLS), consistent intercept and consistent variance of the composite error, $(V_i - U_i)$.

The frontier model (equation 2.3) gives the estimates of both technical efficiency and technical inefficiency in a single estimation approach (Battese & Coelli, 1995). However, the estimation of the technical inefficiency, U_i, for each observation is often desirable. To do this, Jondrow *et al*. (1982) suggests that the expected value of the component that captures inefficiency, is estimated subject to the overall error that is measured. Therefore, the expectation of the conditional distribution of the inefficiency term, U_i, given the error term, ε_i, of the efficiency of any production can be specified as:

$$E(U_i|\varepsilon_i) = \sigma_*^2 \left[\frac{f^*(\varepsilon_i\lambda/\sigma)}{1-F^*(\varepsilon_i\lambda/\sigma)} - \frac{\varepsilon_i\lambda}{\sigma}\right] \quad (2.5)$$

where $\lambda = \sigma_u/\sigma_v$; $\sigma = \sqrt{\sigma_u^2 + \sigma_v^2}$; $\sigma_*^2 = \sigma_v^2\sigma_u^2/\sigma^2$; and f^* represents the standard normal density function and F^*, the distribution function which is evaluated at $(\varepsilon_i\lambda/\sigma)$.

2.2.3.5 Common Functional Forms for the Deterministic Kernel

The functional forms most commonly used to operationalized the deterministic kernel, $f(X_i;\ \beta)$, in equation (2.3) are the Cobb-Douglas and translog production functions. In the Cobb- Douglas production function, the estimated β coefficients are interpreted as partial elasticities of output, when specified in its log form given the respective input (Battese & Broca, 1997). The Cobb-Douglas functional form is mostly employed due to its ability to address statistical issues like multicollinearity and heteroscedasticity (Ogujiba *et al*., 2014). However, it assumes constant returns to scale across all inputs and also assumes that the elasticity of substitution between the inputs is one (Onumah *et al*., 2010).

The translog functional form overcomes the limitations of the Cobb-Douglas in that it is more flexible and can represent any structure of production technology (Baten *et al.*, 2009). There are no a priori restrictions on the scale of returns, therefore it allows for a more general specification of the production technology. It requires no *a priori* restrictions such as a perfect substitution or competition between factors of production (Klacek *et al*., 2007). It also permits a transformation of the relationship between output and the inputs from a linear relationship to a non-linear one.

The translog functional form can therefore be used for the estimation of elasticities of substitution as well as measuring the dynamics of total factor productivity (Pavelescu, 2011). However, this functional form is faced with statistical problems such as multicollinearity which is as a result of the high number of parameters it requires to be incorporated in the model. Unlike the Cobb-Douglas functional form, the estimated β coefficients cannot be interpreted directly as elasticities. It is only when the variables are scaled by their unit-means that the derivatives of the output with respect to each of the input variables can be interpreted as elasticities.

2.3 Empirical Review

2.3.1 Determinants of Technical Efficiency

Asante *et al*. (2013) estimated smallholder tomato farmers' technical efficiency in Ghana, using a stochastic frontier. The study found that the farmers were on average 85.4 percent technically efficient. Land and fertilizer application contributed positively to technical efficiency while labour and pesticide application negatively affected the technical efficiency. In Nigeria, Makinde *et al*. (2015) estimated the technical efficiency of cassava farmers in Ogun State using a stochastic frontier. The study found that cassava stem cuttings, farm size, the quantity of fertilizer were the significant factors influencing technical efficiency. Nmadu and Simpa (2014) also assessed the technical efficiency of cassava farmers in Kogi State of Nigeria using the stochastic frontier. The study found that labour, land, planting materials were the leading factors contributing to technical efficiency. They however found that age, education, farmer's membership in a group contributed to the reduction of technical inefficiency.

Focusing on the technical efficiency of maize farmers in Northern Ghana, Abdulai *et al*. (2013) studied factors that influence maize farmers' ability to increase yields as well as attain sustainable production using 360 maize households for the 2011/2012 crop season. Using the stochastic frontier, the study found that the size of the farm, seed, fertilizer and herbicides significantly increased maize output. In addition, the study revealed that experience, agricultural mechanization and gender positively influenced technical efficiency.

In another study in Ghana, Donkor and Owusu (2014) assessed the effect of land tenure on resource-use efficiency of rice production. The data was drawn from the Ghana Agricultural Production Survey and employing the stochastic frontier model, found that rice farms were 61.8 percent technically efficient with the size of owned land and fixed rent reducing technical inefficiency. Kuwornu *et al.* (2013) analysed maize farmer's technical efficiency in the Eastern Region of Ghana using a stochastic frontier. The study found that technical inefficiency was significantly reduced by extension visits, membership in farmer-based organizations, formal training in maize farming, as well as access to credit.

2.3.2 Agricultural Credit-Technical Efficiency Nexus

The relationship between agricultural credit access and technical efficiency has been extensively studied through different approaches with different underlying assumptions. Some studies employ the propensity score matching techniques (Abate *et al.*, 2015; Asante *et al*., 2014; Martey *et al.*, 2015) while others employ the stochastic frontier analysis (Amaza & Maurice, 2005; Moses & Adebayo, 2007). The underlying hypothesis in these studies is that access to financial services positively influences farmers' decisions to invest in new technologies, thereby enhancing their technical efficiency.

Akram *et al*. (2013) assessed the effect of agricultural credit on production efficiency of smallholder farmers in India using a stochastic frontier. The study found that the mean technical efficiency was 0.90 and 0.79 percent among credit users and non-users respectively. The high technical efficiency of credit users was attributed to credit availability, which enabled farmers timely access to farm inputs. Ayaz and Hussain (2011) evaluated how institutional credit impacts production efficiency of smallholder farmers in Pakistan using Data Envelopment Analysis (DEA) technique. The study found an overall mean efficiency of 0.84. The study also found that access to institutional credit, farming experience, education among other factors, had a significantly positive effect on farmer's farmers' technical efficiency in the study area.

In Nigeria, Awotide *et al*. (2015) investigated how credit access impacts agricultural productivity. Using the endogenous switching regression model (ESRM), the study found that access to credit positively enhanced cassava productivity. Still in Nigeria, Amaza and Maurice (2005) found that formal education and farming experience positively influenced farmers' technical efficiency. In Ghana, Akudugu (2016) also investigated the effect of access to credit on the agricultural productivity of households using a hierarchical competitive model. The findings revealed that agricultural productivity of households positively influenced by their access to credit.

2.4 Summary

Following the literature reviewed, it is observed that the relationship between credit from RCBs in Ghana and technical efficiency has not been extensively studied. This study was therefore to fill this gap in knowledge. The study employed the stochastic frontier and the ESR to assess the impact of access to RCB credit on technical efficiency of cassava farmers in Ghana. The study further sheds light on factors that affect the technical inefficiency among smallholder farmers in Ghana with the hope of contributing to understanding between credit access by smallholder farmers and their technical efficiency.

CHAPTER THREE

METHODOLOGY

3.1 Conceptual Framework

The literature sheds ample light on crucial role access to adequate and timely financing plays in enhancing the efficiency of smallholder farmers. Whereas a few farmers could adequately finance their production from their own funds, the study assumed that smallholder farmers were credit-constrained. Farmers who were aware of the existing credit programmes ran by the rural banks can participate in the programme in the form of applying for the loan. Once the loan was applied for, the farmer received the credit either in the desired amount or an amount less than he applied for, but on time. The farmer would then be able to procure improved inputs, and hence productivity and efficiency will be improved.

A farmer who was not aware of the existence of the bank as well as the credit programme, would not be able to participate in the programme hence remained credit-constrained. That farmer would be unable to procure the needed productivity-enhancing inputs. This also applied to the farmer who was aware of the existence of the credit programmes ran by the bank, yet failed to participate in it for some reasons.

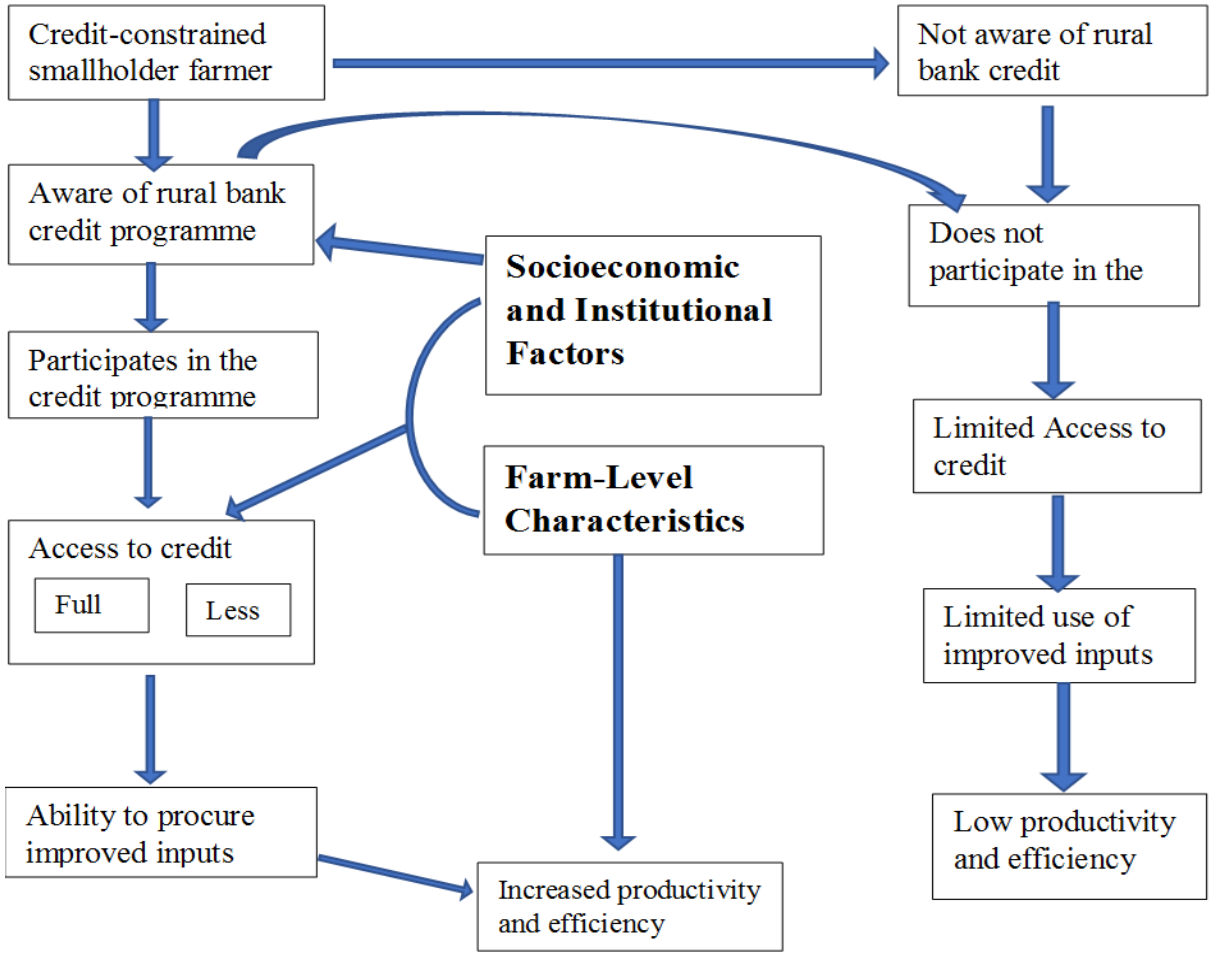

Figure 2: Impact of RCB credit access on technical efficiency of smallholder farmers

Source: Author's conceptualization

3.2 Theoretical Framework

The study was anchored on the program theory of change (Jones & Rosenburg, 2018). The theory explains how an intervention contributes to a chain of results that produce the intended outcome or impact. In other words, the theory describes the processes and mechanisms through which the intervention is supposed to work to achieve the intended impact. Generally, the theory uses a set of "if, then" statements to show the mechanisms of the change and the intended results. The 'if' statements depict what the intervention seeks to do; and the "then" statements depict what the results will look like. The "if, then" statements show the step-by-step causal mechanisms underlying the intervention. It is usually illustrated through a diagram or a model.

In this study, if smallholder farmers access credit from RCBs, they will have access to improved inputs on time and in the right quantities, their technical efficiencies will increase, ultimately leading to increased productivity. This can be illustrated using boxes and arrows as shown in Figure 3.

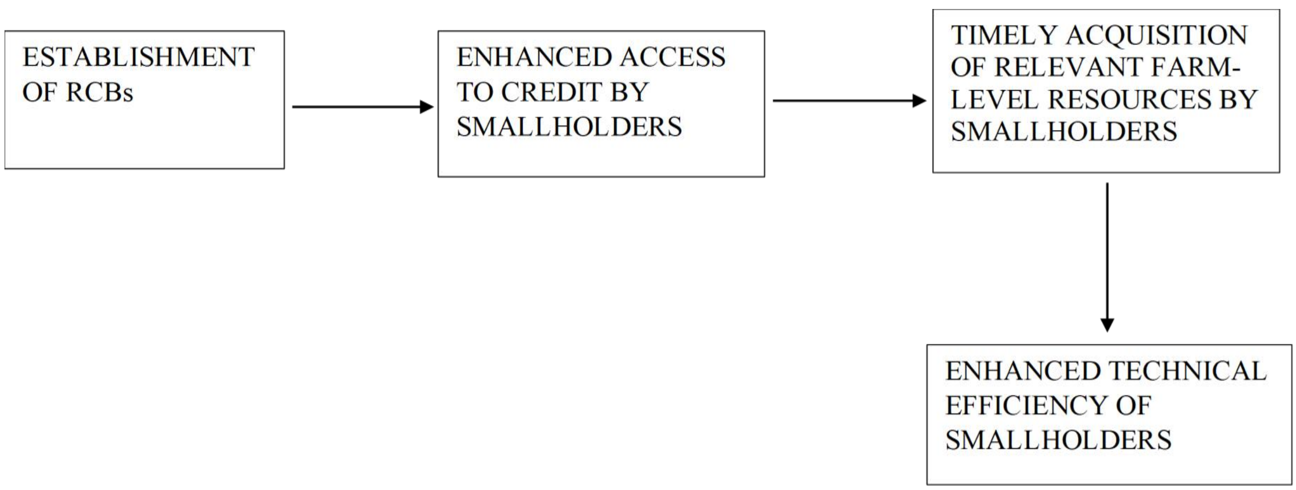

Figure 3: RCB credit intervention's program theory of change

Source: Jones and Rosenberg, (2018)

3.3 Empirical Framework

3.3.1 Assessment of Smallholder Farmer Awareness of RCB Credit Programmes

Farmer awareness was ascertained by asking whether the farmer had had knowledge of any credit facility provided by the RCBs in the district. Thus, farmer awareness was observed as a dummy taking the values 1 if the farmer answered "yes" and 0 if the farmer answered "no". The factors influencing farmer awareness of RCB credit programmes in the district, was investigated with a probit regression. The probit model was employed because of the assumption that the errors are normally distributed (Greene, 2003). Therefore, assuming a latent variable P_i^* determining the value of P_i (that is the likelihood that an individual i will make a certain decision) such that;

$P_i^* = \alpha Z_i + \varepsilon_i;$ with

$$P_i = \begin{cases} 1 & if P_i^* > 0 \\ 0, & if\ P_i^* \leq 0 \end{cases} \quad (3.1)$$

where Z_i represents a vector of exogenous variables; α is a vector of unknown parameters to be estimated; ε is disturbance term and follows a normal distribution. Following the above, the probability that an individual belongs to a group *j* is given by

$$\Pr(P_i = 1|Z_i) =,\ for\ j = 0, 1 \quad (3.2)$$

Following Maddala (1987), the marginal effects in a probit model are calculated as:

$$\frac{\partial P((P_i = 1|Z_i)}{\partial Z_i} = \frac{\partial E((P_i|Z_i)}{\partial Zi} = \varphi(Z_i{}'\beta)\beta \quad (3.3)$$

The dependent variable, in this study, was awareness of RCBs credit programmes. Accordingly, the probit model for assessing the factors influencing farmer awareness of credit programmes provided by RCBs was specified as:

$$Aware_i^* = \beta_0 AGE + \beta_1 GEN + \beta_2 EDUC + \beta_3 HHSZ + \beta_4 EXXT + \beta_5 GRP + \beta_6 OWNER + \beta_7 OUTPUT + \beta_8 DSMKT + \beta_9 OFFINC + \beta_{10} MEDIA + \beta_{11} SAVINGS + \varepsilon_i \quad (3.4)$$

$Aware_i^*$ represents the potential benefits a farmer will derive from being aware of credit programmes provided by RCBs. Table 3.1 presents the variables hypothesized to influence farmer awareness of RCB credit programmes in the district, their units of measurement and expected signs.

Table 3.1: Definition and measurement of variables hypothesized to influence farmer awareness of RCB credit programmes in Fanteakwa district, Ghana

Variable	Definition	Expected Sign
AGE	Age of household head; measured in years	+ or -
GEN	Sex of the household head; dummy with 1=Male; 0=Female	+ or -
EDUC	Education level of cassava farmers; Dummy with 1=At least primary education 0=No formal education	+
HHSZ	Number of individuals under the care of the household head	+ or -
EXXT	Access to extension services (whether there was contact with extension agents during the 2017/2018 farming season; Dummy with 1=Yes 0=No	+
GRP	Membership of household in farmer-based organization; Measured as a dummy with 1=Yes and 0=No	+

Table 3.1 continued

Variable	**Definition and Measurement**	**Expected Sign**
OWNER	Type of land ownership; Measured as a dummy with 1= Owned with title deed, and 0=Otherwise	+
YIELD	Quantity of cassava produced last farming season; measured in kilograms per hectare	+ or -
DSMKT	Physical distance between the nearest market center and the farmers' homestead; measured in kilometers	-
OFFINC	Income generated from off-farm activities; measured in Ghana Cedi	+ or -
MEDIA	Access to media outlets (TV, Radio Mobile phones, Newspapers); Measured as a dummy with 1=Yes and 0=No	+
SAVINGS	Having a savings account with an RCB; measured as a dummy with 1= Yes and 0=No	+

3.3.1.1 Justification of Variables Hypothesized to Influence Farmer Awareness of RCB Credit Programmes

The older a farmer is, the more experienced he may be, and that positively influences the farmer's access to information. However, studies show that younger farmers are more active in searching for information related to their enterprise thus, have a higher likelihood of having knowledge of new and improved agricultural technologies. In view of that, this study hypothesized a mixed relationship between age and farmer awareness of RCB credit programmes.

Several studies have highlighted the role gender plays in the making of decisions with regards to accessing information and taking up new technologies (Adesina *et al*., 2000). In a study by Okello *et al.* (2010) in Kenya, it was found that in Africa, men are relatively less constrained in terms of perception and mobile phones use for market linkage. This study therefore hypothesized that male smallholder cassava farmers would be more aware of RCB programmes than their counterpart female farmers in the study area.

Educational level of the household head was measured as the highest level of formal education attained by the household head. It was therefore coded as a dummy with 0 representing no formal education, and 1 if the household attained at least primary education (1 to 6 years). Muatha *et al*. (2017) found that education significantly improves farmer awareness of agricultural extension in Kenya. Okello *et al*. (2012) also found that the more years of education a farmer has, the easier it is for the farmer to access and understand new technologies. Therefore, this study hypothesized that, farmers who have attained at least primary education would have a higher probability of knowing about RCB credit programmes in the district.

Household size was measured as the number of individuals living under the care of the household head. Rutter and Madge (1976) stated that larger households are poorer compared to their counterpart smaller households, and are therefore not able to afford the tools that can improve their awareness. Other studies have however found household size to play significant role in farmers perception of, and decision to adopt new technologies. For instance, Danso-Abbeam *et al*. (2017) found that household size positively influences farmers' perception and taking up of enhanced maize varieties in Ghana. Based on this, the study hypothesized both positive and negative effect on farmer awareness of RCB credit programmes in the district.

Agricultural extension is a means of increasing the level of information available to farmers with regards to new technologies. The role of extension services includes capacity building for farmers to follow up on their own development agenda (Conley *et al.*, 2010; Owens *et al*. 2003). Based on that, this study hypothesized access to agricultural extension to have a positive effect on farmer awareness of RCB credit programmes.

Farmer-based organizations (FBO) helps to connect farmers to markets thereby helping individual farmers to overcome deficiencies in information flow with regards to consumer preferences and standards (Wollni *et al*., 2009; Danso-Abbeam *et al*., 2017). In a study by Kirui *et al*. (2010), it was found that membership in an FBO has a positive relationship with farmer awareness and use of mobile-banking services agriculture in Kenya. Therefore, this study hypothesized a positive relationship between membership in FBOs and farmer awareness of RCB credit programmes.

According to Smucker *et al*. (2000) farmers make investment decisions based on how they perceive chances of having long-term access to the land. Thus, the perception of stable access to land is a determining factor of farmer awareness and adoption of new technology. This study therefore hypothesized a positive relationship between land ownership and farmer awareness of RCB credit programmes.

Distance to certain social and economic infrastructure has been observed to influence awareness of new technology. A study by Okello *et al.* (2012) revealed that proximity to a market area has a positive effect on awareness and use of ICT tools by farm households. In this study, the variable was observed in terms of the physical distance between the farmer's homestead and the nearest output market. The study hypothesized a negative relationship between distance to the nearest market and farmer awareness of RCB credit programmes. The higher the income from off-farm economic activities, the easier it is for the farmer to afford several sources of information, thereby increasing the chances of knowing about RCB credit programmes. Based on this, the study hypothesized a positive relationship between off-farm income and farmer awareness of RCB credit programmes in the district.

Media was included because it is a major source of information for most households. Having access to media tools such as television, radio, mobile phones, newspapers have been found to significantly increase awareness (Okello *et al*., 2012). Therefore, this study hypothesized that smallholder cassava farmers who have access to the media would have a greater chance of being aware of RCB credit programmes. A savings or checking account increased has been found to increase the borrower's chances of being aware when there is credit available by the banks since most banks have the habit of informing their account holders when there is credit available (Rehman *et al*., 2015). Thus, this study hypothesized a positive effect of owning an active savings account and farmer awareness of RCB credit programmes.

3.3.2 Estimating Smallholder Cassava Farmers' Technical Efficiency

The translog functional form, was employed to specify the cassava production system in the district, after the log-likelihood ratio test was conducted following Kuwornu *et al.* (2013). Following Kymn and Hisnanick (2001), the translog production function was specified as:

$$lnY_k = \beta_0 + \sum_{i=1}^{n} \beta_{ik} \, lnX_{ik} + 0.5 \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ijk} lnX_{ik} lnX_{jk} \quad (3.5)$$

where Y_k is the kth farmer's real output; X_{ik} is the ith factor of production employed by the kth farmer. In this study, five factors of production were considered, i.e., labour, seed, farmland, herbicides and pesticides. Thus, the production function was empirically specified as:

$$lnY_k = \beta_0 + \sum_{i=1}^{5} \beta_{ik}\, lnX_{ik} + 0.5 \sum_{i=1}^{5} \sum_{j=1}^{5} \beta_{ijk} lnX_{ik} lnX_{jk} + (V_{ik} - U_{ik}) \quad (3.6)$$

where Y_i represents the cassava yield of farmer i in kilograms per hectare; X_{ij} represents five inputs used by the *k*th farmer, i.e., labour measured in labour, seed, land, herbicides and pesticides. All the quantities were standardized by dividing each quantity by its respective mean and then log-transformed. The parameters to be estimated are denoted by β_0, β_{ik} and β_{jk}; V_{ik} and U_{ik} are the random noise and inefficiency component respectively. The regressors were defined as follows: X_{1k} was the quantity of labour used by the *k*th farmer; X_{2k} was the quantity of cassava stem cuttings used by farmer *k* measured as the number of cassava stem-cuttings per hectare of farmland. X_{3k} was the quantity of herbicides used by farmer *k* during the 2017/2018 farming season in litres per hectare; X_{4k} was the quantity of pesticides used by farmer *k* during the 2017/2018 farming season in litres per hectare of farm-land, and X_{5k} was hectares of land cultivated by the *k*th farmer during the 2017/2018 production season.

Following Wang and Schmidt (2002), the effects of regressors on technical efficiency can be estimated in a one-step procedure by imposing those variables in the estimation of the technology and the firm's efficiency levels. Thus, the factors influencing farmers' technical inefficiency was captured in the inefficiency model specified as

$$\mu_k = \delta_0 + \sum_{l=1}^{n} \delta_k\, Z_{ik} + \varepsilon_k \quad (3.7)$$

where μ_i is the inefficiency component of the stochastic frontier and Z_{ik} is the vector of the farm-level, socio-economic and institutional factor hypothesized to influence the *k*th farmer's technical inefficiency ($k = 1, 2, \dots, m$), while δ represents a vector of unknown parameters.

Equation (3.6) and (3.7) was estimated in a one-step maximum likelihood estimation procedure that allows the for the joint estimation of the translog production function and the determinants of inefficiency. The parameter estimates of the translog are primarily interpreted as output elasticities of respective inputs (Kymn & Hisnanick, 2001). These elasticities are calculated as (Kymn & Hisnanick, 2001):

$$\frac{\partial lnE(Y_k)}{\partial lnX_{ji}} = \left(\beta_i + \beta_{ii} lnX_{ji} + \sum_{j=i} \beta_{ij} lnX_{ji}\right) \quad (3.8)$$

However, when the variables are normalized by dividing them by their averages respectively, the first order coefficients can be explicated as the elasticities (Mutoko *et al.*, 2008). The sum of the elasticities gives the returns to scale or the function coefficient or the total output elasticity, which captures how responsive output is to changes in inputs (Mutoko *et al.*, 2008). In this study, the variables were normalized, therefore, the first order coefficients were interpreted as elasticities. Returns to scale were, afterwards, calculated from those elasticities.

(a) The Technical Inefficiency Model

Empirically, equation (3.7) was specified as:

$$\mu_k = \delta_0 + \delta_1 GEN + \delta_2 GRP + \delta_3 EXXT + \delta_4 FARMLOC + \delta_5 OWNER + \delta_6 EDUC + \delta_7 DSHS\_1 + \delta_8 EXP_N + \varepsilon \quad (3.9)$$

μ_k is the inefficiency component of the stochastic frontier model. he other variables and their hypothesized signs are presented in Table 3.2, and explained in section 3.2.2.1

Table 3.2 Description of variables hypothesized to influence technical inefficiency of smallholder cassava farmers, and their hypothesized signs

Variable	Description	Expected Sign
GEN	Sex of the household head; Dummy with 1=Male 0=Female	-
GRP	Membership in Farmer-based Organization; Dummy with 1=Yes 0=No	-
EXXT	Access to extension services (whether there was contact with extension agents during the 2017/2018 farming season; Dummy with 1=Yes 0=No	-
FARMLOC	Community in which farmland is located; Categorical with 1=Ahomahomasu 2=Obuoho 3=Begoro 4=Feyiase 5=Akoradarko (Reference community=Obuoho)	+/-
OWNER	Type of land ownership; Measured as a dummy with 1= Owned with title deed, and 0=Otherwise	-
EDUC	Education level of cassava farmers; Dummy with 1=At least primary education 0=No formal education	-
DSHS_1	Distance between farmer's homestead and farmland; measured in kilometres	+
EXP_N	Number of years of cassava cultivation; measured in number of years	-

3.3.2.1 Justification for Inclusion of Regressors in the Technical Inefficiency Model

Incorporating education, access to extension, and experience in cassava farming, was based on the findings of previous studies (Bempomaa & Acquah, 2014; Abdallah, 2016; Ayerh, 2015; Al-hassan, 2008). These studies found a negative relationship between the factors and technical inefficiency. This study hypothesized education, extension access, and experience to negatively influence technical inefficiency of cassava farmers in the district.

Ownership of land allows farmers to make certain farm investments which may enhance their technical efficiency. However, Sitko *et al.* (2014) found that the productivity of land title holders was no different from that of non-title holders in Zambia. Al-hassan (2008) also found the effect of land ownership on technical efficiency of smallholder paddy farmers in Ghana to be statistically insignificant. Based on these findings, this study hypothesized a negative relationship between land ownership and technical inefficiency of cassava farmers in Ghana. Location of the farm was included in the model, based on the findings of Kuwornu *et al*. (2013) that, differences in zones (locations) may lead to differences in management practices or climatic factors, thus influences the inefficiency of maize farmers in Ghana.

3.3.2.2 Hypotheses Tests

The generalized likelihood ratio test was employed in testing the following hypotheses

1. $H_0: \beta_{jk} = 0$; the appropriate functional form is the Cobb-Douglas production function
2. $H_0: \gamma = \delta_1 = \delta_2 ... = \delta_k = 0$; Inefficiencies are absent at every level

The test statistic is calculated as:

$$LR = -2\left[ln\left(\frac{H_0}{H_1}\right)\right] = -2[lnH_0 - lnH_1] \quad (3.10)$$

Where lnH_0 and lnH_1 are the log-likelihood values for the null and alternative hypothesis respectively. The results of the test are presented in Table 3.3.

Table 3.3: Stochastic frontier hypotheses validation

Null Hypothesis	Likelihood ratio	Critical value	Decision
$\boldsymbol{H_0: \beta_{jk} = 0}$	98.26	28.49	Reject H_0
$\boldsymbol{H_0: \gamma = \delta_1 = \delta_2 \ldots = \delta_k = 0}$	147.39	36.94	Reject H_0

Critical values were obtained from table 1 of Kodde and Palm, (1986)

Source: Survey data (2019)

3.3.3 Assessment of Impact of RCB Credit Access on Cassava Farmers' Technical Efficiency

The main focus of this study was to investigate how RCB credit access impacts technical efficiency. The ESR model was employed in achieving the objective. The model has the capability to address the issue of selection bias which is a major issue in impact evaluation models (Maddala, 1986). It does it by estimating actual and counterfactual outcomes through conditional means whiles controlling for both observed and unobserved heterogeneities (Ngoma, 2018). The estimation procedure involves two steps. The first step uses a probit model to estimate the determinants of farmers' decision to access credit from RCB. The second step involves estimating the factors influencing the technical efficiencies for accessors of RCB credit and then for non-accessors.

Following Sebopetji and Belete (2009), we define a latent variable P_i^*, which observes the benefits of accessing credit from RCBs as:

$$P_i^* = \pi Z_i + \omega_i; \tag{3.11}$$

with $$P_i = \begin{cases} 1 & if\ P_i^* > 0 \\ 0, & if\ P_i^* \leq 0 \end{cases} \tag{3.12}$$

where P_i^* is a latent variable capturing the potential benefits of accessing RCB credit; Z_i is an $n\ x\ j$ matrix of household and farm- level characteristics that influences a household's decision to access credit from RCB and π is a $j\ x\ 1$ vector of parameters to be estimated; ω_i is a $n\ x\ 1$ vector of normally distributed error terms.

The outcome equation is estimated separately for each regime of credit access as specified below

$TE_1 = X_1\theta_1 + \varepsilon_1, \quad if\ \ P_i = 1$, i.e., farmers access RCB credit (3.13)

and

$TE_0 = X_0\theta_0 + \varepsilon_0, \quad if\ \ P_i = 0$, otherwise (3.14)

where TE_1 and TE_0 are the technical efficiency scores for cassava farmers that take RCB credit and those who do not, respectively; X_1 and X_0 are $n\ x\ k$ matrices of covariates, β_i and β_0 are parameters to be estimated and ε_1 and ε_0 are $n\ x\ 1$ vectors of random error terms with a zero mean and a non-zero covariance matrix

$$cov(\varepsilon, \varepsilon_1, \varepsilon_0) = \begin{bmatrix} \sigma_\varepsilon^2 & \sigma_{\varepsilon\varepsilon_1} & \sigma_{\varepsilon\varepsilon_0} \\ \sigma_{\varepsilon_1\varepsilon} & \sigma_{\varepsilon_1}^2 & \sigma_{\varepsilon_1\varepsilon_0} \\ \sigma_{\varepsilon_0\varepsilon} & \sigma_{\varepsilon_0\varepsilon_1} & \sigma_{\varepsilon_0}^2 \end{bmatrix} \tag{3.15}$$

According to Maddala (1986), the non-zero covariance may result from the presence of some unobservable characteristics that influence both the access credit decision as well as the technical efficiency. The expected errors of the outcome variable (that is technical efficiency) conditional on credit access decision are thereby given as (Ngoma, 2018; Maddala 1986):

$$E(\varepsilon_1|P_i = 1) = E(\varepsilon_1|\omega > -\pi Z_i) = \sigma_{\varepsilon_1\varepsilon}\left[\frac{\theta(Z_i\alpha|\sigma)}{\varphi(Z_i\alpha|\sigma)}\right] = \sigma_{\varepsilon_1\omega}\lambda_1 \tag{3.16}$$

$$E(\varepsilon_0|P_i = 0) = E(\varepsilon_0|\omega \leq -\pi Z_i) = \sigma_{\varepsilon_0\varepsilon}\left[\frac{-\theta(Z_i\alpha|\sigma)}{1-\varphi(Z_i\alpha|\sigma)}\right] = \sigma_{\varepsilon_0\omega}\lambda_0 \tag{3.17}$$

where φ and θ represent the cumulative density function (CDF) and the probability density function (PDF) respectively; λ_1 and λ_0 represent the ratio of θ and φ estimated at αZ_i and is called the inverse mills ratio (IMR) (Lokshin & Sajaia, 2004). It provides the correlation between credit access and efficiency and is incorporated in the outcome equations to control for selection bias. Thus, the outcome equations are re-specified as

$$TE_1 = X_1\theta_1 + \sigma_{\varepsilon_1\varepsilon}\lambda_1 + \mu_1\,,\ for\ \ P_i = 1 \qquad (3.18)$$

and

$$TE_0 = X_0\theta_0 + \sigma_{\varepsilon_0\varepsilon}\lambda_0 + \mu_0, \qquad for\ \ P_i = 0 \qquad (3.19)$$

3.3.3.1 Specification of Actual and Counterfactual Outcomes

The expected technical efficiency scores of farmers who accessed RCB credit are the actual outcomes, while the expected technical efficiency score of farmers who accessed RCB credit would have been had they not accessed, is the counterfactual outcome (Ngoma, 2018). Given this state of affairs, there are four possible conditional expectations for different combinations of actual and counterfactual outcomes:

$$E(TE_1|P_i = 1) = X_1\theta_1 + \sigma_{\varepsilon_1\varepsilon}\lambda_1 \qquad (3.20)$$

$$E(TE_0|P_i = 0) = X_0\theta_0 + \sigma_{\varepsilon_0\varepsilon}\lambda_0 \qquad (3.21)$$

$$E(TE_0|P_i = 1) = X_1\theta_0 + \sigma_{\varepsilon_0\varepsilon}\lambda_1 \qquad (3.22)$$

$$E(TE_1|P_i = 0) = X_0\theta_1 + \sigma_{\varepsilon_1\varepsilon}\lambda_1 \qquad (3.23)$$

Equations (3.20) and (3.21) are the expected outcomes (technical efficiency scores) for accessors and non-accessors of RCB credit respectively. Equation (3.22) is the expected technical efficiency of non-accessors had they accessed the credit (i.e., counterfactual for credit non-accessors), and equation (3.23) is the expected technical efficiency of accessors had they not accessed the credit (i.e., counterfactual for credit accessors).

The average treatment effect on the treated (ATT) measures the difference between the actual outcome for RCB credit accessors and the counterfactual outcome for RCB credit non-accessors (that is, equation (3.20) minus equation (3.21)). The ATT measures the difference between the technical efficiency of credit accessors and the technical efficiency of credit non-accessors had they accessed it. It captures the effect of RCB credit access on technical efficiency of cassava farmers that actually accessed it (Di Falco *et al.,* 2011). Thus,

$$ATT = E(TE_1|P_i = 1) - E(TE_0|P_i = 1) \quad (3.24)$$

On the other hand, the average treatment effect on the untreated (ATU) is the difference between the expected outcome for credit non-accessors and the counterfactual outcome for accessors (i.e., equation (3.23) minus equation (3.22)) (Di Falco *et al.*, 2011). This gives the difference between the technical efficiency of RCB credit accessors had they not accessed it and the technical efficiency of credit non-accessors for actually not accessing:

$$ATU = E(TE_1|P_i = 0) - E(TE_0|P_i = 0) \quad (3.25)$$

Another parameter is the average treatment effect (ATE) which measures the difference between the actual outcomes. That is, the difference between the technical efficiency of farmers who accessed credit from RCB and the technical efficiency of farmers who did not access credit from RCB and is specified as (Di Falco *et al.*, 2011):

$$ATE = E(TE_1|P_i = 1) - E(TE_0|P_i = 0) \quad (3.26)$$

However, the ATE is not enough to conclude on the impact of access to RCB credit on technical efficiency of smallholder cassava farmers since ATE does not include the counterfactual scenarios. Thus, the transitional heterogeneity (base heterogeneity effect) was estimated. This is the difference between the ATT and the ATU (Ngoma, 2018; Di Falco *et al*., 2011). That is,

$$TH = ATT - ATU$$

$$= E(D_1|P_i = 1) - E(D_0|P_i = 1) - \{ E(D_1|P_i = 0) - E(D_0|P_i = 0)\} \quad (3.27)$$

3.3.3.2 Empirical Specification

Equation (3.28) presents the empirical specification of the probit model for assessing the factors influencing smallholder cassava farmers' decision to access RCB credit. Equation (3.29) presents the empirical model for assessing the determinants of farmers' technical efficiency in the second stage of the ESR.

Stage 1:

$$ACC_i = \pi_0 + \pi_1 GEN + \pi_2 GRP + \pi_3 EXXT + \pi_4 OFFINC + \pi_5 OWNER + \pi_6 AGE + \pi_7 FARMLOC + \pi_8 FRMSYZ + \pi_9\, SAVINGS + \pi_{10} EDUC + \pi_{11} HHS + \pi_{12} DSBANK + \omega_i \quad (3.28)$$

Stage 2:

$$TE = \theta_0 + \theta_1 GEN + \theta_2 GRP + \theta_3 EXXT + \theta_4 OFFINC + \theta_5 OWNER + \varepsilon \quad (3.29)$$

Equations (3.28) and (3.29) were jointly estimated using the procedure proposed by Lokshin and Sajaia (2004). The description of regressors and their measurements are presented in Table (3.4).

Table 3.4 Description of variables in the ESR and their expected signs

Variable	Description and Measurement	Expected Sign	
		Stage 1	**Stage 2**
GEN	Sex of the household head; Dummy with 1=male, 0 =female	+	+
GRP	Membership in an FBO; Dummy with 1= Yes, 0=No	+	+
EXXT	Extension Visits; Dummy with 1= at least one Extension visits during last farming season, 0=No extension visits during last farming season	+/-	+
OFFINC	Income from off-farm economic activities	+	-
OWNER	Land ownership; Dummy with 1= Owned, 0= otherwise	+	+
AGE	Age of the household head (measured in years)	+	
FARMLOC	Community in which farmland is located; Dummy with 1=Begoro 0=Otherwise	+	
FS	Size of productive farmland (measured in hectares)	+	
SAVINGS	Having an active savings account with the RCB; Dummy with 1=Yes, 0=No	+	
EDUC	The education level of the household head (Number of years in formal education)	+	
HHSZ	Household Size of the farmer (Measured by the number of persons living in the same house under the care of the household head)	-	
DSBANK	Physical distance between the farmer’s homestead and the RCB (Measured in kilometres)	-	

3.3.3.3 Justification for Inclusion of Regressors in the ESR model

Akudugu (2012) found that male household heads have a higher probability of accessing micro-credit in Northern Ghana. This study hypothesized that gender would positively affect smallholder cassava farmers' decision to access RCB credit as well as on technical efficiency of the farmers.

Membership in a group has been found to be a requirement for individuals who want to borrow from formal sources (Lukytawati, 2009). Most financial institutions in Ghana rely on social groups to provide some form of social collateral for farmers (Akudugu, 2012). The expectation of this study was that membership in a farmer-based group would positively affect both farmers' decision to access RCB credit, and their technical efficiency.

Agricultural extension agents in most developing countries are a primary source of information for smallholder farmers. Akpan *et al.* (2013) however found a negative relationship between extension access and farmers' decision to access micro-credit. This study therefore hypothesized both a negative and positive relationship between extension access and smallholder cassava farmers' decision to access RCB credit. It was however, expected to have a positive effect on the technical efficiency of cassava farmers.

Income diversification has been found to provide a means for farmers to increase their farm investments (Kilic *et al*., 2009; Oseni & Winter, 2009). A regular inflow of income from off-farm activities can also be used as collateral (Hert, 2009). Therefore, this study hypothesized that off-farm income would positively influence smallholder cassava farmers' decision to access RCB credit. It was also expected to have negative influence on the technical efficiency of the cassava farmers because engagement in other activities outside the farm require time resources which may affect the output of the farm. Land ownership was also hypothesized to positively influence farmers' decision to access RCB credit. This is because farmers who own their lands have the rights over the land. They could therefore put the land up as collateral for the credit (Brasselle *et al*., 2005).

Age of household head was employed as a proxy for experience and the farmers' maturity and capability to efficiently use the credit and repay (Akudugu *et al*., 2009; Nguyen 2007). Based on this, the study hypothesized a negative relationship age of household head and RCB credit access.

The inclusion of size of farmland as a determining factor in farmers' decision to access RCB credit was because the potential income of the farmer can be estimated from it. Thus, the larger farmland has the potential for a higher income. Farmers will therefore be willing to access credit (Akpan *et al*., 2013; Akudugu, 2012; Nguyen, 2007;). Also, the inclusion of savings was based on the fact that, it could be used as a proxy to the wealth and financial literacy of the farmer (Baiyegunhi & Fraser, 2014; Akudugu, 2012). Thus, it was expected that smallholder cassava farmers who have savings account with RCB would have a higher likelihood of accessing RCB credit.

Formal education has been found to influence farmers' decision to access credit. For instance, Ayamga *et al*. (2006) found education to be a significant factor affecting rural households' decision to access micro-credit in Northern Ghana. Therefore, this study hypothesized a positive relationship between formal education and decision of smallholder cassava farmers to access RCB credit. Distance between RCB and the farmer's homestead, was hypothesized to have a negative effect on farmers' decision to access RCB credit. That is, farmers who stay farther from the banks will be less motivated to access RCB credit. This is because farmers who stay farther from the banks may have to incur higher transactions cost and therefore may deter them from accessing.

3.4 Diagnostic Tests

3.4.1 Multicollinearity

The existence of an exact relationship between at least two regressors in a model leads to multicollinearity. This phenomenon results to inflated variance of the estimated coefficients. This means that the estimates become very responsive to minor changes in the model (Gujarati, 2007). To test for multicollinearity, a Pearson correlation test was conducted. Each pair of explanatory variables showed a correlation coefficient of less than 0.40 (see Appendix II). According to Alin (2010), absolute correlation coefficients of less than 0.40 shows weak correlation.

3.4.2 Heteroscedasticity

Heteroscedasticity is a common problem with cross-sectional data. The presence of heteroscedasticity makes parameter estimates inefficient although the parameters may be unbiased and consistent making the OLS estimators no longer Best Linear Unbiased Estimator (BLUE) (Wooldridge, 2010). In this study, the Breusch-Pagan-Godfrey (BPG) test was employed to test the null hypothesis of no heteroscedasticity. The test failed to rejected the null hypothesis at 1 percent significance level implying that the error term had a constant variance. This test was important as stochastic frontier model is based on the distribution of errors.

3.5 Sampling

3.5.1 Sample Size Determination

Yamane (1967) (as cited in Singh et al., 2014) suggested the following formula for calculating the sample size from a known population:

$$n = \frac{N}{1+N(e)^2} \tag{3.30}$$

where n denotes the sample size; N represents the size of the population; and e is the degree of precision. Now given the population size of the district as 121879 (GSS, 2013), the required sample size for the study was calculated as

$$n = \frac{121879}{1 + 121879 * (0.05)^2}$$

$$n = \frac{121879}{305.698}$$

$$n = 398.691 \approx 399 \tag{3.31}$$

Thus, the sample size for the study was 399 respondents. However, the study settled for 300 due to missing or incomplete data.

3.5.2 Sample Selection

The multistage sampling technique was employed to get the respondents for the study. The first stage of the technique involved the purposive selection of five communities in Fanteakwa District that are primarily involved in cassava production, following information obtained from the district assembly. In the second stage, a list of smallholder cassava farmers was obtained from each of the five cassava-producing communities selected in the first stage. In the third stage, a simple random sampling was done using Microsoft Excel application. Random numbers were assigned to each cassava farmer on the list and the first 60 cassava farmers in each of the five communities were selected for the interview making a total of 300 smallholder cassava farmers for the whole sample.

3.6 Data Collection

A semi-structured questionnaire was used to collect data on the household and farm characteristics from the 300 selected smallholder cassava farmers. The survey captured data from the 2017/2018 farming season. Five extension officers were trained and used as enumerators. A pre-test was then carried out in each of the five selected communities (6 respondents from each community). This activity was done to ensure that the questionnaire was capable of generating the needed data for the study. Overall, the questionnaire required on average, 45minutes to complete.

3.7 Data Management and Analysis

The data was captured using open data kit (ODK) software. The data was then cleaned and prepared for analysis using SPSS version 22. In analyzing the data, descriptive statistics were obtained using SPSS version 22, and STATA version 15 for estimation of the models.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Respondents' Socio-demographic Profiles

4.1.1 Household Characteristics

About 51.3% of the farmers were aware of RCB credit program in their locale; the rest did not. Table 4.1 presents the distribution of cassava farmers in Fanteakwa district based on some key variables.

Table 4.1 Socio-demographic characteristics of farmers based on awareness of RCB credit programmes

Variable	Aware (n=154)	Not Aware (n=146)	Total (n=300)
Gender			
Male	114	103	217
Female	40	43	83
Education			
None	46	51	97
At least primary	108	95	203
Extension contact			
Yes	88	61	149
No	66	85	151
FBO membership			
Member	60	35	95
Non-member	94	111	205

Source: Survey data (2019)

Table 4.1 continued

Variables	Aware (n=154)	Not Aware (n=146)	Total (n=300)
Land tenure system			
Stool land	2	11	13
Family Land	49	32	81
Rented	55	45	100
Share cropping	48	58	106

Source: Survey data (2019)

Approximately 72.3 percent of the farmers were male, suggesting that cassava farming in the district is primarily done by males. This finding supports that of Donkoh *et al*. (2013) that male involvement in agriculture in Northern Ghana, to be around 70 percent and 30 percent for women. A majority of males (52.5 percent) were aware of the RCB credit programmes. Most (51.8 percent) of female farmers were not aware of any RCB credit programmes. This level of awareness among female farmers could be accounted for by the fact that women take up many responsibilities in the household. Also, the lack of ownership of assets influence their access to information.

As shown in Table 4.1, the average age of cassava farmers were 45 years (range = 21-76). About 51 percent of the farmers were aged below the mean age. This age distribution suggests that cassava cultivation is undertaken mainly by the youth. Abdul-Kareem and Sahinli (2018) also found the mean age of cassava farmers in the Savannah Zone of Northern Ghana to be 42 years. The mean age of those who were aware of the RCB credit programmes was 45 years while that for those who were not aware was 42 years. The two means were statistically different ($p<0.05$), suggesting that more older farmers than younger ones were aware than younger ones, of the existence of RCB credit programmes in the district.

Approximately 67 percent of the farmers, had some form of formal education with the rest having no formal education. According to Al-hassan (2008), some level of formal education is required for farmers to enable them use any modern agricultural technologies. Most (approximately 53 percent) of the educated farmers knew about the RCB credit programmes compared to only 47 percent of the non-educated. This suggests that majority of cassava farmers in Fanteakwa have attained at least some level of formal education. In terms of experience in cassava cultivation, which was measured by the number of years a farmer had grown cassava prior to the survey, the average number of years was 12 years. Farmers who were aware of the RCB credit programme had significantly more cassava growing experience than their counterparts with 8 years ($p<0.05$).

The mean household size was found to be 5 individuals. Only about 38 percent of the total sample had more than the mean household size. Statistically, mean household size of households which were aware of RCB credit programmes was no different from that of those who were not ($p<0.05$). This connotes that on average, farmers who were aware of RCB credit programmes had the same household size as their counterparts who were not aware.

4.1.2 Farm Characteristics

Literature stresses the influence tenure of land has on agricultural productivity (Bugri, 2008). Approximately 35 percent of the farmers were practicing share cropping while 33.3 percent rented land. Of those who share-cropped, 48 percent were aware of RCB credit programmes. In addition, out of the ones who rented, 55 percent were aware of RCB credit programmes. The average distance of households from their farms was 2.57km. A greater percentage (61.7 percent), lived within 6 kilometres from their farms. This suggests that majority of farmers travelled some distance to get to their farms. There was no significant difference between farmers who were aware of RCB credit programmes and their counterparts who were not ($p<0.05$).

On average, cassava farmers in Fanteakwa district cultivated farmlands of size 3.64 acres. About 32.67 percent of the farmers cultivated farmlands of sizes between 1 and 3 acres. Majority (47 percent) cultivated lands of sizes between 4 and 6 acres. About 18 percent of the total respondents cultivated farmlands whose sizes range from 7–9 acres. Only 2.33 percent cultivated 10 or more acres of farmland in the district. Average size of farmland did not differ statistically between farmers who were aware of RCB credit programmes and their counterparts.

4.1.3 Institutional Factors

Access to agricultural extension is a means by which farmers get information on more innovative and improved agricultural practices which helps to enhance farm productivity (Donkoh *et al*., 2013). As can be observed from Table 4.1, 149 had access to extension agents during the 2017/2018 farming season. Of these, 96 farmers had 1 to 10 contacts with the extension agents during the 2017/2018 farming season. Strangely, one farmer had made more than 30 contacts. The average number of contacts with extension agent was 9 contacts. This number was significantly different between those who were aware of RCB programmes and those who were not. According to Addai *et al*. (2014), farmer-based organizations (FBOs) enable farmers to easily access information on improved technology and sometimes act as technology dissemination channels. In this study, only 31.7 percent of the cassava farmers belonged to farmer organizations. This finding corroborates the findings of Martey *et al*. (2015) who also found the majority of farmers in Northern Ghana to be non-members of FBOs.

4.2. Factors Influencing Farmer Awareness of RCB Credit Programmes

Table 4.2 presents the estimated parameters of the probit model. The likelihood ratio chi-square statistic of 37.42 with p-value of 0.0004 shows that the model fitted the data well. The results show that seven out of ten regressors included in the model, namely, age, household size, extension access, membership in a FBOs, land ownership, distance to market, and savings with the bank, had a significant influence.

Table 4.2: Determinants of smallholder cassava farmers' awareness of RCB credit programmes

Variable	Marginal Effect	t-value
Age	0.06 (0.03)	1.79*
Gender (1=Male)	0.05 (0.08)	0.62
Household size	-0.04 (0.02)	-2.15**
Marital Status (1=Married)	0.09 (0.7)	1.14

Source: Survey data (2019)

*****, **, *** represent significance at 1%, 5% and 10% respectively. Standard errors are in parenthesis.

Table 4.2 continued

Variable	Marginal Effect	t-value
Education	0.001 (0.01)	0.10
Extension access (1=Yes)	0.15 (0.07)	2.29**
Membership in FBO (1=Yes)	0.12 (0.07)	1.79*
Land ownership (1=Owned)	0.13 (0.07)	1.82*
Cassava yield	-0.004 (0.04)	-0.13
Off-farm Income	0.04 (0.03)	1.10
Savings	0.13 (0.07)	1.87*
Distance to market	-0.01 (0.00)	-2.84***
Media	0.03 (0.04)	0.82
Constant		-2.22**
Goodness-of-fit measures		
LR Chi2 (10)	37.42	
Prob>Chi2	0.00***	
Log-Likelihood	-189.13	

Source: Survey data (2019)

*****, **, *** represent significance at 1%, 5% and 10% respectively. Standard errors in parenthesis.

Age had a statistically significant positive effect on the farmers' farmer awareness of RCB credit programme in Fanteakwa District of Ghana ($p<0.1$). Accordingly, what it implies is that as a farmer gets older his chances of becoming more inclined and knowledgeable of RCB credit programmes rises by 6 percent. The finding confirms that of Tang *et al*. (2013) who found that age is a significant determinant of awareness of water scarcity among farmers in China. Household size, however, showed a negative effect on farmer awareness of RCB credit. This contradicts the *a priori* expectation of a positive relationship ($p<0.05$). Accordingly, what it means is that a percentage increase in household size reduces the probability of a farmer being aware of RCB credit programmes by 4 percent. Thus, households with larger household sizes are less chances to be aware of credit programmes provided by RCBs in Fanteakwa district. This finding could be explained by the fact that households with large family sizes are poorer compared to smaller households (Rutter & Madge, 1976). Therefore, they may not be able to afford tools like television, radio, mobile phones that could increase their awareness of RCB credit programmes.

As expected *a priori*, access to extension services had a positive and significant effect on the likelihood of a farmer being aware of RCB credit programmes ($p<0.05$). This finding can be explained by the fact that farmers' contact with extension agents may have informed them about RCB credit facilities. Accordingly, access to extension would increase the probability of awareness by 15 percent. Muatha *et al*. (2017) found that farmers' access to extension improved their chances of being the aware of agricultural extension devolution in Kenya.

Distance to market had a significant negative effect on the likelihood of a farmer being aware of RCB credit facilities in the district as expected *a priori* ($p<0.01$). This could be explained by the fact that the market place is where diffusion of information takes place. Therefore, farmers who stay farther away from market areas may not be exposed to such information in time. The marginal effect of -0.03 suggests that a percentage increase in the distance between the farmer's homestead and the market would reduce the likelihood of the farmer being aware of the RCB credit facility by 3 percent. Simtowe *et al*. (2016) found that farmers who stayed farther from the nearest main markets were less exposed to new pigeon pea varieties. It can also be seen from Table 4.2 that membership in FBO met the *a priori* expectation of a positive relationship with farmer awareness of RCB credit programmes ($p<0.1$). The implication is that, farmers who belong to an FBO are more likely to be aware of RCB credit programmes. Thus, becoming a member of farmer group increases the farmer's likelihood of being aware of RCB credit programmes by 12%. This finding is consistent with that of Wawire (2013) who found that membership in a social group improves farmers' chances of being aware of Kenya Agricultural Commodity Exchange Services (KACE).

As expected *a priori*, land ownership had a positive and significant effect on the likelihood of a farmer being aware of RCB credit programmes ($p<0.1$). Certainty of ownership serves as motivation for farmers to undertake long-term farm investments. Accordingly, the probability of a farmer being aware of RCB credit programmes will increase by 13 percent. This finding is consistent with those of Muatha *et al.* (2017) who found that ownership of the farm with title deed increases farmers' likelihood of knowing about extension devolution in Kenya. Savings with the bank also had a significant positive on farmer awareness of RCB credit programmes, as expected *a priori* ($p<0.1$). This suggests that farmers who have active savings accounts with RCBs are more 13 percent more likely to be aware of RCB credit programmes. This may be explained by the fact that, savings is a good financial practice for farmers with low incomes. And people who save are regarded as being financially sound. They mare therefore be the first to be contacted by the banks when there is any available credit facility.

4.3 Technical Efficiency of Cassava Farmers

4.3.1 Summary Statistics

As indicated in Equation 3.6, five inputs namely; labour, seed, land, herbicides and pesticides, were regressed against the quantity of cassava produced by each farmer. Table 4.3 presents a summary of the quantity of cassava output realized as well as the quantities of inputs used by each of the 300 households during the 2017/2018 cassava growing season.

On average, each farmer realized 2,013.284kg/ha of cassava (range=364-32760) during the 2017/2018 production season.

Table 4.3. Summary statistics of cassava yield and quantity of inputs used by smallholder farmers

Variable	Units	Mean	Minimum	Maximum	Std. Dev.
Yield	Kg/ha	2013.3	364.0	32760	2946.4
Labour	Manhours/ha	61.4	12.8	153.6	28.2
Seed	Stem-cuttings/ha	149.0	40	440.0	95.0
Farmland	Hectare (ha)	1.5	0.4	8.4	1.1
Herbicides	Litres/Ha	4.7	1.0	15.0	1.9
Pesticides	Litres/Ha	5.3	1.0	50.0	4.3

Source**:** Survey data, (2019)

4.3.2 Results of Estimation of the Stochastic Frontier

Fitting equation (3.6) into the data produced a log-likelihood value of -192.5 and a likelihood ratio chi-square value of 215.31 at 20 degrees of freedom, which was statistically significant at the 1 percent level (Table 4.4). This shows that the model fitted the data well. The value of lambda, which is the ratio of the standard error of the inefficiency component, U_i,and the standard error of the stochastic term, V_i, was significantly different from zero at 1 percent significance level implying that the model fitted the data well and that the distributional assumptions were correctly specified.

As shown in Table 4.4, all main variables (labor, seed, land, herbicides and pesticides) were statistically significant and had the expected positive signs, implying that as the quantities of the inputs increased, the output also increased, which is consistent with the theory of production (Simar & Wilson, 2007). Accordingly, a 1 percent increase in the quantity of labor, seed, farmland, herbicides and pesticides would increase cassava output by 34, 27, 53, 33, and 14 percent respectively. The variables were significant at 1 percent significance level except for pesticides which was significant at 10% significance level. Farmland had the greatest contribution to cassava output and this could be due to the high fertility of the soil. This finding is in likeness to that of Nyagaka *et al*. (2010) who found land to be the highest contributor to Irish potato output in Nyandarua North Sub-County of Kenya.

Table 4.4. Maximum likelihood estimates of the translog production function

Variable	Coefficient	Std. Err.	t-value
Pesticides	0.15	0.08	1.91*
Herbicides	0.31	0.11	2.78***
Labour	0.29	0.09	3.16***
Farm	0.51	0.07	7.34***
Seed	0.24	0.07	3.27***
$Labour^2$	0.96	0.25	3.82***
$Seed^2$	0.08	0.15	0.52
$Farm^2$	-0.02	0.12	-0.17
$Pest^2$	-0.09	0.12	-0.69
$Herb^2$	1.12	0.26	4.25***
SeedxLabour	-0.51	0.23	-2.23**
FarmxLabour	-0.11	0.23	-0.46
FarmxSeed	0.28	0.16	1.81*
SeedxPesticides	0.59	0.22	2.64***
PestxLabour	1.13	0.30	3.77***

Source: Survey data (2019)

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

Table 4.4 continued

Variable	Coefficient	Std. Err.	t-value
PesticidesxFarm	0.02	0.22	0.11
HerbicidexLabour	-0.56	0.38	-1.48
HerbicidexFarm	0.04	0.26	0.15
HerbicidexSeed	-0.52	0.27	-1.88*
HerbicidexPesticide	-0.29	0.33	-0.87
Constant	1.05	0.11	9.24***
Lambda	0.50	0.10	5.08***

Source: Survey data (2019)

*, *** represent 10% and 1% significance levels respectively

The coefficients of the squared terms of the inputs represent the second order derivatives. A positive coefficient of the squared term suggests that output would increase with additional units of the variable and vice versa holding all other inputs constant (Mutoko *et al.,* 2008). Thus, the coefficients of labour squared ($Labour^2 = 0.95$) and herbicides squared ($Herb^2=1.12$), were positive and statistically significant suggesting that output would continue to increase with increases in the quantities of labour and herbicides respectively. Mutoko *et al*. (2008) had similar results in Kenya where he found the square of labour to be positive and significant for smallholder maize farmers.

The coefficient of the interaction indicates whether the interacted inputs are complements or substitute to each other (Asante *et al*., 2019; Mutoko *et al*., 2008). For instance, the interaction between seed and pesticides produced a positive effect at 1 percent significance level suggesting that seed and pesticides are complements. This finding can be explained by the fact that pesticides are used during seed dressing to protect seeds against pests and fungal diseases (Zaller *et al*., 2016). The interaction between pesticides and labour also produced a positive effect which implies that labour and pesticides are complements. This is also explained by the fact that labour is required during the application of pesticides. Seed and labour, however, had a negative effect on cassava output implying that the two variables are substitutes. Mutoko *et al*. (2008) also found seed and labour to be substitutes amongst smallholder maize farmers in Kenya.

4.3.3 Output Elasticities and Returns-to-Scale

The returns-to-scale was estimated by summing up the elasticities (Ayerh, 2015). As shown in Table 4.5, farmland, labor and herbicides had the highest output elasticity. This suggests that farmland had the highest contribution to cassava output followed by herbicides and labour. The returns-to-scale of 1.61 suggests that, *ceteris paribus*, doubling the amount of inputs used would more than double the cassava output realized. This means that cassava farmers in Fanteakwa district are in the first stage of the production function. This result supports the findings of Adeleke *et al*. (2008) and Ayerh, (2015).

Table 4.5: Output elasticities and returns to scale of cassava farmers

Variable	Output elasticity	Std. Err.	t-value
Labour	0.29	0.09	3.16***
Farmland	0.51	0.07	7.34***
Seed (Stem cuttings)	0.24	0.07	3.27***
Herbicide	0.31	0.11	2.78***
Pesticide	0.15	0.08	1.91*
Returns-to-scale	**1.61**		

Source: Survey data (2019)

* and *** represent 10% and 1% significance levels respectively.

The concavity condition of a production function requires that the second order derivatives of the production function with respect to the inputs, are negative. This implies that there should be diminishing marginal productivity of the inputs (Sauer *et al*., 2006). In this study, the condition is fulfilled for farmland and pesticides although the coefficients were insignificant (Table 4.6).

Table 4.6: Concavity test

Change in variable	Coefficient	Std. Err.	t-value
Labour	0.96	0.25	3.82***
Farmland	-0.02	0.12	-0.17
Seed	0.08	0.15	0.52
Herbicide	1.12	0.26	4.25***
Pesticides	-0.09	0.12	-0.69

*** represent 1% significance level

Source: Survey data, (2019)

4.3.4 Distribution of Technical Efficiency among Smallholder Cassava Farmers

Figure 4 shows the distribution of technical efficiency scores of cassava farmers in Fanteakwa District. The mean technical efficiency score was 0.71 (range=19.1-99.4), implying that cassava farmers were technically inefficient, producing 29 percent below their potential. This suggests that it is possible for farmers in the area to increase cassava production by 29 percent if they either adopted new productivity-enhancing technologies or reorganized their input use. This finding is consistent with that of Mari and Lohano (2007). The most frequent score was between 0.90 and 0.99 achieved by 33.3 percent of the farmers. About 42.3 percent of the farmers had technical efficiency score below the mean.

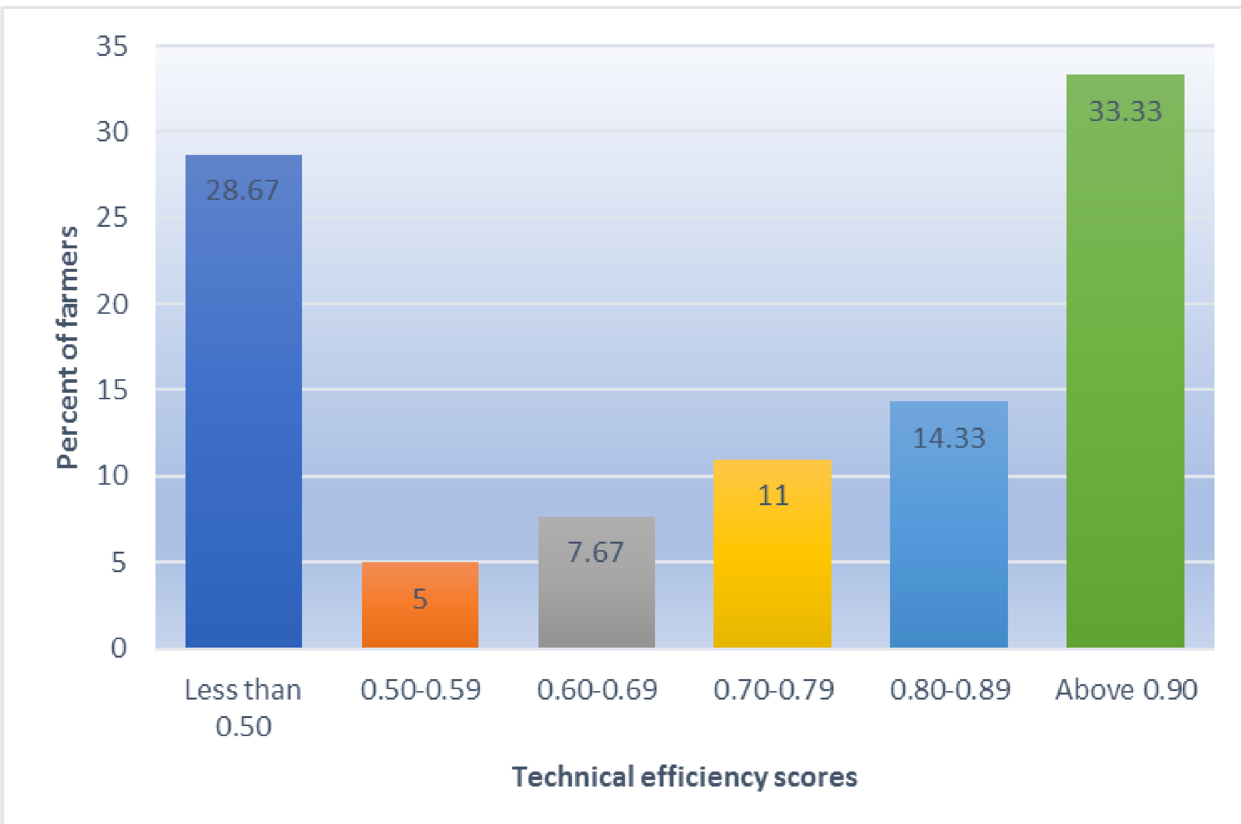

Figure 4: Distribution of technical efficiency scores

Source: Survey data (2019)

4.3.5: Factors Influencing Technical Inefficiency of Smallholder Cassava Farmers

Table 4.7 presents results of fitting equation (3.9) into the data to assess the factors influencing cassava farmers' technical inefficiency.

Table 4.7: Determinants of technical inefficiency amongst cassava farmers

Variable	Coefficient	Std. Err.	t-value
Gender (1=Male)	-0.26	0.12	-2.07**
Membership in FBO (1=Yes)	-0.25	0.13	-1.84*
Extension Access (1=Yes)	-0.24	0.11	-2.19**
Location of Farmland (Obuoho[a])			
Ahomahomasu	0.80	0.24	3.3***
Begoro	0.86	0.29	3.0***
Feyiase	-6.92	11.9	-0.58
Akoradarko	-0.18	0.26	-0.7
Land ownership (1=Owned)	-0.01	0.10	0.06
Education	-0.26	0.14	-1.82*
Income from off-farm activity	-0.10	0.06	-1.52
Distance to farmland	-0.23	0.08	-2.83***
Experience	-0.01	0.01	-0.72
Constant	1.78	0.45	3.92***

Source: Survey data (2019)

*, **, *** represent 10%, 5% and 1% significant levels respectively. [a]Obuoho was specified as the reference community against which the other four communities were juxtaposed.

As expected *a priori*, gender had a significant negative effect on technical inefficiency of cassava farmers ($p<0.05$). The results suggest that male farmers are less technically inefficient (more technically efficient) than their female counterparts. Women undertake several activities including non-economic activities such as cooking, housekeeping, and child care which go a long way to affect the time and resources they invest on the farm. Furthermore, women are faced by some social norms that limit their access and ability to use efficiency-enhancing technologies like tractors. This finding is in line with that of Abdallah (2016) who also found male farmers to be more technically efficient than women in Ghana. Duvel *et al*. (2003), Tamiru, (2004), Marinda *et al*. (2006), and Njuki *et al*. (2006) also made similar findings.

Access to extension services also met the a priori expectation of a negative effect on technical inefficiency ($p<0.05$). This implies that farmers who had access to extension services were more technically efficient than their counterparts who did not. Access to extension leads to a reduction in technical inefficiency because through extension services, farmers learn about new and improved technologies that when applied may lead to improvements in their technical efficiency. Bempomaa and Acquah (2014) also found a negative relationship between extension access and technical inefficiency of maize farmers in Ghana.

As expected *a priori,* education level of household head had significant negative effect on technical inefficiency of cassava farmers in the district ($p<0.1$). This suggests that farmers who have attained some level of formal education are more technically efficient compared to their counterparts who have no formal education. This finding is consistent with that of Wongnaa *et al.* (2018) who found a negative relationship between education and technical inefficiency of maize farmers in Ghana;

and Ambali (2013) who also found education to significantly reduce technical inefficiency of rural farm households in Nigeria.

With regards to the location of the farm, being in either Ahomahomasu or Begoro increased farmer's technical inefficiency relative to being in Obuoho community. This implies that cassava farmers in Ahomahomasu and Begoro were less technically efficient than those in Obuoho community. This could be due to the fact that Begoro is the district capital, that is, the central business area of the district which may influence the management practices of the farmers. Feyiase and Akoradarko showed insignificant results. Contrary to *a priori* expectations, distance to farmland had a negative effect on technical inefficiency of smallholder cassava farmers ($p<0.01$), implying that farmers who resided farther away from their farmland are more technically efficient compared to their counterparts who stay in close proximity to their farms. Al-hassan (2012) made similar findings among smallholder paddy farmers in Ghana.

Membership in a farmer-based organization reduced farmer's technical inefficiency as expected from theory ($p<0.1$). This suggests that farmers who belonged to a farmer-based organization are less technically inefficient (more technically efficient) than their counterparts. This could be due to the fact that FBOs through collective action benefit from easy access to inputs and training which may lead to improvements in their technical efficiency. This finding is consistent with that of Nyakaga *et al*. (2010) who found that membership in a farmer association improves the technical efficiency in resource use among smallholder irish potato farmers in Kenya.

Land ownership also met the a priori expectation. It was, however, not statistically significant in explaining the variations in technical inefficiency of smallholder cassava farmers in Fanteakwa district, Ghana.

4.4 Impact of RCB Credit Access on Cassava Farmers' Technical Efficiency

4.4.1 Distribution of farmers based on RCB credit access

About 42 percent of the smallholder cassava farmers accessed credit RCBs in the study area. The remaining 58 percent did not access credit from the RCBs. This distribution suggests that RCBs in the district are not highly patronised by cassava farmers. Table 4.8 presents the mean differences in some socioeconomic characteristics of farmers who accessed credit from RCBs and farmers who did not. The results show that farmers who accessed credit from RCBs are not statistically different from farmers who did not access credit from those banks in terms of age, household size, cassava output, income from off-farm activities, farm size, distance to farmland and distance to the bank. The test however showed that non-accessors were more experienced in cassava cultivation than their counterparts.

Table 4.8: Test of mean differences between RCB credit accessors and Non-accessors

Variable	Total n=300	Accessors (n=126) (a)	Non-Accessors (n=174) (b)	Mean Difference (b-a)
Age	44 (0.60)	44 (0.98)	43 (0.77)	-1.58 (1.22)
Household size	4.80 (2.23)	4.77 (2.22)	4.82 (2.25)	0.05 (0.26)
Experience	10.61 (7.61)	12.60 (9.24)	9.17 (5.79)	-3.42 (0.87) ***
Output	5045.04 (7364.21)	4281.33(9120.15)	5598.07 (3686.60)	1316.74 (859.51)
Off-farm income	595.24 (629.28)	594.39 (555.74)	595.85 (679.16)	1.45 (73.74)
Farm size	3.64 (2.81)	3.51 (2.97)	3.74 (2.69)	0.23 (0.33)
Distance to Bank	4.14 (7.71)	3.83 (7.08)	4.36 (8.15)	0.53 (0.90)
Distance to farmland	2.75 (1.81)	2.74 (1.74)	2.77 (1.87)	.027 (0.21)

*** represent 1% significance level. Standard errors in parenthesis

Source: Field survey (2019)

However, the statistics in Table 4.8 do not depict the exact impact of access to credit from RCBs on technical efficiency of smallholder cassava farmers in Fanteakwa district. The statistics only point to the fact there is the presence of self-selection into sample, thus, conclusions on the impact of access to RCB credit on technical efficiency, based on the above differences, will be biased. Policy recommendations should therefore not be based on them.

4.4.2 Determinants of Cassava Farmers' Decision to Access RCB Credit

Table 4.9 presents the results of fitting equations (3.28) and (3.29) into the data in a single step using the endogenous switching regression. The parameters *rho_1* and *rho_0* represent the correlation between the selection equation (3.12) and the credit access outcome equation (3.13) and non-access outcome equation (3.14) respectively. The correlation coefficients of *rho_1* is significantly negative and different from zero. What this means is that farmers who choose to access RCB credit are more technically efficient compared to a random individual from the sample. Similarly, the correlation coefficient for *rho_0* is significantly different from zero, therefore, connotes that farmers who choose not to access RCB credit have higher technical efficiency than a random farmer from the sample. The negative correlation coefficients (*rho_0* and *rho_1*) suggest the presence of selection bias such that more technically efficient farmers have a higher likelihood of accessing credit from RCBs (Abdoulaye *et al.*, 2018). The test for joint independence produced a chi-square value of 61.94 ($p<0.01$). What this suggests is that it was right to assume that the regressors have different effects on the two groups (accessors and non-accessors) (Negash & Swinnen, 2013).

Table 4.9: Determinants of cassava farmers' decision to access RCB credit and technical efficiency

Variable	**Stage 1**		**Stage 2**			
	Access decision		**Technical efficiency**			
	Access=0/1		**Access=0**		**Access=1**	
	Coef.	**S. E**	**Coef.**	**S. E**	**Coef.**	**S. E**
Gender (1=Male)	0.38**	0.18	0.09*	0.05	-0.03	0.05
Membership in FBO (1=Yes)	0.16	0.16	0.02	0.05	0.01	0.05
Extension access (1=Yes)	0.33**	0.15	0.20***	0.04	0.01	0.05
Off-farm Income	0.15*	0.08	-0.04**	0.02	-0.06***	0.02

Source: Survey data (2019)

*, **, *** represent 10%, 5% and 1% significant levels respectively. Coef. (Coefficient) S.E (Standard error)

Table 4.9 continued

Variable	Access Decision		Technical Efficiency			
	Access=0/1		Access=0		Access=1	
	Coef.	**S. E**	**Coef.**	**S.E**	**Coef.**	**S. E**
Land ownership (1=owned)	0.55***	0.16	-0.11**	0.05	-0.10**	0.05
Age	0.00	0.01				
Farm Location (1=Begoro)	-0.83***	0.16				
Farm size	-0.05**	0.02				
Savings	0.32***	0.11				
Education	-0.06	0.05				
Household size	-0.04	0.03				
Physical Distance to Bank	0.02***	0.01				
Constant	-1.30***	0.50	0.85***	0.15	1.38***	0.16
Rho0			-1.58***	0.27		
Rho1					-1.57***	0.27
LR test chi (2)	61.94***					

Source: Survey data (2019)

*, **, *** represent 10%, 5% and 1% significant levels respectively. Coef. (Coefficient) S.E (Standard error)

The determinants of farmer's RCB credit access decision is given as Stage 1 results of the probit regression (equation 3.12). As expected *a priori*, sex of household head had statistically significant positive effect on decision to access RCB credit in the district ($p<0.05$). Accordingly, male household heads are more likely to access credit from RCBs than female household heads in Fanteakwa district. This could be accounted for by the fact that cassava cultivation in the district is dominated by men, thus, are most likely to access loans to invest in the farm. This finding contradicts that of Akpan *et al*. (2013) that male poultry farmers are less likely to access credit from formal sources in Nigeria.

As expected *a priori*, land ownership was found to positively influence farmers decision to access RCB credit ($p<0.01$). This suggests that farmers who have ownership rights to their farmlands are more likely to access RCB credit in the Fanteakwa district. This behaviour can be explained by the fact that, having ownership rights to the land enables the farmer to put the land up as collateral. This finding is in line with the findings of Akudugu (2012) and Domeher (2012), who found that ownership of land was a significant factor in farmers' demand for RCBs credit in Ghana.

Extension access met the *a priori* expectation of a positively influencing farmers decision to access RCB credit ($p<0.05$). This implies the probability of farmers accessing RCB credit is higher for farmers who have access to extension services. This result is in line with that of Dadze *et al*. (2012) who also found access to extension to significantly influence credit access in Ghana. The finding however, contradicts that of Akpan *et al*. (2013) who found that extension agent visit did not encourage farmers to access credit from formal sources. He attributed his findings to the policy content of the extension system and that farmers may have been misinformed about credit access.

As expected *a priori,* savings was also found to positively influence farmers' decision to access RCB credit ($p<0.01$). This implies that farmers who have active savings account with RCBs are more likely to access credit from the RCBs. Most RCBs in Ghana require a borrower to have an active savings account before credit is granted. This may explain the behaviour of cassava farmers in Fanteakwa district since the main reason for opening saving accounts with banks is to have access to credit when needed. This result corroborates the findings of Akram *et al*. (2008) and Akudugu (2012) who both found that savings is a determining factor in farmers' decision to access credit from formal sources in Pakistan and Ghana respectively.

Contrary to the *a priori* expectation, the result showed that physical distance between farmer's homestead and the RCB positively influences farmers' decision to go for RCB credit, suggesting that farmers' who stay farther from the RCBs are most likely to access credit from the RCBs in the district. This was significant at 1 percent ($p<0.01$). This finding could be due to the fact that most farmers stay outside the district capital where all the RCBs in the district are located. This finding contradicts the findings of Akpan *et al*. (2013) and Ayamga *et al*. (2006) who found that farmers in close proximity to the source of credit have higher probability of accessing credit in Nigeria and Ghana respectively. Size of farmland was found to have a negative effect on farmers decision to access RCB credit. This was contrary to the *a priori* expectation of a positive effect on the probability of farmers accessing credit from RCBs, significant at 5 percent. Membership in a farmer-based organization, age of household head, education level of household head as well as household size showed to have statistical insignificance in influencing the probability of smallholder cassava farmers accessing RCB credit in Fanteakwa district.

4.4.2 Determinants of Cassava Farmers' Technical Efficiency

As shown in Table 4.9, cassava farmers' technical efficiency was significantly influenced by gender, extension access, income from off-farm activities and land ownership. Sex of household met the *a priori* expectation of a positive effect on technical efficiency of cassava farmers who accessed RCB credit and those who did not, but was significant only for cassava farmers who did not access RCB credit. This suggests that, male farmers who did not access RCB credit are more technically efficient compared to their counterpart female farmers. Access to extension services also met the *a priori* expectations of a positive effect on technical efficiency. Again, it was significant at 1 percent only for farmers who did not access RCB credit. This suggests that, for farmers who did not access RCB credit, access to extension services significantly improved their technical efficiency.

Income from off-farm activities did not meet the *a priori* expectation. It showed a negative effect on technical efficiency of cassava farmers and was significant at 1 percent only for farmers who accessed RCB credit. This suggests that for farmers who accessed RCB credit, participation in off-farm economic activities was detrimental to the technical efficiency. This could be due to fact that engagement off-farm activities also require resources (for instance, time) which could otherwise have been spent on the farm to improve technical efficiency. This finding is consistent with that of Al-hassan (2012) who also found a negative relationship between off-farm activities and technical efficiency of smallholder paddy farmers in Ghana. Land ownership, also, did not meet the *a priori* expectation of a positive effect on technical efficiency of cassava farmers suggesting that farmers who have ownership rights to their farmlands are less technically efficient compared to their counterparts who do not. This was significant at 1 percent but only for farmers who accessed RCB credit. This finding contradicts that of Kariuki *et al*. (2008) who found that farmers with land titles have higher technical efficiency in Kenya.

4.4.3 Impact Assessment of RCB Credit Access on Cassava Farmers' Technical Efficiency

Table 4.10 presents the results of the assessment of the impact of RCB credit access on technical efficiency of cassava farmers in Fanteakwa District. The Table shows the expected technical efficiencies under actual and counterfactual scenarios.

Table 4.10: Impact of access to RCB credit on cassava farmers, technical efficiency

n	**Sub-Sample**	**Decision**		**Treatment effects**	
		To access	Not to access		
126	Accessors	(a) 0.72 (0.12)	(b) 1.13 (0.09)	ATT	0.48 (0.01)***
174	Non-accessors	(c) 0.24 (0.16)	(d) 0.71 (0.16)	ATU	0.42 (0.01)***
	Heterogeneity effect			TH	0.06 (0.01)***
				ATE	0.01 (0.02)***

Source: Survey data (2019)

*, **, *** represent statistical significance at 10%, 5% and 1%, respectively; ATT=(a)-(c), ATU=(b)-(d) and TH=ATT-ATU are average treatment effects on the treated, average treatment effects on the untreated, and treatment heterogeneity respectively. ATE is average treatments effect given by (a-d).

From the first two rows of Table 4.10, the diagonal elements (a) and (d) represent the expected technical efficiencies under actual scenarios, while the off-diagonal elements (b) and (c) represent the expected technical efficiencies under the counterfactual scenarios. ATT is the difference between the expected technical efficiency of farmers who accessed RCB credit (actual scenario for accessors) and the expected technical efficiency of farmers who did not access RCB credit, if they had accessed it (the counterfactual scenario for non-accessors). The ATU gives the difference between the expected technical efficiency of farmers who accessed RCB credit had they not accessed it (counterfactual scenario for accessors) and the expected technical efficiency of farmers who did not access RCB credit assuming they did not (actual scenario for non-accessors). The

ATE represents the difference between the expected technical efficiency of farmers who accessed RCB credit and farmers who did not.

The actual and counterfactual outcomes were computed after controlling for confounding variables. The ATE shows that access to RCB credit led to an increase in cassava farmers' technical efficiency by only 0.01 for farmers who accessed the credit. This indicates that farmers who accessed RCB credit were 1 percent more technically efficient compared to their counterpart farmers who did not access. However, it is insufficient to conclude that access to RCB credit positively impacted farmers' technical efficiency as the counterfactual scenarios have not been accounted for. In that case, the transitional heterogeneity was computed as the difference between the ATT and ATU (Ngoma, 2018). As shown in Table 4.10, the transitional heterogeneity was 0.06 and statistically significant ($p<0.01$). What this means is that farmers who accessed RCB credit were significantly more technically efficient than their counterparts. The transitional heterogeneity also implies that a farmer who did not access RCB credit was 6% worse off compared to one who accessed the credit

However, the mean technical efficiency score of farmers who accessed credit from RCBs (0.48) is lower than the mean technical efficiency of the whole sample (0.71). The reason could be fungibility of the credit from the RCBs. The farmers may be diverting the funds into other activities rather than into cassava cultivation thereby leading to the low technical efficiency. Another reason could be that farmers are allocatively inefficient. So that even after farmers accessed credit from RCBs and are able to acquire the inputs, they inefficiently allocated the inputs leading to low levels of output.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Cassava is one of the leading food staples in Ghana. Its production has however been beset with numerous challenges over the past decades. Output continues to fluctuate despite numerous government programmes in place to support the production to meet food self-sufficiency. The fluctuation of cassava yield has been blamed largely on the difficulty of resource poor smallholder farmers to access funding. The rural and community bank (RCB) credit programme was instituted by the Government of Ghana in the early 1980s to improve credit access among rural entrepreneurs. However, the is little evidence of the impact of RCBs on resource use among smallholder cassava farmers in Ghana.

This study sought to examine the impact of cassava farmers' access to RCB credit on their technical efficiency in Fanteakwa District of Ghana. A purposive sampling was done to select 5 cassava farming communities in the Fanteakwa district and then 60 cassava farmers were selected randomly from each of the five communities to make a total the sample. Semi-structured questionnaire was used to collect data on the socioeconomic, farm-specific and institutional characteristics of the farmers. Descriptive statistics involving frequencies and t-test were computed to determine the mean difference. A probit model was used to ascertain the factors that influence cassava farmers' awareness of RCB credit facilities. A stochastic frontier model was used to estimate the technical efficiency of cassava farmers and then the endogenous switching regression model was employed to assess the impact of RCB credit access on the farmers' technical efficiency.

The results showed significant differences between cassava farmers who were aware and those who were not, in terms of age, income from off-farm activities, and distance to the market. The results of the probit model showed that extension contact, possession of a savings account with the RCB and distance to the nearest market were the major determinants of cassava farmers' awareness of RCB credit programmes in the district.

Cassava farmers in Fanteakwa district of Ghana were technically inefficient, operating at 29 percent away from the efficient frontier. Being a male household head, membership in farmer-based groups and extension access reduced farmer's technical inefficiency. However, farmers exhibited increasing returns-to-scale of 1.61, which implies that they are operating in the first stage of the production function where increases in the quantities of inputs lead to more than proportionate increase in cassava output. Results of the first stage of the endogenous switching regression showed possession of a savings with RCB, being male, individual land tenure and off-farm income positively influenced cassava farmer's decision to access credit from the RCBs. On average, farmers who accessed RCB credit had significantly higher technical efficiency than their counterparts.

5.2 Conclusions

Access to extension services, savings account with the RCB, and distance to the nearest market are the major contributors to the awareness state of cassava farmers in the district about credit facilities available to them from the RCBs. Cassava farmers in the district are only able to achieve about 71 percent of best possible output from quantities of inputs using the available technology, making them technically inefficient. The technical inefficiencies are significantly influenced by gender, membership in farmer-based groups, and extension access.

Savings with the bank, sex of the household head and land tenure and income from off-farm as well as access to extension services, are the major contributing factors to the farmer's decision to access credit from the RCBs. On average, farmers who accessed credit from RCBs have higher technical efficiency than farmers who did not. Thus, access to credit from RCBs have a significantly positive impact on the technical efficiency of smallholder cassava farmers in Fanteakwa district of Ghana.

5.3 Recommendations

Following the conclusions above, the following recommendations are made:

1. Considering the importance farm credit plays in improving the productivity of smallholder farmers, it is important for more effective strategies to be developed and implemented both by government and the RCBs so that more farmers will have full knowledge of available credit programmes tailored for them.
2. Considering the fact that extension access had a positive and significant effect on RCB credit awareness, as well as in reducing farmers' technical inefficiencies, it is crucial that farmers be exposed to more extension agents. It is therefore recommended that the Government of Ghana should enhance the scope and mode of extension service delivery in the country. The study also found a positive relation between individual land ownership and cassava farmers' RCB credit awareness. It is therefore recommended that farmers be enabled to have title deeds to their land. This will likely motivate them to make more tangible investments in their land.

3. Farmers in Fanteakwa District should also be encouraged to save, particularly, with the RCBs in the districts as it increases their chances of being aware of any credit facilities provided by their banks. It is also recommended that RCBs in the country should put in extra effort to make their credit programmes easily accessible and known to farmers in their catchment area. They should also be given credit management training to enable them efficiently use the credit for the purposes for which they were taken.

5.4 Areas for Further Research

This study employed cross-sectional data in the estimation of the technical efficiency and so it was not able to capture efficiency changes over time. Future studies may consider employing a time series approach in order to capture farmers' technical efficiency changes, over time, possibly since the establishment of RCBs in the country. Additionally, this study did not consider the extent of access to credit from the RCBs. Therefore, future studies may consider examining the extent of the access to credit from RCBs.

Considering the fact that the technical efficiency of farmers who accessed RCB credit was lower than the average technical efficiency score for the whole sample, raises questions about fungibility of credit from the RCBs. Therefore, future studies may consider the uses of the credit from the RCBs. Future studies may also consider the allocative efficiency of the farmers.

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APPENDICES

Appendix 1: Household Survey Questionnaire

UNIVERSITY OF NAIROBI

THE EFFECT OF RURAL BANK CREDIT ACCESS ON TECHNICAL EFFICIENCY OF SMALLHOLDER CASSAVA FARMERS IN THE FANTEAKWA DISTRICT OF GHANA

QUESTIONNAIRE

ENUMERATOR'S NAME:	DATE:
LOCATION:	COMMUNITY:

SEEKING CONSENT

Good day Sir/Madam,

My name is Arnold Missiame and I am working with the Department of Agricultural Economics of the University of Nairobi, Kenya. We are carrying out research on the effect of rural bank credit access on technical efficiency of smallholder cassava farmers in Fanteakwa District of Ghana. The purpose of this study is to get views, experiences and suggestions of farmers on rural bank credit access, challenges involved, and its effect on the production of cassava. Respondents of this survey should be cassava farmers who must be at least 18 years old. You have been randomly selected and your participation in this survey is voluntary. The findings of this study will be mainly used to inform policy on improving the technical efficiency of cassava farmers. The interview will require about 45 minutes to complete. Can I proceed with the interview?

*If **NO,** enter **00** here* [|] *and end the interview.* ***Find a replacement household.***

*If **YES**, enter **01** here* [|] *to acknowledge that consent has been granted by the respondent.*

SECTION A: Socio-Economic Characteristics of Cassava Farmer

A1. Are you the head of this household? 1=Yes [ ]   0=No [ ]

A2. If NO, who is the head of the household?

__[ENUMERATOR:__ If the Respondent is NOT the household head, ask him/her the following questions about the household head]

A3. What is the gender of the household head?   1 = Male [ ] 0 = Female [ ]

A4. What is the age of the household head? (*in years)*: ………………………………………

A5. What is the marital status of the household head? 0 = Single [ ] 1 = Married [ ] 2 = Separated [ ] 3 = Divorced [ ]

A6. What is the religion of the household head? 1 = Christian [ ] 2 = Muslim [ ] 3 = Traditionalist [ ] 4 = Others (specify) …………………………

A7. What is the highest education level attained by the household head? 1=Primary [ ]   2= [ ] 3=SHS/Technical [ ] 4=Tertiary [ ] 5=None [ ]

A8. What is the household size of the household head? ………………………………person(s)

Number of adults >18yrs		Number of adults<18yrs		Number of Children <5yrs	
a. Males	b. Females	a. Males	b. Females	a. Males	b. Females

SECTION B: LIVELIHOOD SOURCES

i. Livelihood Sources

B8. What are your sources of livelihood? 1=Crop farming [ ]   2=Fishing [ ] 3=Livestock keeping [ ] 4=Business [ ] 5=Petty trade [ ] 6=Wage employment [ ]   7=Salaried employment [ ] 8=Other (Specify) [ ]

B9. Please give the approximate income obtained from each source over the last ONE year.

Income source	**Approximate Amount over last <u>ONE</u> year (In GHC)**
Sale of crop produce	
Fish sales	
Livestock sales	
Sale of livestock products (e.g., milk, ghee, hides & skins, etc)	
Sale of crop produce	

Salary from employment ***[Multiply monthly salary by 12 to get annual amount]***	
Wage employment ***[Determine annual amount]***	
Pension/retirement benefit ***[Multiply monthly benefit by 12 to get annual amount]***	
Remittances ***[Determine annual amount]***	
Business	
Other income source (Specify)………………	

B10. How frequently do you receive remittances? 1=Daily [ ] 2= Weekly [ ] 3= Monthly [ ] 4=Bi-monthly [ ] 5= Yearly [ ]

B11. From whom do you usually get remittances?..

ii. Livestock Ownership

B12. How many of the following livestock type do you have now?

Species	**Total**	**Number owned**	**Number not owned**
Cattle			
Sheep			
Goats			
Chickens/Fowls			

iii. Ownership of other Assets

B13. Indicate the number of assets owned by the household.

Housing type	**Number**	**Farm transport**	**Number**	**Water storage**	**Number**
Grass roof/stick wall		Donkey cart		Plastic tank	
Grass roof/mud wall		Human-drawn cart [Truck/Wheel Barrel]		Iron tank	
Iron sheet roof/wooden wall		Bicycle		Stone tank	
Iron sheet roof/mud wall		Motorcycle [*Okada*]		Other (Specify) _	
Iron sheet roof/iron sheet wall		Car		**Other Assets**	
Iron sheet roof/concrete wall		Pickup		Working mobile phones	
		Lorry		Working radio	
		Tractor		Working TV	

SECTION C: Crop Production

C14. Are you involved in cassava farming? 1=Yes [ ] 2=No [ ]

C15. If YES, what is the total size of your land? ____________________________ Acres

C16. Except cassava, which other crops did you grow last season?

Crop	Approximate acreage with the crop last season (Acres)	Approximate quantity produced (Kgs)	Approximate quantity consumed in the household (Kgs)	Approximate quantity sold (Kgs)	Which market?

C17. Do you use irrigation? 1=Yes [ ] 2=No [ ]

C18. *[IF YES]*, What area did you irrigate **last season**? ________________ acres.

C19. Where do you usually get your irrigation water from? ________________

C20. What is the type of tenure of your land?

1=Individual 2=Leasehold 3=Communal 4=Other (Specify)_____

SECTION D: Basic information on cassava farming

C12. How many years has the household been involved in cassava production? ………… years

B13. Please indicate the seasons in which you usually cultivate your cassava. 1= Only in the main season [ ] 2= Only in the minor season [ ] 3= In both seasons [ ]

B22. Please indicate the kind of implements employed on your farm? 1= Only simple farm tools [ ] 2= Plough [ ] 3=Ridge [ ] 4= Only 1 and 2 [ ] 5= Only 1 and 3[ ] 6= All [ ]

B23. Did you use the services of the agricultural mechanization centre for 2017/2018 farming season? 1= Yes [ ] 2= No [ ]

C28. How much does an acre of land cost if it was rented? GHS (per acre) ……………………

SECTION F: Institutional factors

D21. Do you belong to any farm-based group/association? 1= Yes [ ] 0= No [ ]

D22. Please indicate the most important contribution received from the group since you joined.

1= Book-keeping Training [ ] 2= Agronomic Practices [ ] 3= Credit Management [ ] 4= Others (specify)…………..….

SECTION G: Input Use

Please indicate the quantity of inputs used on cassava during the MAIN season of 2017/2018 production:

Input	**Unit**	**No. of units**	**Quantity**	**Unit price**	**Source/market**
Land	Acres				
Owned					
Given					
Rented					
Labor	Manhours				
Bush clearing					
Ploughing					
Harrowing					
Sowing					
Fertilizing					
Manuring					
Weeding					
Irrigation					
Herbicide application					
Pesticide application					
Harvesting					
Packaging					

Marketing					
Pesticides	Litres				
Herbicides	Litres				
Fertilizer	Kgs				
DAP					
Etc					
Sacks					
Irrigation water	Litres?				
Machinery	Machinehours				
Type of Cassava Stem	Number of stems				
Improved Stems					
Locally developed-improved					
Recycled locally developed-improved					
Other (specify)…………					
Cassava Variety					
AGRA Bankye					
Dudzi					
Abrabopa					
Lamesese					
Duade Kpakpa					
Amansan					

C37. Did you apply inorganic fertilizer during the 2017/2018 farming season?

1= Yes [ ] 0= No [ ]

C38. If Yes, please indicate the type, the quantity and the cost of the inorganic fertilizer used during the 2017/2018 farming season

Inorganic Fertilizer	Unit	Qty Used		Price per unit (GHS)		Total Cost (GHS)	
		Major Season	Minor Season	Major Season	Minor Season	Major Season	Minor Season
NPK	50kg						
Winner	50kg						
Urea	50kg						
Sulphate of Ammonia	50kg						
Others	50kg						

C39. Did you use any agro-chemical during the 2017/2018 farming season? 1= Yes [ ] 2= No [ ]

C340. If yes, please indicate the types, quantity and the total cost involved

Inorganic Fertilizer	Unit	Qty Used		Price per unit (GHS)		Total Cost (GHS)	
		Major Season	Minor Season	Major Season	Minor Season	Major Season	Minor Season
Field Fungicides	1000ml						
Nematicides	1000ml						
Weedicides	1000ml						
Others	1000ml						

SECTION H: Cassava Output

E46. Please indicate how many kilograms of cassava you harvested during the MAIN & MINOR seasons of 2017/2018 farming season.

Season	Approximate quantity produced (Kgs)	Approximate quantity consumed in the household (Kgs)	Approximate quantity sold (Kgs)	Unit price (GHS)	Which market?
Main					
Minor					

SECTION I: Access to Services

E47. What is the distance from your farm to the nearest cassava buying centre? (*in kilometres)* ……….

What is the distance from your farm to the nearest market? (*in kilometres)*

E48. What is the distance from your farm to your house? (*in kilometres*) ……………

5.9C. How far is the nearest all weather road from your home? _________km

5.6C. How far is the nearest primary school from your home? _________km

5.7C. How far is the nearest hospital/health centre from your home? _________km

5.8C. How far is the nearest extension service provider from your home? _________km

5.10C. How far is the nearest water source from your home? _________km

5.8C. How far is the nearest cassava inputs provider from your home? _________km

Did you ever have contact with any extension agent in the 2017/2018 production year?

1 =Yes [ ] 0= No [ ]

If yes, how many times in: a. Major season ……………. b. Minor season………………….

What was the primary information rendered by extension agents in the 2017/2018 production year?

1= Production Information [ ] 2= Marketing Information [ ] 3= Handling and Storage Information [ ] 4= Others (specify) ……………………………….

B17. Did you receive any formal training on cassava cultivation during the 2017/2018 production year? 1= Yes [ ] 2= No [ ]

B18. If YES, where was the training conducted? 1= On the farm [ ] 2= Off farm [ ] 3= Others (Specify)…………………

B20. What was the training on? 1= Postharvest technology [ ] 2= Agronomic practices [ ] 3= Credit application processes

[ ] 4= Others (specify)………………..

SECTION J: Awareness of Rural Bank Credit Programme

F49. Are you aware of any rural bank credit programme in your community?

1=Yes [ ]   0=No [ ]

F50. If yes, how did you become aware of the programme?

1=FBO member [ ] 2=Staff of RCB [ ] 3=Extension agent [ ] 4=Advertisement [ ] 5=Other, Please Specify………..

SECTION K: Access to Rural Bank Credit

G51. Did you access rural bank credit last during the 2017/2018 farming season? 1=Yes [ ]

0= No [ ]

G52. If Yes, did you get the amount you applied for? 1=Yes, I got the full amount [ ] 2=No, I got less than the amount I applied for [ ] 0=No, I did not get anything at all [ ]

If the answer to question G52 is either option (1) or (2), then please answer question G53. Otherwise skip to question G54.

G53.What did you use the credit for? 1=To pay school fees [ ] 2=For food consumption purposes [ ] 3=To purchase cassava farming inputs [ ] 4=To pay rent 5=Other (specify)………………..

G56. Do you have a savings account with the Rural Bank? 1=Yes [ ]   0=No [ ]

G57. Is the credit from the rural bank enough to support your cassava production? 1=Yes [ ] 0=No [ ]

G58. Do you have any other sources of funds to support your cassava production? 1=Yes [ ] 0=No [ ]

If YES, which sources and how much did you get during the 2017/2018 production year?

Source	Amount (GHS)

G59. Please state when you placed in your request for credit? (*dd/mm/yyyy*) ....

G60. How long did it take to receive the credit from the rural bank? (*in number of weeks*) ....

Thank you for your time

Appendix 2: Maximum likelihood estimation of the probit model for awareness

```
Probit regression                               Number of obs     =        300
                                                LR chi2(13)       =      37.42
                                                Prob > chi2       =     0.0004
Log likelihood =   -189.127                     Pseudo R2         =     0.0900
```

aware	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
age_group	.1509818	.0843493	1.79	0.073	-.0143398	.3163035
gen	.1294667	.2089756	0.62	0.536	-.2801179	.5390512
hhs_n	-.0889736	.0413581	-2.15	0.031	-.1700341	-.0079132
Marital_Status	.2201973	.193521	1.14	0.255	-.1590968	.5994914
school	.0020343	.0204586	0.10	0.921	-.0380639	.0421325
exxt	.3814967	.1665696	2.29	0.022	.0550264	.707967
grp	.3144831	.1757391	1.79	0.074	-.0299592	.6589253
LandOwner	.3218901	.1760284	1.83	0.067	-.0231192	.6668995
lnq	-.0148734	.1149366	-0.13	0.897	-.240145	.2103982
lnOFIncome	.0895477	.0811059	1.10	0.270	-.0694169	.2485124
Savings	.328859	.1759817	1.87	0.062	-.0160588	.6737768
dsmkt_1	-.0308685	.0108816	-2.84	0.005	-.052196	-.009541
Media	.0780883	.0947385	0.82	0.410	-.1075957	.2637723
_cons	-1.257677	.5640731	-2.23	0.026	-2.36324	-.152114

Appendix 3: Marginal effects after the probit model

```
Marginal effects after probit
      y  = Pr(aware) (predict)
         =   .5148598
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.]		X
age_gr~p	.0601913	.03362	1.79	0.073	-.005711	.126094	2.81333
gen*	.0516119	.08321	0.62	0.535	-.111473	.214697	.723333
hhs_n	-.0354707	.01649	-2.15	0.031	-.067787	-.003155	4.79667
Marita~s*	.0876687	.07674	1.14	0.253	-.062743	.238081	.66
school	.000811	.00816	0.10	0.921	-.015175	.016797	6.12
exxt*	.1511664	.06521	2.32	0.020	.023366	.278966	.496667
grp*	.1243886	.06854	1.81	0.070	-.009956	.258733	.316667
LandOw~r*	.1270807	.06833	1.86	0.063	-.006842	.261003	.27
lnq	-.0059295	.04582	-0.13	0.897	-.095738	.083879	.56098
lnOFIn~e	.0356996	.03234	1.10	0.270	-.027676	.099076	5.90101
Savings*	.1305224	.06921	1.89	0.059	-.005125	.26617	.503333
dsmkt_1	-.0123062	.00434	-2.84	0.005	-.020812	-.003801	5.03147
Media	.0311311	.03777	0.82	0.410	-.042892	.105155	1.78333

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Appendix 4: Test for Multicollinearity amongst explanatory variables in probit model for awareness

```
. pwcorr age_group gen hhs_n Marital_Status school exxt grp LandOwner lnq lnOFIncome Savings dsmkt_
> 1 Media, star(1)
```

	age_gr~p	gen	hhs_n	Marita~s	school	exxt	grp
age_group	1.0000						
gen	0.0587	1.0000					
hhs_n	0.4448*	0.0473	1.0000				
Marital_St~s	0.1171	0.4370*	0.3296*	1.0000			
school	-0.2237*	0.0531	-0.0910	0.0889	1.0000		
exxt	0.0483	0.0033	0.1267	0.0234	0.3345*	1.0000	
grp	0.2107*	0.0846	-0.0344	-0.0560	-0.0848	0.0547	1.0000
LandOwner	0.0704	-0.0770	0.0353	-0.0390	0.0414	0.0866	-0.0589
lnq	-0.0082	0.2799*	0.0599	0.1482	-0.1047	0.0473	0.0676
lnOFIncome	0.0692	-0.3244*	0.1302	-0.0566	0.1685*	0.1593*	0.0345
Savings	-0.1038	0.1159	-0.0518	-0.0656	-0.2646*	-0.0266	-0.0834
dsmkt_1	-0.0818	0.1670*	0.0832	0.1269	0.0997	0.1119	-0.1912*
Media	-0.0034	0.0146	0.1565*	0.2314*	0.5222*	0.3122*	-0.0098

	LandOw~r	lnq	lnOFIn~e	Savings	dsmkt_1	Media
LandOwner	1.0000					
lnq	-0.0985	1.0000				
lnOFIncome	0.1105	-0.1552*	1.0000			
Savings	0.0485	0.3185*	-0.1442	1.0000		
dsmkt_1	0.0358	0.2416*	0.0004	0.1446	1.0000	
Media	0.0113	-0.1185	0.2382*	-0.3316*	0.1040	1.0000

.

Appendix 5: Maximum likelihood estimation of stochastic frontier model

```
Stoc. frontier normal/tnormal model               Number of obs =       300
                                                  Wald chi2(20)  =    215.31
                                                  Prob > chi2    =    0.0000

Log likelihood =  -192.5008
```

lnq	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
lnPesticides	.1522288	.0797445	1.91	0.056	-.0040676	.3085252
lnHerbicides	.3140447	.1129842	2.78	0.005	.0925996	.5354897
lnLabour	.2902563	.0919749	3.16	0.002	.1099887	.4705239
lnFarm	.513484	.0699775	7.34	0.000	.3763306	.6506375
lnSeed	.2416344	.0739957	3.27	0.001	.0966055	.3866632
lnLabour2	.9573495	.2507486	3.82	0.000	.4658912	1.448808
lnSeed2	.0801661	.1539928	0.52	0.603	-.2216542	.3819863
lnFarm2	-.0188448	.1140436	-0.17	0.869	-.2423661	.2046766
lnPest2	-.0851385	.1226612	-0.69	0.488	-.32555	.155273
lnHerb2	1.123007	.2642409	4.25	0.000	.6051044	1.64091
SeedxLabour	-.5100825	.2290481	-2.23	0.026	-.9590086	-.0611565
FarmxLabour	-.1069979	.2330756	-0.46	0.646	-.5638176	.3498219
FarmxSeed	.282326	.1559013	1.81	0.070	-.023235	.587887
SeedxPesticides	.5854968	.22197	2.64	0.008	.1504435	1.02055
PestxLabour	1.13109	.2996739	3.77	0.000	.5437395	1.71844
PestxFarm	.0247684	.223382	0.11	0.912	-.4130523	.4625891
HerbsxLabour	-.5595119	.3789866	-1.48	0.140	-1.302312	.1832881
HerbxFarm	.0397059	.2582964	0.15	0.878	-.4665458	.5459576
HerbxSeed	-.5205007	.2764709	-1.88	0.060	-1.062374	.0213723
HerbxPest	-.2895468	.3317655	-0.87	0.383	-.9397952	.3607017
_cons	1.053567	.1140697	9.24	0.000	.8299942	1.277139

Appendix 5 continued

Mu						
gen						
Female	.25	.	.	.	.	.
Male	-.2580039	.1243444	-2.07	0.038	-.5017144	-.0142933
grp						
No	.25	.	.	.	.	.
grp						
Yes	-.2456247	.1331648	-1.84	0.065	-.5066229	.0153734
exxt						
No	.25	.	.	.	.	.
exxt						
Yes	-.2392194	.1094078	-2.19	0.029	-.4536548	-.024784
0.FarmLoc_Ahom	.25	.	.	.	.	.
1.FarmLoc_Ahom	.7973516	.2413359	3.30	0.001	.3243419	1.270361
0.FarmLoc_Beg	.25	.	.	.	.	.
1.FarmLoc_Beg	.8592823	.2866864	3.00	0.003	.2973874	1.421177
0.FarmLoc_Fey	.25	.	.	.	.	.
1.FarmLoc_Fey	-6.928126	11.91992	-0.58	0.561	-30.29074	16.43449
0.FarmLoc_Akora	.25	.	.	.	.	.
1.FarmLoc_Akora	-.180572	.2568609	-0.70	0.482	-.68401	.3228661
LandOwner						
No	.25	.	.	.	.	.
LandOwner						
Yes	.0058805	.1010747	0.06	0.954	-.1922222	.2039832
educ						
None	.25	.	.	.	.	.
Primary	.1437699	.1503723	0.96	0.339	-.1509544	.4384942
JHS	-.264133	.1448782	-1.82	0.068	-.5480891	.019823
SHS/Technical	-.0415707	.1429165	-0.29	0.771	-.321682	.2385405
Tertiary	.0167132	.2505115	0.07	0.947	-.4742803	.5077066
lnOFIncome	-.1001992	.0660459	-1.52	0.129	-.2296468	.0292483
dshs_1	-.2272338	.0804347	-2.83	0.005	-.384883	-.0695846
exp_n	-.007685	.0106751	-0.72	0.472	-.0286077	.0132377
_cons	1.780336	.4542074	3.92	0.000	.8901063	2.670567

Usigma						
_cons	-3.043177	.7350956	-4.14	0.000	-4.483938	-1.602416
Vsigma						
_cons	-1.666784	.1207736	-13.80	0.000	-1.903496	-1.430072
sigma_u	.2183647	.0802595	2.72	0.007	.1062491	.4487865
sigma_v	.4345727	.0262424	16.56	0.000	.3860656	.4891745
lambda	.5024815	.0989846	5.08	0.000	.3084752	.6964878

Appendix 6: Test for multicollinearity in the inefficiency component of the stochastic frontier model

```
. pwcorr gen grp exxt FarmLoc_Ahom FarmLoc_Beg FarmLoc_Fey FarmLoc_Akora LandOwner educ lnOFIncome
> dshs_1 exp_n, star(1)
```

	gen	grp	exxt	FarmLo~m	FarmLo~g	FarmLo~y	FarmLo~a
gen	1.0000						
grp	0.0846	1.0000					
exxt	0.0033	0.0547	1.0000				
FarmLoc_Ahom	-0.1192	0.0358	0.3867*	1.0000			
FarmLoc_Beg	0.0671	-0.2508*	0.0867	-0.2500*	1.0000		
FarmLoc_Fey	0.0112	-0.2508*	-0.3133*	-0.2500*	-0.2500*	1.0000	
FarmLoc_Ak~a	-0.0261	0.2150*	-0.0967	-0.2500*	-0.2500*	-0.2500*	1.0000
LandOwner	-0.0770	-0.0589	0.0866	-0.0601	0.2215*	-0.0601	-0.1915*
educ	0.0703	-0.0698	0.3319*	0.2974*	0.3186*	-0.3439*	-0.2171*
lnOFIncome	-0.3244*	0.0345	0.1593*	0.1636*	0.2079*	-0.4343*	-0.1072
dshs_1	0.1290	-0.0936	0.0355	-0.2129*	0.3465*	0.1219	-0.1761*
exp_n	0.1180	0.3218*	-0.0565	-0.2022*	-0.3250*	-0.1561*	0.3011*

	LandOw~r	educ	lnOFIn~e	dshs_1	exp_n
LandOwner	1.0000				
educ	0.0227	1.0000			
lnOFIncome	0.1105	0.1637*	1.0000		
dshs_1	0.0712	0.0156	-0.0582	1.0000	
exp_n	0.0127	-0.2879*	0.0608	-0.1777*	1.0000

Appendix 7: Full information maximum likelihood estimation of the ESR model

```
Endogenous switching regression model             Number of obs   =        300
                                                  Wald chi2(5)    =      14.65
Log likelihood = -139.64024                       Prob > chi2     =     0.0120
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
efficiency_1						
gen	-.0335726	.052393	-0.64	0.522	-.136261	.0691158
grp	.0071527	.049332	0.14	0.885	-.0895361	.1038416
exxt	-.0096637	.0450882	-0.21	0.830	-.0980349	.0787074
lnOFIncome	-.0636631	.0217388	-2.93	0.003	-.1062704	-.0210558
LandOwner	-.1023729	.0469728	-2.18	0.029	-.1944378	-.010308
_cons	1.384071	.1574224	8.79	0.000	1.075529	1.692614
efficiency_0						
gen	.0869443	.0490639	1.77	0.076	-.0092192	.1831077
grp	.0175624	.0477791	0.37	0.713	-.0760829	.1112078
exxt	-.1979245	.0446195	-4.44	0.000	-.2853771	-.1104719
lnOFIncome	-.0481946	.0219632	-2.19	0.028	-.0912417	-.0051474
LandOwner	-.111727	.0503921	-2.22	0.027	-.2104937	-.0129603
_cons	.8484889	.1423377	5.96	0.000	.5695121	1.127466
acc						
gen	.3794907	.1795825	2.11	0.035	.0275153	.731466
grp	.1591779	.1634303	0.97	0.330	-.1611396	.4794955
exxt	.3305448	.1540532	2.15	0.032	.0286061	.6324836
lnOFIncome	.1536437	.0772461	1.99	0.047	.002244	.3050433
LandOwner	.4631417	.163523	2.83	0.005	.1426426	.7836408
age	.0014396	.0055599	0.26	0.796	-.0094576	.0123368
fs_1	-.0538723	.024306	-2.22	0.027	-.1015111	-.0062335
FarmLoc_Beg	-.825871	.1637732	-5.04	0.000	-1.146861	-.5048815
educ	-.0643315	.0536956	-1.20	0.231	-.1695729	.0409098
hhs_n	-.0430008	.0265963	-1.62	0.106	-.0951286	.0091271
DisBank	.0210997	.0082274	2.56	0.010	.0049743	.0372251
Savings	.328314	.1106177	2.97	0.003	.1115073	.5451207
_cons	-1.298988	.5278614	-2.46	0.014	-2.333578	-.2643991
/lns1	-1.269166	.0878782	-14.44	0.000	-1.441404	-1.096928
/lns2	-1.154226	.079424	-14.53	0.000	-1.309894	-.9985578
/r1	-1.538953	.2727623	-5.64	0.000	-2.073557	-1.004349
/r2	-1.576172	.2800501	-5.63	0.000	-2.12506	-1.027284
sigma_1	.281066	.0246996			.2365954	.3338954
sigma_2	.3153015	.0250425			.2698486	.3684104
rho_1	-.9119442	.0459216			-.9688722	-.7634144
rho_2	-.918002	.0440441			-.9718761	-.7728167

LR test of indep. eqns. :   chi2(1) =   61.94   Prob > chi2 = 0.0000

Appendix 8: Test for Multicollinearity amongst explanatory variables in the ESR model

```
. pwcorr gen grp exxt lnOFIncome LandOwner acc age fs_1 FarmLoc_Beg educ hhs_n DisBank Savings, sta
> r(1)
```

	gen	grp	exxt	lnOFIn~e	LandOw~r	acc	age
gen	1.0000						
grp	0.0846	1.0000					
exxt	0.0033	0.0547	1.0000				
lnOFIncome	-0.3244*	0.0345	0.1593*	1.0000			
LandOwner	-0.0770	-0.0589	0.0866	0.1105	1.0000		
acc	0.0734	0.1612*	0.0867	0.0319	0.1518*	1.0000	
age	0.0629	0.2258*	0.0832	0.1060	0.0579	0.0746	1.0000
fs_1	0.0807	-0.0452	0.3766*	0.1335	-0.0163	-0.0406	0.0544
FarmLoc_Beg	0.0671	-0.2508*	0.0867	0.2079*	0.2215*	-0.0203	-0.0902
educ	0.0703	-0.0698	0.3319*	0.1637*	0.0227	0.0527	-0.1629*
hhs_n	0.0473	-0.0344	0.1267	0.1302	0.0353	-0.0103	0.4505*
DisBank	0.1617*	-0.1509*	0.0885	0.0002	0.0304	-0.0339	-0.1179
Savings	0.1159	-0.0834	-0.0266	-0.1442	0.0485	0.1159	-0.1150

	fs_1	FarmLo~g	educ	hhs_n	DisBank	Savings
fs_1	1.0000					
FarmLoc_Beg	0.2218*	1.0000				
educ	0.3983*	0.3186*	1.0000			
hhs_n	0.1788*	0.0007	-0.0834	1.0000		
DisBank	0.0307	0.4642*	0.0685	-0.0064	1.0000	
Savings	-0.1865*	-0.0200	-0.2924*	-0.0518	0.1798*	1.0000