DETERMINANTS OF ACCESS TO AGRICULTURAL CREDIT AND ITS EFFECT ON COFFEE PRODUCTION AMONG SMALLHOLDER COFFEE FARMERS IN GISAGARA DISTRICT, RWANDA

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Determinants of Access to Agricultural Credit and its Effect on Coffee Production among Smallholder Coffee Farmers in Gisagara District, Rwanda

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DECLARATION

This thesis is my original work and has not been submitted for a degree in any other university

Signature……. Date…..……

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This thesis has been submitted for examination with our approval as the university supervisors.

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DEDICATION

This thesis is dedicated to my beloved family and friends.

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LIST OF ABBREVIATIONS

EDPRS	:	Economic Development and Poverty Reduction Strategy
FAO	:	Food Agriculture and Organization
GDP	:	Gross Domestic Product
LDCS	:	Less Developed Countries
MINAGRI	:	Ministry of Agriculture and Animal Resource
MOLAD		Ministry of Livestock and Development (Kenya)
NAEB	:	National Agricultural Export Development Board
NISR	:	National Institute of Statistics of Rwanda

DEFINITION OF KEY TERMS

Credit

Credit is a transaction between two parties in which, one acting as creditor or lender supplies the other, the debtor or borrower, with money, goods, services, or securities in return for the promise of future payment. As a financial transaction, credit is the purchase of the present use of money with the promise to pay in the future according to a pre-arranged schedule and at a specified cost defined by the interest rate (Guarcello, Mealli & Rosati, 2010).

Microcredit

This refers to the process of lending small amount of money, without collateral to help poor people to become entrepreneurs. Microfinance is defined as "a diversity of financial services such as deposit facilities / savings, money transfers, remittances, loans for different purposes and insurance for a diversity of poor people among those micro entrepreneurs, employees, farmers and poor households (Karlan & Zinman, 2011).

Smallholder farmers

The term "smallholder" refers to their limited resource endowments relative to other farmers in the sector. Thus, the definition of smallholders differs between countries and between agro-ecological zones. Smallholders represent a large number of holdings in many developing countries and their numbers have increased in the last two decades (Godfray *et al*., 2010).

Productivity

The term "productivity" is commonly defined as a ratio between the output volume and the volume of inputs. The long-term productivity growth reflects improvements in

farmer production efficiency and technological progress (Itam, Ajah, & Agbachom, 2014).

Technical efficiency

The term “technical efficiency” is the effectiveness with which a given set of inputs is used to produce an output. A firm is said to be technically efficient if a firm is producing the maximum output from the minimum quantity of inputs, such as labour, capital, and technology (Ingabire, 2014).

ABSTRACT

Agricultural credit plays a dominant role in the development of the agricultural sector especially in developing countries. Credit remains important in financing production especially in the acquisition of inputs such as improved seed, fertilizers and pesticides, payment for labour services, purchasing of agricultural equipment and value addition among others. Despite the importance of agricultural credit, smallholder farmers in Rwanda face the challenge of access to agricultural credit. Consequently, the agricultural productivity has not only fluctuated but also declined over the last 5 years (since 2015 up to 2019). Thus, the purpose of this study was to investigate the determinants of agricultural credit access among smallholder coffee farmers in Rwanda. The objectives of the study were two-fold. First, the study assessed the determinants of credit access by smallholder coffee farmers in Gisagara District, Rwanda. Second, the study analyzed the determinants of technical efficiency in coffee production among smallholder coffee farmers who access and those who do not access agricultural credit in Gisagara District, Rwanda. A multi stage sampling technique was employed to select the respondents. The study collected primary data (for a period from 2015 up to 2019) from 222 smallholder coffee farmers using structured questionnaire. The binary logistic regression and stochastic production frontier models were employed to estimate the data. The results from the logit model indicated that the determinants of access to credit for the coffee farmers were gender, age, farm size, interest rate and cooperative membership. The results from the stochastic production frontier model revealed that all the production inputs (land under coffee, organic fertilizer, inorganic fertilizer and pesticide) except labour were significant ($p<0.01$) and had a positive influence on technical efficiency in coffee production for the farmers with access to agricultural credit. Amongst others, only the land under coffee was significant ($p<0.01$) and had a positive influence on technical efficiency in coffee production for the coffee farmers without access to agricultural credit. For socio- demographic and institutional characteristics in the stochastic model, the findings showed that there is a relationship between gender and technical efficiency in coffee production at 5%. Another relationship was found between farm size and technical efficiency in coffee production at 1% for coffee farmers with access to credit and at 5% for the coffee farmers without access to credit. The last relationship was found between cooperative membership, training and the technical efficiency in coffee production at 5% for coffee farmers without access to credit. The results of gamma show that the variations in coffee production were attributed to technical inefficiency at 89 % for farmers' users of credit and at 99 % for farmers' non-users of credit. The mean efficiency scores of the farmers were 0.94 and 0.84 respectively for coffee farmers who had accessed credit and those who had not accessed agricultural credit. This implies that on average the farmers who had accessed credit operated on a higher technical efficiency with a potential of increasing coffee production by a further 6 % only given the same level of inputs keeping all the other factors constant while those who had not accessed credit had lower technical efficiency than their counterparts who accessed credit. Thus, the farmers who did not access credit had a potential to increase coffee output by a further 16 % given the same level of inputs if

they accessed credit keeping all the other factors constant. The minimum efficiency scores of the farmers were 0.64 and 0.25 respectively for coffee farmers who had accessed credit and those who had not accessed agricultural credit. The maximum efficiency scores of farmers were 0.99 and 0.98 respectively for coffee farmers who had accessed credit and those who had not accessed agricultural credit. Further, the results of one-way ANOVA showed that the coffee farmers who had received credit were more productive than those who did not receive credit. Based on the findings of the study, the study concluded that 3 socio- demographic factors (gender, age, farm size) and 2 institutional factors (interest rate and cooperative membership) influenced the access to agricultural credit, and that agricultural credit had a significant effect on coffee production since in most cases it facilitated acquisition of farm inputs such as purchases of fertilizers and pesticides as well as payment of labour services. The study recommends that programs that encourage and put gender at an equal footing, policies aimed at empowering farmers' groups, and improving agricultural credit access will help boost coffee production in the study area. The study also recommended the introduction of more financial institutions such as agricultural and microfinance banks in rural areas so that the farmers can have more options and procedures for securing agricultural credits. There should also be streamlined in order to make it simple for the farmers.

CHAPTER ONE

INTRODUCTION

1.1 Background information

Agriculture remains a key sector of the economies of many developing countries. The agricultural sector accounts for a large share of gross domestic product (GDP) ranging from 30 to 60 percent, employs a large proportion of the labour force (ranging from 40 to 90 percent). It is a major source of foreign exchange (ranging from 25 to 95 percent) and it is a supplier of the bulk of basic food stuffs and provides subsistence and other income to more than half of the developing countries population (FAO, 2018). Agriculture remains the backbone of Rwanda's economy. Agriculture in Rwanda is a major source of income with over 80% of the population surviving through crop and livestock rearing (Bhattacharjee & Rajeev, 2010). In Rwanda, agriculture contributes approximately 33% of the national GDP, 70% revenue from exports of coffee and tea, and offers employment to over 72 % of the Rwandese population (FAO, 2018). Rwanda's principal crops include coffee, pyrethrum, tea, flowers, beans, cassava banana, Irish potatoes, rice, wheat, sugarcane, among others which cater for approximately 66% of the domestic food requirements and 34% of the income (MINAGRI, 2012). Livestock products and animals such as cattle, goats, sheep, poultry, pigs and rabbits are a major source of livelihood for the Rwandese farmers (MINAGRI, 2012; Hirwa *et al*., 2017). In Rwanda, 75% of agricultural production comes from smallholder farmers.

Whereas agriculture is the backbone of Rwanda's economy, the productivity of the agricultural sector for both food and cash crops such as coffee is still low and has been fluctuating since 2015 (FAO, 2018). Small-scale farmers in Rwanda face a number of challenges such as: low level of production and productivity enhancing technologies; low levels of agricultural skills; limited processing capacity and value addition facilities;

high cost of inputs; high transport cost associated with long distances from the sea ports, and poor transport infrastructure; weak coordination at all levels of the commodity value chains and poor access to markets, agricultural credit and extension services among other factors (Karangwa & Mbitsemunda, 2017).

Agricultural credit plays an important role in enhancing the agricultural productivity in developing countries such as Rwanda. Credit remains important in financing production especially in the acquisition of inputs including improved seed, fertilizer and pesticides, payment for labour services, purchasing of agricultural equipment and value addition among others (FAO, 2015; FAO, 2016). As noted by Nzomo & Muturi (2014), credit enables producers to meet their cash needs that are brought about by the production cycle which characterizes agriculture production. Activities such as land preparation, planting, cultivation and harvesting of the crops are often carried out over a period of several months with very little cash revenue or none earned, while expenditures on materials, purchased inputs and consumption need to be made in cash. When the cash income is received it is often for a short time after the crop harvest. Thus, in the absence of functional credit markets, farmers would have to maintain cash reserves so as to facilitate production and consumption in the next cycle. The availability of credit thus allows both greater consumption and greater purchased input use, and thus increases welfare of the farmers. This indicates that financing of agricultural inputs and labor wages require liquid cash which is not often readily available to the smallholder farmers. Therefore, it is essential to expand the status of rural credit at large to improve agricultural productivity. This will act as leverage to the problem of credit acquisition to the farmers. Hence, financial institutions should be encouraged to disburse more credits to farmers to address the credit needs of smallholder farmers (Henri-Ukoha *et al*., 2011).

In Rwanda formal credit from financial institutions remains scarce. The “credit terms” which are the minimum conditions set by lending institutions to which borrowers must adhere in order to qualify for loan are stringent in Rwanda which locks out many farmers from accessing credit (Hakim & Parrey, 2015). Thus, a number of farmers and generally households thus have resorted to borrowing credit informally from informal

sources such as friends or neighbors to finance their agricultural activities. However, lack of social capital and social network are some of the problems experienced in informal credit markets, thus, informal credit to remain highly segmented. Further, the cost of accessing informal credit varies depending on the lenders and the participants are often limited to only those with personal relationships such as friends and family or private moneylenders (Ringkvist, 2013).

Wiggins (2009) classifies the challenges to financial services into five main categories. The first category is the one which relates to socio-economic constraints that limit both the supply of and the demand for financial services. The second category deals with weaknesses in the macroeconomic environment that deters large segments of the population from using the services provided by the formal financial system. The third category identifies the characteristics in the operations of the formal financial system that impede the adequate provision of financial services to households and firms. The fourth category focuses on environmental deficiencies, with emphasis on the quality of the legal framework and the governability of countries. And finally, the fifth category identifies regulations that tend to distort the provision of financial services. The financial exclusion of smallholder farmers from credit is normally part of a wider social exclusion, which involves income, type of employment and education level amongst other factors. In general, the countries with greater access to social services and a better quality of life are the ones which have developed a stronger financial culture in which the use of financial services through formal markets becomes indispensable. The poor rural households in developing countries lack adequate access to credit and this lack of credit has negative consequences for poor people's agricultural productivity, food security, health, and overall household welfare (Girma & Abebaw , 2015).

Policy makers in Rwanda have prioritized credit as one of their key strategies for successful rural development. In addressing the problem of poor access to credit to farmers the National government of Rwanda has developed policies that cushion financial institutions particularly agriculture-based SACCOS against losses arising from defaulters (Henri-Ukoha *et al*., 2011). More over the Ministry of agriculture has also

been mandated to implement various programs including of training farmers on management of agricultural credit with view of enhancing of credit by farmers (Kajigija, 2018). While such policies have gone a long way in improving access to agricultural credit limited access to financial services by smallholder farmers is still a major constraint to agricultural productivity (Kajigija, 2018; Karangwa & Mbitsemunda, 2017; Muhongayire, 2012). It has been consistently reported over the last five years (2015-2019) that less than half of the farmers who need agricultural credit receive it (AFR, 2016; AFR, 2017; AFR, 2019). As noted by Ali, Deininger & Duponchel (2014), 78% of the coffee farmers in Rwanda are not able to access agricultural credit.

Various studies from different parts of the world including Abate, Francesconi and Getnet (2014); Chandio *et al*. (2017b) and Duy, Neuberger & Suwanaporn (2015) reported that credit enhances the living conditions of people by raising their farm productivity to boost their self-confidence by raising profits and well-being. Further, Kokoye *et al*. (2013) ; Saqib *et al*. (2016) ; Afrin *et al*. (2017); Chandio *et al*. (2018) and Silong & Gadanakis (2019) among others identify formal agricultural credit as an effective tool for capitalizing farm households in order to spend further and introduce new technology for agricultural production to increase agricultural efficiency. Dube, Mariga and Mrema (2015) investigated the determinants of access to formal credit by smallholder tobacco farmers in Makoni District, Zimbabwe. Fecke, Feil & Musshoff (2016) investigated the factors influencing loan demand in agriculture in Germany while the research of Akoété and Ablamba (2019) examined the impact of credit on cereal crops productivity in Togo. The motivation of this study is that whereas the increase in coffee production may come from credit access but also through improvement in farmers' technical efficiency is an important aspect for coffee production. Thus, not accounting for potential efficiency improvements due to credit constraints may be causing miscalculation of the benefits of credit programs.

There is scant information on the determinants of credit access for Rwanda and more so in coffee production. Although access to credit by farmers may be an important source of technical efficiency, the effect of credit access on efficiency of coffee production is

little known in the Rwandan context. This study fills the above gaps by investigating the determinants of credit access and its effect on technical efficiency of coffee production amongst smallholder farmers in Gisagara District, Rwanda. Coffee is used as the crop of interest because it is a major source of rural households' income and livelihood and remains the main export earner for Rwanda through its generation of about 27% of the total export revenue (Pinard, Boffa & Rwakagara, 2014). The findings of this study are important in provision useful insights to policy makers and coffee farmers that will help establish measures boosting coffee production in Rwanda.

1.2 Statement of the problem

Coffee plays a key role major role in the Rwandan economy, contributing significantly to foreign exchange earnings and offering a significant source of livelihood to the rural people. Coffee farming in Rwanda which is majorly dominated by smallholder farmers in land holdings of less than one hectare contributes to the Rwandan economy in terms of employment and income (Mutandwa *et al*., 2009; NAEB, 2017). For the last two decades, coffee farming has been Rwanda's top export product and thus main source of foreign exchange income (Tobias & Boudreaux, 2009). Statistics indicate that in 2012, coffee accounted for almost 30 percent of Rwanda's total export revenue (Hakorimana & Akcao, 2017). Currently, coffee provides a livelihood for almost 500,000 Rwandan families (corresponding to approximately 2 million people and 25 per cent of the total population) who belong to cooperatives and grow coffee in small plots (Boudreaux, 2007; NAEB, 2017). Coffee covers an estimated 42,000 hectares which is approximately 2.3% of total cultivated arable land in Rwanda. While the area under coffee and the number of coffee farmers have been increasing, coffee yields have remained stagnant and, in some cases, even declining since 2015.

The data reported by the International Coffee Organization (ICO) have shown that Rwanda's average productivity from 2011/12 to 2013/14 was 385 kg / ha for Arabica green coffee, or approximately 43% below the East Africa average of 604 kg / ha (Clay *et al*, 2016). Other data from NISR (2015) had shown that the Country produces

between 16,000 and 20,000 MT of coffee annually, with a productivity index of approximately 400 to 600 Kg / ha of green coffee. Rather, the primary reason for Rwanda's continued low productivity is widely believed to be due to farmer non-adoption of best practices, especially in the use of fertilizers, manure and other inputs, as well as in how coffee trees are maintained in the field through pruning, mulching, stumping, and other labor-intensive practices. In point of fact, fertilizer applications in Rwanda are reported to be less than a quarter of what is recommended as industry best practice (Clay *et al*, 2016). For instance, production of green coffee was 18,793 metric tons in 2015 while in 2016 the production dropped by 152 Mt to 18,641 MT while in 2017 the production rose only by 123 metric tons to 18,670 metric tons which is far less than the drop in 2016. The initial production of 18,793 metric tons was thus not attained in two consecutive years. Although, a significant improvement of 2,643 metric tons was documented for the period between 2017 and 2018, with a total production of 21, 313 in 2018, a big short fall of 5,095 metric tons was documented in the year 2019 (NAEB, 2019). Some studies have associated continued decline in coffee production to increased cost of inputs (Clay *et al*, 2016). This implies that many farmers are not able to afford purchase of key required inputs for coffee production hence the decline in production. Financing of smallholder coffee farmers through formal credit could thus offer a solution to the decline in production. However, as noted by Ali, Deininger & Duponchel (2014), 78% of the coffee farmers in Rwanda are not able to access agricultural credit. Further, quantitative information on specific credit access constraints and its effect on coffee production in Rwanda is scanty. Very little information is available on determinants of agriculture credit access among smallholder coffee farmers in Rwanda. Further, the effect of credit access on efficiency of coffee production in Rwanda is little known. Thus, the purpose of this study was to investigate the determinants of access to agricultural credit and its effect on efficiency of coffee production among smallholder coffee farmers in Gisagara District, Rwanda.

1.3 Objectives

1.3.1 Main Objective

The main objective of this study was to investigate the determinants of access to agricultural credit and its effect on coffee production among smallholder coffee farmers in Gisagara District, Rwanda.

1.3.2 Specific objectives

i) To assess the socio - demographic and institutional determinants of agricultural credit access among smallholder coffee farmers in Gisagara District, Rwanda.
ii) To analyze the determinants of technical efficiency in coffee production among smallholder coffee farmers who access and those who did not access agricultural credit in Gisagara District, Rwanda.

1.4 Hypotheses of the study

This study tested the following two hypotheses:

i) Socio - demographic and institutional factors have no significant influence on agricultural credit access among smallholder coffee farmers in Gisagara District, Rwanda.
ii) There is no significant difference in coffee production among smallholder coffee farmers who access and those who do not access agricultural credit in Gisagara District, Rwanda.

1.5 Justification of the study

Coffee remains one of the most important globally traded commodities and substantially contributes to the livelihoods of millions of smallholders worldwide. In Rwanda, coffee is the major export earner and a source of livelihood and income for the majority of the households. Rwanda has a remarkable comparative advantage in high quality specialty

coffee, an advantage not shared by any other high priority crops such as maize, bean, rice, wheat, and cassava. Coffee also grows well on the steep hillsides of Rwanda, which thus protects the landscape against devastating soil erosion and thus eliminating the need for high-cost terrace construction and maintenance that is required to make steep fragile slopes stable and productive (Clay & Bizoza *et al.*, 2018). Coffee in Rwanda is mainly grown by the smallholders and remains the backbone of its economy. Whereas coffee is the backbone of Rwanda's economy, its productivity is still low and has been fluctuating since 2015 (FAO, 2018). One of the challenges that smallholder farmers face in Rwanda is the high cost of inputs and the dwindling market prices of the cherries. The smallholder coffee farmers face the problem of access to credit, which is an important precursor to the adoption of improved farm technologies, innovations and access to appropriate market channels (Hussain & Thapa, 2012; Jan & Khan, 2012). Notably, as observed by Nouman *et al*. (2013), Girma and Abebaw (2015), financing agriculture through access to both formal and informal credit would lead to adoption of technology and hence improved production. Access to credit may affect farm productivity because farmers facing binding capital constraints would tend to use lower levels of inputs in their production activities compared to those not constrained (Feder *et al*., 1989; Petrick, 2004). Improved access to credit may therefore facilitate optimal input use and have a major impact on productivity. Thus, access to credit allows farmers to satisfy their cash needs induced by the agricultural production cycle and consumption requirements. Unfornately, credit access to farmers especially in Rwanda remains a challenge (Kajigija; 2018). Thus, identifying the demographic, socio-economic and intervening factors affecting credit access of farmers is expected to inform policy by providing information to lenders and policy- makers that will enable designing appropriate measures to improve smallholder farmers' access to formal credit in the study area. This study provides useful insights that would serve as an input for policy makers and financial institutions in formulating sustainable rural credit policy.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theories on access to credit and productivity

The study is guided by four theories. The three theories of credit markets which are: permanent income model, upward sloping credit supply to individual borrowers and constrained credit due to imperfect enforcement. There is also a productivity theory to analyze the effect of credit access on coffee productivity in Rwanda.

2.1.1 Permanent income model

This theory attempts to describe how farmers spread consumption over their lifetimes and supposes that farmers' consumption at a point in time is determined not just by their current income but also by their expected income in future years. It states that changes in permanent income, rather than changes in temporary income, are what drive the changes in a consumer's consumption patterns (Hall, 1978). The farmer income consists of a permanent (anticipated and planned) component and a transitory component. The permanent income is defined as expected long-term average income. The longer-lasting changes in income will have a large effect on spending. A farmer's permanent income is determined by assets such human (education and experience), physical (property) and financial (shares, bonds). These influence the farmer's ability to earn income and can help a farmer to make an estimation of anticipated lifetime income. The farmers save only if they expect that their long-term average income, i.e., their permanent income, will be less than their current income. The permanent income model has the advantage (among others) that it can help resolve the (alleged) inconsistency between occasionally arising large-scale fluctuations of disposable income and the considerable stability of consumption expenditures. According to the permanent income model, the distribution of consumption across consecutive periods is the result of an optimizing method by which each consumer tries to maximize his utility. At the same time, whatever ratio of

income one devotes to consumption in each period, all these consumption expenditures are allocated in the course of an optimization process, that is, consumer units try to optimize not only across periods but within each period.

2.1.2 Upward sloping credit supply to individual borrowers

This theory reveals that individual's choices over time determine how much he or she will borrow or lend (Stiglitz & Weiss, 1981). In particular, a farmer loan supply is upward sloping: when the real interest rate increases, a typical household will supply a greater quantity of funds to the credit market. The market loan supply is obtained by adding together the individual loan supplies of everyone in an economy. The demand for credit comes from households and firms that are borrowing. The market loan demand is obtained by adding together all the individual demands for loans. The theory explains that when real interest rates increase, borrowing is more expensive, so the quantity of loans demanded decreases. That is, loan demand obeys the law of demand. Borrowers and lenders interact in the credit market (or loan market), credit market equilibrium occurs at the real interest rate where the quantity of loans supplied equals the quantity of loans demanded. At this equilibrium real interest rate, lenders lend as much as they wish, and borrowers can borrow as much as they wish. All gains from trade through loans are exhausted in equilibrium. As the real interest rate increases, more loans are supplied, and fewer loans are demanded.

2.1.3 Constrained credit due to imperfect enforcement

This theory defines the range of financial contracts that can be signed or honored due to capital market imperfections into three main reasons (Korinek, 2011). First, asymmetric information, where lenders do not have full information about the borrower, whether they have the capacity to pay back their debt and/or whether they are willing to pay. The asymmetric information defined in two ways: Adverse selection which occurs before signing the contract. Here, the lenders do not have information about the type of borrowers (i.e., whether the borrower tends to engage in riskier projects or not). The

borrower type is only known by the individual and occurs when there are not enough tools to screen the borrower types. The screening offers different types of funds having different interest rates and asking different amounts of collateral in order to reveal the information about the type of the borrower. Moral hazard often occurs after signing the contract. Here, the borrower will tend to make riskier project since he does not take the full responsibility of the funds. As the interest rate increases, the possibility of the borrower to engage in riskier projects increases in order to increase the expected return. It is assumed that the riskier projects have higher expected return.

Second, limited commitment where lender needs to trust the borrower to commit and to pay back his / her debt or there needs to be a third party to enforce the contract as it is more difficult to enforce contracts. The borrower may declare bankruptcy, and thus, may not pay the debt back. One of the options in dealing with the limited commitment problem is providing collateral. The contract is formed such that in case of default, the lender has all/some rights to seize the collateral. This is called a secured loan in finance. However, it does not fully solve the problem because there are costs (money and time) associated with seizing the pledged asset. Another reason for capital market imperfections associated with limited commitment is the ability of the borrower to renegotiate the terms of the contract. Even though the contract is signed as a secured loan, because of the enforcement costs, the lender never gets the full payment in case of default. The borrower always has the option to offer more than the lender would get in case of default, but less than the full payment. That is why the incentive compatibility is needed to ensure binding contracts, in imperfect capital markets.

Third, since the exchange does not happen at the same time, there is always room for renegotiation. In perfect capital market case, assuming complete markets, perfect rationality of agents and under full information, the equilibrium occurs where the interest rates clear the market, with the supply of funds equal to the demand. In an idealized perfect market, economists expect the market to achieve every desired exchange for homogeneous goods when there is only one price. Based on that, to have a perfect capital market, every agent may exchange funds at the existing single interest

rate for each type of fund. As the interest rate rises, the possibility of selecting riskier borrowers increases as the cost increases less for them as they may not pay it back. Hence, as the interest rate goes up, the return to the lender decreases only considering the adverse selection effect. Considering these two opposite effects, the lender may determine the interest rate to maximize the rate of return so it does not necessarily clear the market. In that situation, some individuals cannot obtain any credit at the existing market interest rate although they are willingly to pay the market value. Hence, there is credit rationing as a result of imperfection in capital markets.

2.1.4 Productivity theory and credit access

The word productivity refers to the process of converting input resources into outputs over a specific period of time. It is the way the input resources are organized to produce goods and services. Productivity is defined as a ratio of combined output (e.g., land, capital and materials) - such as aggregate crop or livestock output to aggregate inputs. Productivity changes occur when output grows faster than the rate of input growth. This leads to an improved real or value output growth, which in turn implies greater output from a given possible input sets and outputs (production possibilities set). Productivity changes may also emanate from increased intensification i.e., higher use of inputs that are not related to land such as capital, labour, water or fertilizer or due to price change thus resulting in an increase in value. Productivity is often a measure that is used to describe the efficiency of a production process. Usually, it is expressed as the ratio of the total output to a single input used in the production process. Productivity measurement has its origins in the microeconomics “theory of the firm”, which provides the possibility of combining inputs through the allocation of scarce resources, thus allowing firms to maximize profits subject to a cost constraint or to minimize costs subject to an output constraint. Both possibilities normally result in an input allocation that is efficient or optimal. When the farmers become efficient or optimal in their production process then they are able to allocate scarce resources to other activities of importance. Thus, farm productivity can be influenced by many factors one of them being credit access. Access to credit may affect farm productivity because farmers facing binding capital

constraints would tend to use lower levels of inputs in their production activities compared to those not constrained (Feder *et al*., 1989; Petrick, 2004). Improved access to credit may therefore facilitate optimal input use and have a major impact on productivity. Thus, access to credit will allow farmers to satisfy their cash needs induced by the agricultural production cycle and consumption requirements.

2.2 Review of empirical studies

2.2.1 Empirical studies on determinants of access to agricultural credit

A number of studies examine the determinants of access to agricultural credit. Chandio *et al*. (2020) analysed the determinants of demand for credit by smallholder farmers in Pakistan. The study used an Ordinary Least Square regression model and collected data from 90 smallholder rice farmers. The study revealed that formal education, experience of farming, landholding size, access to roads and extension contacts positively and significantly influenced the demand for formal credit among smallholder farmers. The study recommended that there was need to improve access to extension services for rice growers and also to provide extension-related information to the rice growers as this increases the probability of access to agricultural credit from financial institutions. In addition, the study recommended that financial institutions should supply agricultural credit to small-scale farmers at low interest rate and the terms and conditions should be made easy and flexible.

Elias, Ahmad and Patil (2015) evaluated the determinants of access to agricultural credit for small and marginal farmers in Dharwad District, Karnataka of India. The study used a binary logistic regression model and collected data from 120 farmers. The results showed that accessibility of agricultural credit for small and marginal farmers was driven by land size, education level, irrigation facilities, income level and gender. The study recommended that policies need to be redirected on government-sponsored and guaranteed agricultural financing schemes that could favour the small and marginal farmers who are the major producers of food crops in the country.

Gebeyehu (2019) evaluated the determinants of access to agricultural credit among smallholder maize farmers in Ethiopia. The study used a probit model on a sample size of 260 households. The results of the study showed that age, sex, education, number of livestock owned, year of membership for the credit institution, frequency of extension contact and distance from credit source were significant factors affecting farmers' accessibility to agricultural credit. The study recommended that the government should formulate a well-functioning system of providing credit.

Ajah, Igiri and Ekpenyong (2017) examined the factors influencing credit accessibility and identified constraints faced by farmers in credit acquisition in Nigeria. The study used a logistic regression model and collected data from 96 Rice farmers from four communities. The results showed that the factors that influenced credit accessibility were age and annual income. The major constraints faced by rice farmers in accessing credit were found to be high interest rate, lack of guarantor and collateral. The study recommended that high rate of interest charge by credit supplier should be reduce and farmers should be encouraged on ways of increasing their farm income through diversification.

Hananu *et al.* (2015) identified the factors influencing agricultural credit demand of farmers using a logistic regression model on sample size of 2,330 farm households in Ghana. The results revealed that age, education, group membership and source of credit influenced agricultural credit demand. The study recommended stakeholders to encourage formation of cooperatives to enable farmers pull resources together and intensify education to farmers on loan procedures and promote flexibility in type of collaterals demanded by financial institutions in order to enhance access.

Chauke *et al*. (2013) investigated the factors that affected smallholder farmer's access to credit in Limpopo Province, South Africa. The study used a logistic regression model and a sample of 250 smallholder maize farmers. The results indicated that the demand for credit, attitude towards risk, the distance between lender and borrower, perceptions on loan repayment and lending procedures and the total value of assets had a significant

impact on access to agriculture credit. The study recommended the establishment of loans offices close to farmers and operated by officer's familiar with farmers to reduce lending procedures, risks and educate them on perceptions on loan repayment.

Muiruri *et al*. (2012) analysed the socio-economic and institutional constraints to accessing credit among smallholder farmers in Nyandarua District of Kenya. The study used a logistic regression model on a sample size of 164 smallholder farmers. The study established that socio-economic constraints such as age, gender, household size, farm income, collateral and awareness are critical determinants of access to credit. The study also established that institutional requirement such as costs involved in operating / maintaining bank accounts, loan requirements and transaction costs involved in the credit process influenced access to credit. The study recommended the need by government to deal with bureaucracies involved in land registration to benefit majority of smallholder farmers who remain insecure in the land they use without proof of ownership and also to make easier the registration of lease certificates for those who do not own land and use land on leasehold tenure system. Financial institutions should also put in place less stringent credit requirements and reduce credit costs especially interest rates to make credit more affordable.

Kajigija (2018) analysed the determinants of smallholder farmers access to formal credit, using a binary logistic on secondary data drawn from the FinScope Rwanda 2016 survey conducted in 2015/2016 in Rwanda. The sample was based on 780 villages enumeration area (villages) and 158, 386 households. Although, the results of the study revealed that both households which were headed by male and female were not statistically significant, there were discrepancies in smallholder farmers living in urban and rural areas in accessing formal credit and also the difference in wealth groups in accessing credit from the formal sources was statistically significant. The study recommended that improving transportation infrastructures such as roads, telecommunication, and other infrastructures in different areas would make financial services providers more accessible across the provinces. Karangwa and Mbitsemunda (2017) investigated the determinants of financial inclusion for small scale farmers by

focusing on the access to formal and informal agricultural credits in the Southern Province of Rwanda. The study used a binary logistic regression model on a sample size of 310 smallholder farmers. The results of the study revealed that the household characteristics and the community attributes are the most important determinants. The household determinants included household income and expenditure, off-farm employment and the size of the land owned by the household whereas community attributes that influenced credit access included residence area, transport and informal financial services availability. Regarding farmer characteristics, the education level was found to be the only factor affecting the smallholder farmers' access to agricultural credit. The study recommended that the need to conduct sensitization sessions focusing on the importance of agricultural credits for smallholder farmers especially in the areas with high level of poverty. In addition, the study recommended that there was need to work on alleviating the formal agricultural credits access barriers, and to conduct a study on the dynamics of informal and formal agricultural credits up take and usage by smallholder farmers to explore all dimensions of financial inclusion in the study area.

Muhongayire (2012) assessed the factors influencing smallholder farmers' access to formal credit in Rwamagana District, Rwanda. The study used a binary logistic model and a sample size of 185 smallholder farmers. The study showed that, participating in informal credit increased the likelihood of participating in formal credit by 29.2 percent. The study further found that off-farm income, agricultural extension service, participating in informal credit and education level of household head were statistically significant at 1 percent level of probability. The farmers earning more off farm income increased the likelihood of participating in formal credit by 4.6 percent. In addition, farmers with higher levels of education and those who receive technical advice from agricultural extension services were found to be more likely to use formal credit (14.9 percent versus 14.5 percent respectively). The study recommended that the following policies aimed at improving farmers' access to formal credit: policies aimed at increasing opportunities for off farm activities, not only focusing on increasing agricultural production; promotion of agricultural extension services geared towards

increasing training to the farmers and redoubling of efforts to improve education levels at Rwamagana District since education made people to arrive at informed decisions about loans.

2.2.2 Effect of agricultural credit on coffee production

Some studies exist in the literature that examines the effect of credit on agricultural production. For example, Shivaswamy *et al.* (2020) examined the impact of institutional credit on agricultural development through complementing working capital, easing liquidity and investment constraints in India. The study analyzed data from the trends and regional variations in institutional credit flow to agriculture for the period 1991-92 to 2016-17 using compound annual growth rate. The findings indicated that institutional credit to agriculture in real terms had registered a significant positive growth during the past four decades and the highest annual growth was observed during 2001-02 to 2010-11. The study recommended that there should be better access to credit of smallholders through simplification of procedures.

Ahmet *et al*. (2019), evaluated the effects of government supports and credits on agriculture in Turkey. The study applied a spatial panel analysis model that incorporated spatial interactions among the dependent and explanatory variables to assess the impact of government support and credit on agricultural output. A provincial data set of agricultural output values, input factors and government subsidies from 2004 to 2014 was used to model the spatial spillover effects of government supports. The findings showed that a 1% percent increase in agricultural credits in a given province led to an average increase of 0.17 percent overall in agricultural value-added per hectare, including 0.05 percent from the direct effect and 0.12 percent from the spillover effect.

Chandio *et al.* (2018) assessed the impact of formal credit on agricultural output in Pakistan. The study used the secondary data from a period of 1996 to 2015. The Johansen Co-integration test (Trace Statistic) was used to find out whether there existed a long run relationship between formal credit and agricultural output while OLS was

used to estimate the impact of formal credit on agricultural output. The empirical regression results indicated that formal credit was statistically significant with 1% increase in credit increasing agricultural output by 0.86%. The author recommended that the procedure of credit should be made simple, flexible, and financial institutions should launch crop insurance scheme in case of crop failure by flood, draught, pest attack, and heavy rains. Also, the government of Pakistan should support small farmers through credit schemes on affordable interest rate.

Akoété and Ablamba (2019) analysed the impact of agricultural credit on maize, sorghum and paddy rice productivity in Togo. The study used: the propensity score matching (PSM), or matched groups method, and the endogenous switching regression (ESR) method to analyse the data. The data was obtained from the Togo National Census of Agriculture for the period of 2012 – 2013 covering all economic regions and rural farm households in the Country. The results revealed credit in kind had a positive and significant impact on the productivity of maize, sorghum but had no significant impact on paddy rice. In contrast, the impacts on productivity of credit in hard cash are negative with respect to maize, positive with respect to sorghum, and no significance with respect to paddy rice. The study recommended that the agricultural credit supply should address the systemic needs of financing family farms in order to reduce the diversion of cash loans. Further, in-kind credit should be encouraged particularly by pursuing the agricultural input subsidy policy.

Akudugu (2016), in Ghana, examined the connections of agricultural productivity, access to credit and farm size. The hierarchical competitive model was used for the quantitative analysis which was supplemented with qualitative analysis of key informant interviews, focus group discussions and household case studies. The results showed that there is significant relationship between credit from formal and informal sources and agricultural productivity. Access to formal and informal credit was found to increase farm household agricultural productivity by about 0.10 ($p=0.05$) and 0.45 ($p < 0.01$), respectively. The research recommended that policy-makers and practitioners in Africa

and Ghana in particular should incorporate credit provision into the agricultural transformation agenda of the continent.

Awotide *et al*. (2015) employed the endogenous switching regression model to analyze the impact of credit access on cassava productivity in Nigeria. The study used a sample of 860 households. The results revealed that total livestock unit and farm size were positive significant determinants. At the second stage of estimation, total livestock unit and farm size were negatively and statistically significant in explaining the variations in cassava productivity among the farmers with credit access, while household size, farm size and access to information assets were negatively and statistically significant in explaining the variation in cassava productivity among farmers without credit access. Finally, access to credit had a significant positive impact on the productivity of cassava. The study recommended that credit institutions should consider boosting their credit services to rural farming households in order to guarantee that more households benefit from it.

Nzomo and Muturi (2014), analyzed the effect of types of agricultural credit programmes on productivity of small-scale farming businesses in Bungoma sub-County, Kenya. The study adopted a cross sectional survey design, where data was collected using a well-structured questionnaire from 123 randomly selected small-scale rural farmers, who were users of micro-credit. Descriptive statistics was used to analyze the qualitative data while cross-tabulations were done to examine the relationship between variables. The findings of the study showed that, agricultural credit had the capacity to enhance the income of farmers who utilize it by more than 100%. Credit was found to help expand the economies of size and increase the productivity of farms from the available resources. The author recommended that the government should provide attractive incentive system to farmers so as to boost production from the smallholder sector including the provision of "soft loans" to farmers on very generous terms.

Kiragu (2015) used secondary data to establish the relationship between agricultural financing and productivity of dairy farming in Central Kenya through a census survey.

Time series data for the period 1981-2013 from the Kenya Dairy Board, MOLAD, Department of Cooperatives and Marketing, National Bureau of Statistics and County Offices in Kenya was used. The regression model was developed to quantify the impact of credit, number of dairy cattle and number of cooperatives on milk yield. From the study it was established that there was a positive relationship between agricultural financing and dairy farming productivity. Financing was found to facilitate acquisition of input resources for improved productivity such as additional dairy cattle, animal feeds, and improved technology and extension services. The study recommended that various stakeholders should strive to carry out researches on other forms of financing which are also key to the productivity of dairy farming including grants, personal savings and supplier's credit. This would enable them to know which form of financing was more impactful and hence be increased. The study also recommended a nation-wide study of the same.

Ali *et al*. (2014) used a direct elicitation approach for a national sample of Rwandan rural households to assess empirically the extent and nature of credit rationing in the semi-formal sector and its impact using an endogenous sample separation between credit-constrained and unconstrained households. The study used secondary data from World Bank survey of 2011 comprising of a sample of 3600 households. The study found that being credit constrained reduced the likelihood of participating in off-farm self-employment activities by about 6.3 percent while making participation in low-return farm wage labor more likely. Even within agriculture, elimination of all types of credit constraints in the semi-formal sector was found to increase output by about 17 percent. The study further suggested that access to information (education, listening to the radio, and membership in a farm cooperative) had a major impact on reducing the incidence of credit constraints in the semi-formal credit sector. The study recommended that expanding access to information in rural areas would be a key strategy in improving credit access in the short term. Further, the study recommended that making it easy to identify land owners and transfer land could also significantly reduce transaction costs associated with credit access.

2.3 Summary and research gap

It is evident that from the existing studies there is no consensus on the determinants of access to agricultural credit. Further; a number of existing studies focus on credit access on agriculture in general with very few focusing on specific enterprises and none focusing on coffee production. So far there is limited information on the determinants of agricultural credit access and its effect on coffee production in Rwanda. Studies conducted under Rwandan context are deficient on determinants of agricultural credit access especially with focus to coffee farmers. None of the existing studies have investigated the determinants of credit access in coffee production for Rwanda. Further, the effect of credit access on coffee production is not yet known under the Rwandan context. This study fills the above gaps by investigating the determinants of credit access and its effect on coffee production amongst smallholder farmers in Gisagara District, Rwanda.

2.4 Conceptual framework

In this study the agricultural household's credit access is modeled to account for decisions at the farm and household levels. The institutional characteristics are incorporated as part of the analysis to establish their effect on credit access. Production inputs such as labour, fertilizer or pesticides have an important implication on amount of coffee production and credit may form a major source for these inputs. All the above factors affect agricultural credit access or amount of coffee produced.

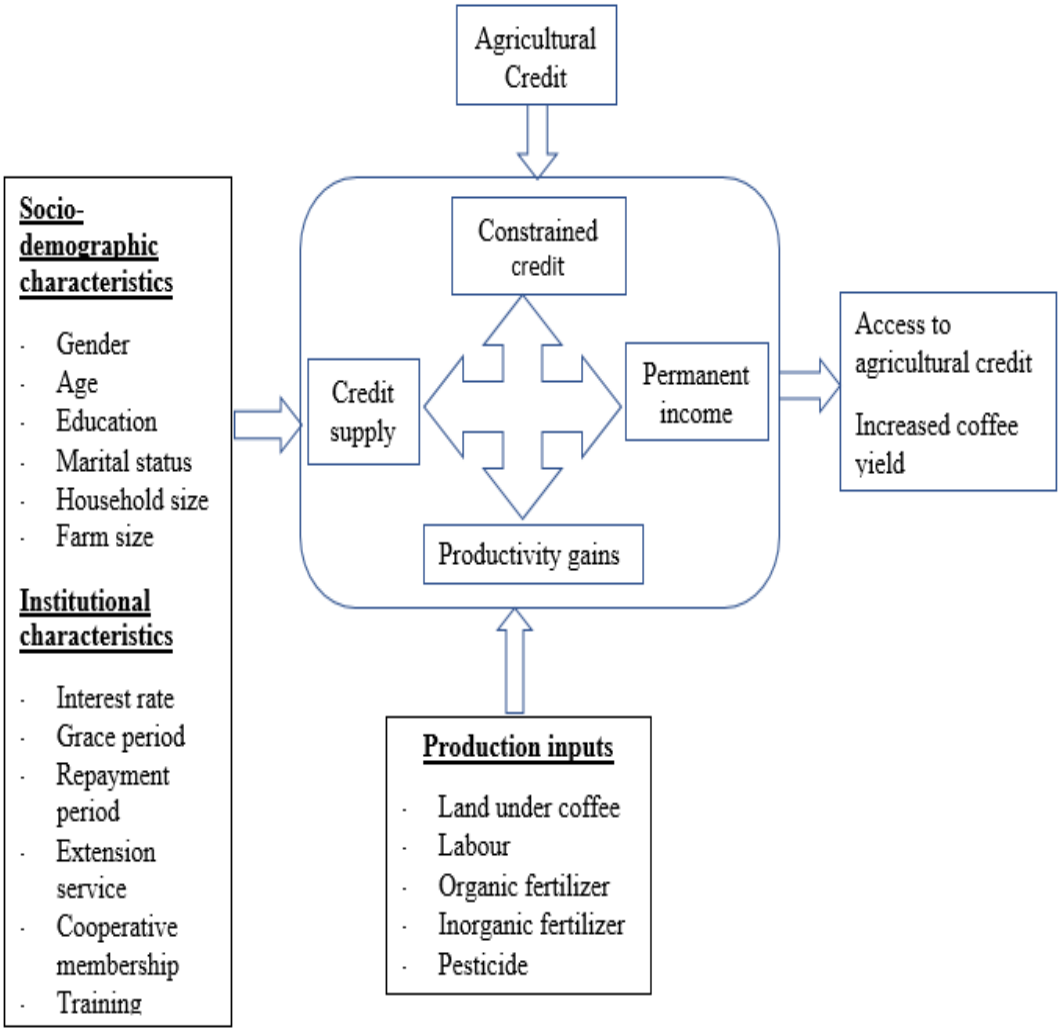

Figure 2.1: Conceptual framework

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter highlights methodological details appropriate to the study. It presents the overall approach to the research process from the theoretical framework to the collection and analysis of data which was used by the researcher in order to ensure the success of the study. It includes the research design in section 3.2, study area in section 3.3, study population in section 3.4 and the sampling and sample size determination in section 3.5. The data collection and data management analysis are outlined in sections 3.6 and 3.7 respectively.

3.2 Research design

The research design is an outline or plan that used to generate answers to research problems or hypotheses (Oluwabunmi, 2017). A research design is an arrangement of conditions of data collection and analysis. This study used a descriptive survey methodology to assess the factors affecting agricultural credit accessibility in Rwanda. A descriptive survey methodology was preferred because statistical information (both qualitative and quantitative) can be obtained and analysis of data can be made to deduce desired results.

3.3 Study area

The study was conducted in Gisagara District, Rwanda. Gisagara district forms one of the 8 Districts that make up the southern province of Rwanda. The district is composed of 13 administrative sectors namely: Gikonko, Gishubi, Kansi, Kibilizi, Kigembe, Mamba, Muganza, Mugombwa, Mukindo, Musha, Ndora, Nyanza and Save and 54 administrative cells. The Gisagara district is bordered to the South by the Republic of Burundi, to the North by Nyanza District, and to the West by Huye and Nyaruguru

Districts. The district covers a surface area of 678 km^2. The total population of Gisagara district in 2010–11 was 322,803 and the increase during last 10 years has been 2.1% per year which accounts for 80% of the national average of 2.6%. The population density is 475 person / km^2 which is 14% higher than the national average of 416 person / km^2. Gisagara district has an altitude ranging between 1600 and 1800 meters with two wet seasons and two dry seasons. The short-wet season is in October and November while the main rainy season lasts from mid-March to the end of May. However, it should be noted that the succession of seasons becomes irregular from year to year and causes dryness resulting to periods of drought. Gisagara's average temperature is 20^0C.

The main crops grown in Gisagara district include rice, maize, cassava, and coffee. Though the majority of the community does farming at a subsistence level, the district has some well-organized commercial farmers, such as rice and coffee growers. Coffee and (to some extent) rice are the only cash crops grown in the district. Agricultural processing (coffee washing stations and rice processing factory) is the only major industry found in the district, but small-scale coltan and cassiterite mining activities are also found in the area. The tertiary sector mainly comprises of retail commerce, transport services, construction, and artisanship.

The choice of this study area was motivated by the fact that Gisagara district is among the districts that have many coffee farmers numbering about 11,350 and 10 processing factories (NAEB, 2015), thus, serves as a good basis for analysing determinants of credit access and its effect on coffee production.

3.4 Target Population

A population refers to the aggregate of all cases that conform to some designated set of specifications; it is the entire set of relevant units of analysis or data (Oluwabunmi, 2017). The research study targeted 500 coffee families registered in 3 sectors during the time of data collection. 176 coffee families were registered in Musha Sector; 157 coffee

families were registered in Kigembe Sector while 167 coffee families were registered in Mukindo Sector.

3.5 Sampling procedure and sample size

There are different sampling procedures in research methodology (Davies *et al.,* 2008), and this study chose four sampling stages amongst others which are purposive sampling, stratified sampling, cluster sampling and simple random sampling. In the first stage, 3 out of the 13 sectors in Gisagara district were purposively selected using criteria such as number of individual coffee farmers, coffee cooperatives, coffee washing stations and financial institutions available in the area. The three sectors that were selected were Musha, Kigembe and Mukindo. In the second stage, stratified sampling was used to divide the sample of coffee household farmers into strata of credit users and non-credit users. In the third stage cluster sampling technique was employed to select equal number of respondents per cell as provided in Table 3.1. Finally, simple random sampling was used this means every coffee farmer was having an equal chance of selection. The list of total household heads in the selected sectors was obtained from the sector office. The Slovin's formula was used to calculate the sample size; at 95% confidence level (this produced a margin of error of 0.05). The formula used was as follows: $n= \frac{N}{1+Ne^2}$, where n is the sample size; N is the population size while e is the acceptance sampling error which is 0.05. Thus, the sample size was calculated as follows: $n = \frac{500}{1+500(e)^2} = 222$. The total number of coffee farmers that was sampled was thus 222 coffee farmers.

Table 3.1: Sampling frame

Sectors	Coffee farmers	Credit users	Non – credit users	Total sample
Musha	176	30	44	74
Kigembe	157	30	44	74
Mukindo	167	30	44	74
Total	**500**	**90**	**132**	**222**

3.6 Data collection instruments and procedures

Primary data were used for this study. Data were collected from the sampled smallholder farmers who accessed credit and those who did not access credit using a structured questionnaire. This method was used to collect primary data from sampled smallholder coffee farmers. The closed questions were adequately used to acquire accurate responses because they are easier for the respondents to understand and answer. The open-ended questions were used to give respondent free space to provide deeper answers to questions. This allowed respondents to explain more about agricultural credit accessibility. The questionnaire was written in a simple and clear language for the respondent to feel free while answering. The information collected from the survey included output data (coffee production and access to credit); socio-demographic data such as gender, age, educational level, marital status, household size and farm income; farm characteristics such as total size of land the household owned, ownership status and land under coffee production; information on production inputs (labour, fertilizer, pesticide), institutional factors (loan received, interest rate, grace period, repayment period, access to extension services, cooperative membership and training status).

3.6.1 Validity and Reliability

The validity test analyses the accuracy, correctness, meaningfulness and usefulness of the questions. Thus, it inquires the intent of the questionnaire and analyse if it is appropriate to the chosen population (Weiner; 2007). The reliability of a measure is the degree to which a measurement technique can be depended upon to secure consistent results upon repeated application while validity of a measure is the degree to which any measurement approach or instrument succeeds in describing or quantifying what it is designed to measure (Weiner, 2007). Then, the reliability test was done to measure how the responses from farmers can be reproduced under a similar methodology (Kiiru; 2011). Cronbach's Alpha was performed to check the reliability of questions as well as measure internal consistency. Cronbach's alpha value normally ranges between 0 and 1. However, there is actually no lower limit to the coefficient. If it is closer to 1.0 it indicates the greater internal consistency of the items in the scale. Lakshmi and Akbar (2013) provided the following rules of thumb that helps in interpreting the value of Cronbach's Alpha: $\alpha > 0.9$ means excellent internal consistency of the items in the scale, $\alpha > 0.8$ implies that it Good, $\alpha > 0.7$ means that acceptable, $\alpha > 0.6$ indicates that it is questionable, $\alpha > 0.5$ signifies that it is poor, and < 0.5 is unacceptable. The total questions were 19 including socio- demographic, institutional characteristics and questions on production inputs. Hence the computed coefficient Cronbach's Alpha was 0.7 indicating an acceptable internal consistency accordingly to Lakshmi and Akbar (2013)**.**

3.6.2 Pilot testing

It was done by pre-testing the questionnaires using sample of 5 respondents from coffee farmers living in Kamonyi District. The process aided correction of the mistakes and errors within the tools of data collection to verify how they are reliable to produce significant information from the field. The reliable data were got and minimised statistical errors.

3.7 Data processing and analysis

After collecting the data, the raw data was checked for any omissions or inconsistencies. Data were keyed in by the researcher in SPSS and Frontier 4.1 software.

3.7.1 Measuring determinants of access to agricultural credit

The logit model was used in this study to establish the relationship between the dependent variable and the independent variable. The logit model is useful for this kind of situation where prediction of the presence or absence of an outcome based on values of a set of predictor variables were needed. There are several regression models such as linear regression, multiple regression analysis, Bayesian linear regression, multinomial logistic, Ordinal Least Square, Tobit and Probit models, to name those. However, the binary logistic regression was preferred because it is useful in the analysis of multiple factors influencing a positive or negative outcome, or any other classification where there are only two possible outcomes. Thus, the binary logistic regression is a special case of the binomial logistic regression where the dependent variable has only two categories 1 and 0. The binary logistic regression model is suited and efficient where the dependent variable is dichotomous. It can then be assumed that Yi is the random variable (dichotomous) and can be assumed that Y_i takes on the value 0 or 1 where 0 denotes non-occurrence of the event in question and 1 denotes the occurrence if x_1, - x_n are characteristics to be related to occurrence of this outcome then the logit model specifies that the conditional probability of event i.e., that Y=1 given the value X_i ……. X_n is as follows:

- $P(Y) = 1/ [1+ \exp – (\alpha - \Sigma\beta i Xi)$ …… (1)

In order to linearize the right-hand side a logit transformation was applied by taking logarithm of both sides therefore we have;

- Logit $P(Y) = \alpha + \Sigma\beta i\ Xi$ ……...……. (2)

Where Y_i if it is equal to 1 implies the respondent had access to agricultural credit and 0 was otherwise, β is the logistic coefficient for independent variables, α is the constant term while Xi is a vector of independent variables.

- Logit $P(Y) = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12}$…… (3)

Where X_1: Gender, X_2 = age, X_3 = Education, X_4 =Marital status, X_5 = Household size, X_6= Farm size, X_7 = Interest rate, X_8= Grace period, X_9= Repayment period, X_{10}= Extension service, X_{11} = Cooperative membership, X_{12}= Training.

3.7.2 Measuring the effect of credit access on technical efficiency in coffee production

The stochastic production frontier model was used to investigate the effect of credit access on coffee production in Gisagara District, Rwanda. This model is used to obtain maximum likelihood estimates of the parameters of a variety of stochastic production and cost frontiers, and estimates of mean and individual technical or cost efficiencies.

There are some other alternative models to measure efficiency such as Data Envelopment Analysis Program, Decomposing Productivity Index Numbers, Total Factor Productivity Index Program, Cobb- Douglas production function, to name those, however, the stochastic frontier analysis (SFA) was preferred because it is a method of economic modeling which is used to estimate the probability of various outcomes while allowing for randomness in one or more inputs over time. The use of this model was also connected with the reason that the stochastic frontier model is a form of financial model that is used to help make investment decisions as it forecasts the probability of various outcomes under different conditions, using random variables. Beyond that, this model results in probability distributions, which are mathematical functions that show the likelihood of different outcomes. One of the main benefits of a stochastic model is that it is totally explicit about the assumptions being made. Further, it allows these assumptions

to be tested by a variety of techniques. Since stochastic frontier processes provides a method of quantitative study through the mathematical model, it plays an important role in the modern discipline or operations research. And finally, in this study we adopt the stochastic frontier approach due to its simplicity, and also providing good empirical fit across a wide variety of data and especially it is mostly applied in agriculture production economics. The Stochastic Frontier Analysis was first introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977). It is a vector of technology parameters to be estimated.

- $y_i = \alpha_i f(x_i;\beta), \qquad 0 < a_i \leq 1, \qquad 3.1$

The above equation is transformed to add a random error component thus is expressed as follows:

- $\ln y_i = \ln\alpha_i f(x_i;\beta) + v_i + u_i \qquad 3.2$

Where y is the output for farm I (i= 1……. N), x_i is the vector of inputs used in production, v_i is a random while u_i is a one-sided error term. Normally $u_i = -\ln a_i \geq 0$ which represents the technical inefficiency and output is bounded from above by the stochastic frontier $f(x_i;\beta)$ exp (v_i). The output-based measure of technical efficiency is recovered as exp ($-u_i$). β are the variables to be estimated by the production function. In this case the stochastic production frontier was estimated as follows:

- $\ln y_i = \ln\alpha_i + \ln(x_i;\beta) + v_i + u_i \qquad 3.3$
- $\ln y_i = \ln\alpha_i + \ln(x_i;\beta) + v_i + u_i \qquad 3.4$
- $\ln y_i = \ln\alpha_i + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + v_i + u_i \qquad 3.5$

Where:

- y_i= Amount of coffee production / acre measured in Kgs
- X_1= Land under coffee in acres

- X_2 = Labour in man-days
- X_3 = Organic fertilizer in Kgs
- X_4 = Inorganic fertilizer in Kgs
- X_5 = Pesticide in Liters

3.7.3 Operationalization of variables

A. Dependent variables

The following two dependent variables were used based on the two objectives:

i) Access to agricultural credit

In this study the access to agricultural credit dependent variable has dichotomous nature representing access or non-access to agricultural credit by smallholder farmers. This is to distinguish or discriminate between those users or non-users of agricultural credit in different sources in the study area. It takes a value of "1" for users and "0" for non-users of agricultural credits.

ii) Coffee yield

It is a continuous variable. This is the total coffee harvested per acre and it is estimated in Kgs. Thus, it is hypothesized that access to agricultural credit can positively influence the coffee harvested per acre.

B. Independent variables

Different theoretical and empirical studies on factors influencing access to credit by smallholder farmers, past research findings and the author's knowledge of the credit schemes of the study area are used to establish working hypotheses of this study. Among a number of factors, which have been related to smallholder farmers' access to agricultural credit, the following socio - demographic, institutional and institutional

characteristics were hypothesized to explain the first dependent variable and the production inputs were hypothesized to explain the second dependent variable.

i) Socio - demographic characteristics

Gender: This is a dummy variable that assumes a value of "1" if the coffee farmer head of the household is male and "0" otherwise. Including the existing gender differences, male - headed households have mobility, participate in different meetings and have more exposure to information. Female-headed households may face some cultural barriers in dealing with the cash economy and lack of control over economic resources (Muhongayire, 2012). Hence, it is hypothesized that male headed households have more access to different sources of credit.

Age: It is a continuous variable representing the age of the household head in years. Age is hypothesized to have positive association with farmers' access to credit. The first assumption in the study is that as the age progress, farmers acquire experience and knowledge in credit use (Henri-Ukoha et al., 2011). Those farmers who had a higher age, due to life experience they might know different source of credit than young farmers and had better access to different sources of credit. Therefore, it has been expected that age of the coffee farmer influences access to credit positively.

Education: It is a continuous variable defined as the level of grades or years of schooling completed by the respondent. A farmer who is educated is expected to have more exposure to the external environment and accumulate knowledge and they have the ability to analyse costs and benefits (Tang, Guang & Jin, 2010). Education is a social capital, which could impact positively on household ability to take good and well-informed production and decisions on access to credit. Therefore, it is expected that those farmers who are educated have better access to credit.

Marital status: This is a dummy variable that assumes a value of "1" if the coffee farmer is married and "0" otherwise. The coffee farmers who are married are more

stable and trustworthy by financial institutions (Muhongayire, 2012). Hence, it is hypothesized that married coffee farmers have more access to credit that single coffee farmers.

Household size: The household size is measured as continues variable and shows the total number of persons living in the coffee farmers' house. It is assumed that as farmers' household size increases, the consumption requirements also increase, and as a result there is stress on limited resources and the financial institutions may fear to provide credits on those families. Hence, it is hypothesized that household size has a negative impact on access to credit.

Farm size: It is a continuous variable. It is the total cultivated land holding by the household in acres. The larger the cultivated land size the more the labour required and input used that demands additional capital that might be obtained through credit (Sisay, 2008; Lensink et al., 2009). Therefore, it is hypothesized that larger size of land would affect access to credit positively.

ii) Institutional characteristics

Interest rate: This is a continuous variable. Those are charges calculated in % per trimester on credit taken and can be higher or lower depending on source of financial institutions. It is hypothesized that the higher interest rate for a financial institution would affect negatively the access to agricultural credit.

Grace period: The grace period is a time given by financial institution before starting paying back the credit. It is a dummy variable which takes a value "1" for those who are given 1 month, and 0 otherwise. It is hypothesized that the shorter time given by financial institution would affect negatively the access to credit.

Repayment period: The loan repayment period refers to the time period at which the borrower should repay the loan. This is a dummy variable which takes a value "1" for farmers who are given 1 year and 0 otherwise. It is hypothesized that the shorter period

given by financial institution to repay the loan, would affect negatively the access to credit.

Extension service: This is a dummy variable which takes a value "1" and "0" for participants' and non-participants' in extension service respectively. If a coffee farmer participates in extension package program, it is expected that he can access credit more than one who does not participate. Then, participation in extension service expected to influence access to credit positively.

Cooperative membership: This is a dummy variable which takes a value "1" and "0" for member of cooperative and non-member of cooperative respectively. If a coffee farmer is a member of cooperative is expected to work well and access credit from financial services that the one is a non-member. Cooperative membership can sometimes serve as collateral and therefore, it has been expected that cooperative influences access to credit positively.

Training: This is a dummy variable which takes a value "1" and "0" for a coffee farmer trained and that not yet been trained respectively. A coffee farmer trained is supposed to get more knowledge on best practices in coffee farming than the one who is not. And being trained increases the chance of access to agricultural credit easier. Therefore, training is hypothesized to influence the access to credit.

iii) Production inputs

Land under coffee: It is a continuous variable. It is the land allocated to coffee plantation in acres. Therefore, it is hypothesized that the larger size of land allocated to coffee would affect coffee production positively.

Labour: It is a continuous variable estimated in man- days for each worker either from household or hired. The labour is an important factor for coffee production as it plays a big role in practices such as weeding, pruning, mulching, fertilizer and pesticide

application and harvesting. The labour must be well controlled by a farmer in order to have more profitable plot. It is hypothesized to increase the coffee production.

Organic fertilizer: It is a continuous variable, estimated in Kgs of manure or compost applied in coffee plot in a year. It is hypothesized to increase the coffee production. It helps the soil to maintain its fertility over years and provides nutrients to the coffee. It is hypothesized to increase the coffee production.

Inorganic fertilizer: It is a continuous variable, estimated in Kgs of agro- chemical fertilizer. It serves as nutrition to the coffee. The inorganic commonly used in coffee in Rwanda is NPK (17-17-17). It is hypothesized to increase the coffee production.

Pesticide: It is a continuous variable, estimated in liters of liquid used for spraying. It is used in pests and disease management in coffee plantation. It is hypothesized to increase the coffee production.

Table 3.2: Summary of variables

Variables	Description	Expected sign
Dependent		
Access to agricultural credit	Dummy (1=Access, 0 = otherwise)	N/A
Coffee yield	Continuous (Kgs of coffee produced per acre in one year)	N/A
Socio - demographic characteristics		
Gender	Dummy (1 = Male, 0 = otherwise)	+
Age	Continuous (in years)	+
Education	Continuous schooling (in years)	+
Marital status	Dummy (1= Married, 0 = otherwise)	+
Household size	Continuous (number)	-
Farm size	Continuous, total land owned by a coffee farmer (in acres)	+
Institutional characteristics		
Interest rate	Continuous, charges to agricultural credit (in % per trimester)	-
Grace period	Dummy (1 = a month, 0 = otherwise)	-
Repayment period	Dummy (1= a year, 0 = otherwise)	-
Extension service	Dummy (1 = access, 0 = otherwise)	+
Cooperative membership	Dummy (1= member, 0 = otherwise)	+
Training	Dummy (1 = trained, 0= otherwise)	+
Production inputs		
Land under coffee	Continuous, land allocated to coffee (in acres)	+
Labour	Continuous, household or hired worker (in man days)	+
Organic fertilizer	Continuous, manure or compost (in Kgs)	+
Inorganic fertilizer	Continuous, industrial fertilizer (in Kgs)	+
Pesticide	Continuous, liquid for spraying (in liters)	+

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the results of the analysis that has been conducted to address the objectives of the study. The chapter is divided into six major sections. The first section of this chapter presents socio - demographic and institutional characteristics of sampled household families in the study area using descriptive results in section 4.2. The second section presents the econometric analysis that identifies the socio-demographic and institutional important factors that affect smallholder farmers' access to agricultural credit in section 4.3. Section 4.4 provides the results of the technical efficiency in coffee production among both coffee farmers who accessed agricultural credit and those who did not. The section 4.5 presents the efficiency scores of both coffee farmers' users and non- users of agricultural credit while the last section 4.6 present the results from one –way ANOVA between coffee produced per acre for both coffee farmers' users and non – users of agricultural credit.

4.2 Descriptive characteristics of the respondents in Gisagara District, Rwanda

The summary descriptive characteristics of the respondents in Gisagara District, Rwanda for both farmers who accessed agricultural credit and those who did not are presented below. The socio – demographic characteristics are presented in table 4.1 while the institutional characteristics are presented in table 4.2.

Table 4.1: Socio- demographic characteristics of the respondents

Variables	Access to agricultural credit					Non-access to agricultural credit				
	Sampled farmers	Min	Max	Mean	Std. Dev.	Sampled Farmers	Min	Max	Mean	Std. Dev.
Gender (Dummy)	90	0	1	0.7	0.5	132	0	1	0.43	0.5
Age (Years)	90	26	84	44.3	11.3	132	19	42	34.8	5.94
Education (Years of schooling)	90	0	12	5.6	2.8	132	0	12	4.53	3.48
Marital status (Dummy)	90	1	1	1	0	132	0	1	0.96	0.19
Household size (Number)	90	1	12	5.6	2.2	132	1	12	5.42	2.29
Farm size (Acres)	90	0.3	5.3	3.1	1.2	132	0.4	3	1.86	0.54

Source: Field survey data

Results on gender, indicate that majority of the respondents (69%) were male while (31%) were female for the farmers who accessed agricultural credit. On the other hand of farmers who did not access the agricultural credit, the results showed that the majority (57%) were female and while (43%) were male.

Results on age for farmers who accessed agricultural credit showed a minimum age of 26 years old while the maximum age was 84 years old, the mean age was 44.3. On the other hand of farmers who did not access agricultural credit, the minimum age of the farmers was 19 years old while the maximum age was 42 years old. The mean age was 34.8. The findings of the study are similar with (NISR, 2016), which revealed that agricultural operators' age group in Rwanda lies between 35 and 44 years old, but contradict with the survey of (NAEB, 2015), which found that the average age of coffee farmers in Rwanda was 51 years.

Results on education for the farmers who accessed agricultural credit showed that the minimum schooling in years was 0 which means that the farmer did not have any formal education while the maximum schooling in years was 12 meaning implied that most farmers had attained secondary school education on average with the average being 5.6

years of schooling. The same results in terms of minimum and maximum schooling in years were found on the other hand of farmers who did not access agricultural credit, only the mean education differed where it was 4.53 years of schooling on average. The foregoing results imply that many coffee farmers in Rwanda have a low of education on average.

Results on marital status for farmers' who access agricultural credit, showed that all the farmers were married. While, the results on marital status for farmers who did not access agricultural credit, showed that 96 % were married and 4% were others.

Results on household size for farmers who accessed agricultural credit, the minimum household size was 1 family member, while the maximum household size was 12 family members, the household size mean was equal to 6 family members. On the other hand of farmers who did not access agricultural credit, the minimum household size was 1 family member, while the maximum household size was 12 family members, the household size mean was equal to 5 family members. The results confirm that a majority of the coffee farmers had large families thus denoting a high level of dependency.

Results on farm size for farmers who accessed agricultural credit have shown a minimum size of 0.3 acre of land while the maximum size was 5.3 acres of land and a mean size of 3.1 acres of land. On the other hand of farmers who did not access agricultural credit, the minimum farm size was 0.4 acre while the maximum size was 3.0 acres of land with a mean size of 1.86 acre of land. This implies that farming in Rwanda is under small scale farming since majority of the farms were less than 5 acres (FAO, 2018).

Table 4.2: Institutional characteristics of the respondents

Variables	Access to agricultural credit					Non-access to agricultural credit				
	Sampled Farmers	Min	Max	Mean	Std. Dev.	Sampled Farmers	Min	Max	Mean	Std. Dev.
Interest rate (%)	90	2	4	3.3	0.94	132	2	4	3.3	0.94
Grace period (Dummy)	90	0	1	0	0.1	132	N/A	N/A	N/A	N/A
Repayment period (Dummy)	90	0	1	0.4	0.5	132	N/A	N/A	N/A	N/A
Extension service (Dummy)	90	1	1	1	0	132	0	1	0.86	0.34
Cooperative membership (Dummy)	90	0	1	1	0.1	132	0	1	0.83	0.37
Training (Dummy)	90	0	1	1	0.1	132	0	1	0.92	0.27

Source: Field Survey data

Results on the interest rate of financial institutions indicate that the minimum interest rate was 2% while the maximum interest rate was 4% per trimester; the mean interest rate was 3.3%. This shows that the higher costs of interest rates can lead to decline of agricultural credits demand among smallholder farmers in Rwanda.

Results on grace and repayment period were only applicable for farmers who accessed agricultural credit. For grace period, the results indicate that majority (98%) of the respondents were given less than a month, while the minority (2%) were given a full month. In terms of repayment period, the majority (62%) was given less than one full year while the minority (38%) was given one full year for credit repayment. The results strongly suggest that the grace and repayment period for credit access is very short since it does not allow the farmer to undertake the full production and marketing activities of coffee. This implies that farmers have to look for alternative sources of financing to service the credit as well as to continue the production activities to completion.

Results on extension service for coffee farmers who accessed agricultural credit, indicate that all farmers had accessed the extension services. On the other hand of farmers who did not access agricultural credit, the results indicate that majority (86%) received extension service while the minority (14%) did not receive extension service.

Results on cooperative membership of farmers who access agricultural credit, the majority (98%) of the respondents were the members of cooperatives while the minority (2%) were not members of cooperatives. On the other hand, for farmers who did not access agricultural credit, the majority (83%) of the respondents were the members of cooperatives while the minority (17%) were not members of cooperatives.

Results on training for farmers' who accessed agricultural credit, indicate the majority (98%) have been trained and the minority (2%) did not attend any training. on the other hand, for farmers who did not access agricultural credit, the majority (92%) have been trained while the minority (8%) did not attend training.

4.3 Determinants of access to agricultural credit among smallholder coffee farmers in Rwanda

A binary logistic regression model was computed to investigate the determinants of agricultural credit access in Rwanda. Results show that gender, age, farm size, interest rate and cooperative membership influenced the credit accessibility among smallholder coffee farmers in Gisagara, Rwanda (Table 4.3).

The gender of the respondents had a significant ($p<0.05$) and positive relationship (β:1.51%) with agricultural credit access. Thus, being male increased the chance of agricultural credit access by 1.51 % on average than their female counterparts. This implies that the probability of accessing credit by the male farmers was higher than that of their female counterparts. These findings concur with that of Elias, Ahmad & Patil (2015) in India, who found that gender and access to agricultural credit had significant and positive relationship, where the probability of a male to access agricultural credit

was higher than that of a female. Similar findings by Gebeyehu (2019) revealed that being a male headed household member increased the probability of accessing agricultural credit from formal sources than that of a female headed household member holding all the other factors constant among smallholder maize farmers in Ethiopia. The results are in line with Muiruri *et al*. (2012), who identified that gender of the household head was important to credit accessibility among smallholder farmers, where women had a lower access to credit than a male in Kenya. Generally, the male had an advantage when accessing credit than the female and this may be due to many factors including better access to collateral such as land titles and assets which in most cases female farmers do not have access to, hence, the access to credit is not easy for them compared to male farmers.

The age of the respondents had a significant ($p=<0.05$) and positive relationship ($\beta=$ 0.08 %) with agricultural credit access. The positive relationship implies that older people were more likely to access agricultural credit from financial institutions by 0.08 % on average than younger people. That was expected because, though the younger people were found to be more engaged in agriculture followed by the older people in the area, the younger people were possible defaulters compared to the older people since the older people owned most productive assets and hence had a better asset base as they accumulate assets with age. Therefore, financial institutions would prefer to lend to older generations than to younger ones. Similarly, Gebeyehu (2019) evaluated the determinants of access to agricultural credit among smallholder maize farmers in Ethiopia. The study used a probit model on a sample size of 260 households. The results of the study showed that age was among the factors affecting farmers' access to agricultural credit. The findings are also in line with Ajah, Igiri and Ekpenyong (2017) who found age among factors influencing the access to agricultural credit in Nigeria. The findings also concur with that of Hananu *et al.* (2015) in Ghana, who revealed that age influenced the agricultural credit demand and access.

The farm size of the respondents was found to be significant (p=<0.05) and positively related (β=1.55%) to access to agricultural credit. The positive relationship implies that the coffee farmers having big farm size were more likely to access agricultural credit from financial institutions by 1.55% on average than coffee farmers having small farm size. The findings are in line with Chandio *et al*. (2020) who analysed the determinants of demand for credit by smallholder farmers in Pakistan. The study revealed that landholding size was among the variables which influenced the demand and access to agricultural credit. Similar findings with Elias, Ahmad and Patil (2015) who evaluated the determinants of access to agricultural credit for small and marginal farmers in Dharwad District, Karnataka of India. The results showed that accessibility of agricultural credit for small and marginal farmers was driven, amongst others, by land size.

The interest rate of the respondents was found to be significant (p=<0.05) and negatively related (β=-0.87%) to access to agricultural credit. The result agrees with a priori expectation as higher interest rate will reduce the rate of demand and access to agricultural credit. Similar findings with Ajah, Igiri and Ekpenyong (2017) who examined the factors influencing credit accessibility and identified higher interest rates as one of the major constraints to access to agricultural credits. The findings concur with Muiruri *et al*. (2012) who analysed the socio-economic and institutional constraints to accessing credit among smallholder farmers in Nyandarua District of Kenya. The study established that institutional requirements such as costs involved in operating / maintaining bank accounts, loan requirements and transaction costs involved in the credit process influenced access to credit; and recommended too financial institutions to put in place less stringent credit requirements and reduce credit costs especially interest rates to make credit more affordable.

The cooperative membership of the respondents was found to be significant (p=<0.05) and positively related (β=1.98%) to access to agricultural credit among smallholder farmers. Cooperative membership was found to increase the coffee farmers' chance of access to agricultural credit by 1.98 % on average. This implies that an improvement of

togetherness and collective actions in the study area led to a positive contribution towards accessing credit financial services. The farmer groups found in the study area help their members to save together some small income from coffee season, thus, a member depending on how much he/ she has saved in cooperative can be given short-term agricultural credit before the coffee season starts. The findings are similar with the finding of Kiplimo, Ngenoh and Bett (2015) in Kenya, who found that lending through groups triggers peer selection effect among farmers who know each other with a consequent rise in productivity and income-base. Adding on the gain of lending to farmer group, the knowledge of each other among smallholder farmers overcome information asymmetry problem in credit financial market, particularly where potential loan beneficiaries are located in sparsely populated remote rural communities. The results are also in line with the findings of Hananu *et al.* (2015) who found that group membership influence agricultural credit demand and access in Ghana. Similar findings by Ijioma and Osondu (2015) in Nigeria indicate that membership of cooperative societies was a significant predictor of the amount of agricultural credit acquired by farmers.

The characteristics such as education, marital status, household size, grace period, repayment period, access to extension services and training were found not significantly influence access to agricultural credit.

Table 4.3: Determinants of access to agricultural credit among smallholder coffee farmers in Gisagara District, Rwanda

Variables	B	S.E.	Wald	Df	Sig.
Gender	1.51	0.45	11.34	1.00	0.00*
Age	0.08	0.04	4.43	1.00	0.04*
Education	0.10	0.07	1.93	1.00	0.17
Marital status	19.92	15640.00	0.00	1.00	1.00
Household size	0.12	0.09	1.88	1.00	0.17
Farm size	1.55	0.42	13.50	1.00	0.00*
Interest rate	-0.87	0.24	13.47	1.00	0.00*
Grace period	1.66	23150.00	0.00	1.00	1.00
Repayment period	19.53	5904.00	0.00	1.00	1.00
Extension service	20.66	8351.00	0.00	1.00	1.00
Cooperative membership	1.98	0.91	4.74	1.00	0.03*
Training	1.15	1.23	0.89	1.00	0.35
Constant	-49.79	17730.00	0.00	1.00	1.00

* variable significant (p=<0.05)

Source: Field Survey data

4.4. Analysis of the determinants of the technical efficiency in coffee production among smallholder coffee farmers in Gisagara District, Rwanda.

4.4.1 Stochastic Frontier model results

The results from the stochastic production frontier model by use of Frontier 4.1 (table 4.4) revealed that all the production inputs except the labour (land under coffee, organic fertilizer, inorganic fertilizer and pesticide) were significant ($p<0.01$) and had a positive

influence on the technical efficiency in coffee production for the farmers with access to credit.

Amongst others, only the land under coffee was significant ($p<0.01$) and had a positive influence on the technical efficiency in coffee production for the coffee farmers without access to credit. For the coffee farmers with access to credit, the estimated parameters were 0.1 for land under coffee, 015 for organic fertilizer, 0.25 for inorganic fertilizer and 0.25 for the pesticide. This implied that land under coffee, organic fertilizer, inorganic fertilizer and pesticide would respectively result to an increase of 0.1%, 0.15%, 0.25% and 0.25% of coffee production if each was increased by 1 %, ceteris paribus. For the coffee farmers without access to credit, the estimated parameter was 0.67 for land under coffee and this implied that the land under coffee would result to an increase of 0.67% coffee production if it was increased by 1%, ceteris paribus. In terms of land under coffee, the results are in line with Ahmed, Haji and Geta (2013) in Ethiopia, who found a positive relationship between land under maize and production of smallholder farmers. The findings are also consistent with those of Ashaolu (2011) in Nigeria, who found a positive relationship between farm under crop and its production among smallholder farmers' users and non- users of microcredit. Similar findings by Ingabire (2014) found a positive relationship between land under rice and its production in Rwanda. However, the option of increasing the land allocated to coffee might be a challenge for many coffee farmers due to land scarcity in Rwanda. The results of the study contradict with Olugbenga and Adepoju (2019) in Nigeria, who found a negative effect on crop productivity for farmers who were credit unconstrained.

In terms of organic fertilizer, the results confirm the importance of use of organic fertilizers, but in some cases, it is still insignificantly used in coffee farming in Rwanda. For the inorganic fertilizer, the results confirm its importance in coffee production since it helps in optimum growth and productivity of the crop. But, too much or too little inorganic fertilizer has a detrimental effect on coffee productivity. As indicated by Dawid and Hailu (2018) a hectare of fast growing highly-yielding coffee takes up an annual total of about 135kg N, 34kg P_2O5, and 145kg k_2O (Nduwumuremyi *et al.*,

2014). Beyond that, the National Agricultural and Export Development Board has come up with a recommendation on inorganic fertilizer use in coffee farming which is applying the fertilizer only twice a year and not applying more than 200 g / per year (100 g / tree / twice a year). In terms of pesticide, the findings are consistent with those by Djokoto (2012) in the study conducted on technical efficiency of agriculture in Ghana who found a positive relationship between pesticide and herbicide use with agricultural output. Changa and Wen (2012) also found the same relationship between pesticide and rice output in Taiwan. The results, thus, confirm the impact of pesticide on coffee production in Rwanda. There is need for these materials to be available for use by the farmers as it is important in pest and disease management in coffee plantations. For socio- demographic and institutional characteristics in the model, the findings showed that there is a relationship between gender and technical efficiency at 5%. For the coffee farmers with access to credit, gender had a positive effect on technical efficiency while for coffee farmers without access to credit it had a negative effect on technical efficiency. In other words, for the coffee farmers with access to credit, being a male would raise the technical efficiency in coffee production while for the coffee farmers without access to credit, it would reduce the technical efficiency in coffee production. Then, the findings showed the relationship between farm size and technical efficiency in coffee production at 1% for coffee farmers with access to credit and at 5% for the coffee farmers without access to credit. In other words, the results indicated that the increase in farm size would reduce the technical efficiency in coffee production in the study area. Finally, the findings showed that there is an effect of cooperative membership and training on the technical efficiency in coffee production at 5% for coffee farmers without access to credit. The cooperative membership and training affect positively the technical efficiency in coffee production. In other words, the results indicated that being a member of cooperative and being trained on coffee farming practices would increase the technical efficiency in coffee production in the study area. The results of gamma show that the variations in coffee production were attributed to technical inefficiency at 89 % for farmers' users of credit and at 99 % for farmers' non- users of credit.

Table 4.4: Determinants of the technical efficiency in coffee production among smallholder coffee farmers in Gisagara District, Rwanda

Variables	Credit users			Credit non-users		
	Coefficient	Standard-error	t-ratio	coefficient	standard-error	t-ratio
Production inputs						
Constant	4.44	0.19	23.95**	5.11	1.33	3.86**
Land under coffee	0.1	0.04	2.75**	0.67	0.05	12.36**
Labour	0.12	0.06	1.81	0.79	0.78	1.02
Organic fertilizer	0.15	0.04	4.03**	0.05	0.03	1.68
Inorganic fertilizer	0.25	0.03	7.73**	-0.36	0.67	-0.54
Pesticide	0.25	0.05	5.27**	-0.33	0.46	-0.71
Determinants of agricultural credit access						
Constant	-0.28	0.85	-0.33	0.03	0.54	0.06
Gender	0.12	0.06	2.18*	-0.43	0.21	-2.03*
Age	0.00	0.00	0.92	-0.02	0.01	-1.54
Education	0.01	0.01	0.61	0.01	0.02	0.59
Marital status	-0.28	0.85	-0.33	0.45	0.32	1.38
Household size	-0.02	0.01	-1.37	0.13	0.07	1.94
Farm size	-0.23	0.07	-3.25**	-1.47	0.67	-2.21*
Interest rate	-0.03	0.02	-1.43	-0.09	0.06	-1.55
Grace period	0.19	0.18	1.03	0.00	1.00	0.00
Repayment period	0.02	0.08	0.31	0.00	1.00	0.00
Extension service	-0.28	0.85	-0.33	0.28	0.18	1.54
Cooperative membership	0.75	0.39	1.91	0.71	0.33	2.12*
Training	0.52	0.31	1.71	0.38	0.18	2.09*
Sigma-squared	0.02	0	4.06**	0.29	0.15	1.92
Gamma	0.89	0.05	16.55**	0.99	0.01	131.87**
Log likelihood function	119.44			68.98		
LR test of the one-sided error	42.68			67.1		

Note: ** and * represent significance level at 1% and 5% respectively

Source: Field survey data

4.4.2 Efficiency scores

Table 4.5 provides a summary of the efficiency scores of the farmers that had access to agricultural credit and those who did not access agricultural credit. The mean efficiency scores of the farmers were 0.94, 0.84 respectively for coffee farmers who had accessed credit and those that had not accessed agricultural credit respectively. This implies that on average the farmers who had accessed credit operated on a higher technical efficiency with a potential of increasing coffee production by a further 6 % only given the same level of inputs keeping all the other factors constant while those who had not accessed credit had lower technical efficiency than their counterparts who accessed credit. Thus, the farmers who did not access credit had a potential to increase coffee output by a further 16 % given the same level of inputs if they accessed credit keeping all the other factors constant. The minimum efficiency scores of the farmers were 0.64, 0.25 respectively for coffee farmers who had accessed credit and those that had not accessed agricultural credit. The maximum efficiency scores of farmers were 0.99, 0.98 respectively for coffee farmers who had accessed credit and those that had not accessed agricultural credit. The standard deviations were 0.07 and 0.15 respectively for coffee farmers' users of credits and for coffee farmers' non-users for credit.

Table 4.5: Summary of efficiency scores of coffee farmers in Gisagara District, Rwanda

	Credit users		Credit non-users	
Efficiency scores	**Number of farmers**	**%**	**Number of farmers**	**%**
0.25 - 0.30	0	0	2	1.52
0.31- 0.35	0	0	0	0
0.36 - 0.40	0	0	0	0
0.41 - 0.45	0	0	0	0
0.46 - 0.50	0	0	0	0
0.51 - 0.55	0	0	4	3.03
0.56 - 0.60	0	0	9	6.82
0.61 - 0.65	1	1.11	7	5.3
0.66 - 0.70	1	1.11	4	3.03
0.71 - 0.75	2	2.22	2	1.52
0.76 - 0.80	1	1.11	5	3.79
0.81 - 0.85	4	4.44	3	2.27
0.86 - 0.90	8	8.89	27	20.45
0.91 - 0.95	24	26.67	46	34.85
0.96 - 0.99	49	54.44	23	17.42
Total	90	100	132	100
Mean efficiency	0.94		0.84	
Min efficiency	0.64		0.25	
Max efficiency	0.99		0.98	
Std. Dev	0.07		0.15	

Source: Field survey data

4.4.3 Hypothesis testing

This study tested the hypothesis that there was no significant difference between coffee production per acre of farmers that had access to agricultural credit and those that did not access the agricultural credit.

The results in table 4.6 of one-way ANOVA rejects the null hypothesis that there was no significant difference in coffee production per acre between coffee farmers that had access to agricultural credit and those that did not. Thus, this study accepts the alternative hypothesis that there was a significant difference ($p=<0.05$) in coffee produced per acre between farmers who had access to agricultural credit and those who did not access agricultural credit holding all the other factors constant. This confirms that access to agricultural credit had a significant effect on coffee produced per acre in the study area. The above finding is consistent with the report by Shivaswamy et al. (2019), who found that the institutional credits had a positive influence on agricultural productivity among smallholder farmers in India. The findings are also in line with Ahmet et al. (2019), who found that a 1% increase of agricultural credits led to a 0.17% increase of agricultural value- added per hectare, which includes a 0.05 percent from the direct effect and 0.12 percent from the spillover effect in Turkey. The results concur with Chandio *et al*. (2018), who found that formal credit was statistically significant with 1% increase in credit, increases agricultural output by 0.86% in Pakistan. Akoété & Ablamba (2019), found similar results that credit in kind had a positive and significant impact on the productivity of maize and sorghum in Togo. Similar findings were obtained by Akudugu (2016) in Ghana, revealed that access to formal and informal credit increases the agricultural productivity. Results in line with Awotide *et al*. (2015) in Nigeria, found that access to credit had a significant positive impact on the productivity of cassava. Similar finding by Nzomo & Muturi (2014) in Kenya, indicate that agricultural credit increases the productivity of small- scale farming businesses. Similarly, Kiragu (2015) found a positive relationship between agricultural financing and dairy farming productivity in Central Kenya.

Table 4.6: One - way ANOVA between coffee yields per acre for coffee farmers' users and non-users of agricultural credit in Gisagara District, Rwanda

Coffee produced per acre	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2150963.638	45	47799.19	1.784	0.029*
Within Groups	1179001.888	44	26795.5		
Total	3329965.526	89			

* represents the level of significance (p=<0.05)

Source: Field survey data

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter outlines the conclusions and recommendations of the study based on findings of the research. In section 5.2 the conclusions are outlined while in section 5.3 the recommendations are provided. Section 5.4 provides the limitations of the study and recommendations for further research.

5.2 Conclusions

In line with the findings of this study it can be concluded that the socio-demographic and institutional determinants of access to agricultural credit are mainly gender, age, farm size, interest rate and cooperative membership. Implying that a variation in each of the five variables will cause change in the ability to access credit for the coffee agricultural farmers in Rwanda.

The findings indicate that the mean technical efficiency scores of the farmers was 0.94 and 0.84 respectively for coffee farmers who had accessed credit and those that had not accessed agricultural credit. This implies that on average the farmers who had accessed credit had a potential of increasing coffee production by 6 % given the same level of inputs while those had not accessed credit had potential to increase coffee output by a further 16% given the same level of inputs. The study tested the hypothesis that there was no significant difference between coffee yields per acre of farmers who had access to agricultural credit and those who did not access the agricultural credit. The results of one-way ANOVA rejected the null hypothesis that there was no significant difference in coffee produced per acre between coffee farmers that had access to agricultural credit and those that did not access agricultural credit. Thus, this study accepted the alternative hypothesis that there was a significant difference ($p<0.05$) in coffee produced per acre between farmers who had access to agricultural credit and those who did not access

agricultural credit holding all the other factors constant. This confirms that access to agricultural credit had a significant effect on coffee produced per acre in the study area. This implies that generally farmers who had access to agricultural credit had a higher coffee produced per acre than those who had no access to agricultural credit. Thus, it is concluded that all other production factors held constant,

access to agricultural credit is an essential component for increased coffee production per acre in Rwanda.

5.3. Recommendations

Based on the findings and conclusions, this study recommends the following: First, since gender and age have a significant effect on credit access, there is need for policymakers to put in place measures that would help access of credit especially the women and youth since men can easily access agricultural credit than women. Examples would include policies that enhance and encourage property ownership to both male and female as well as equal opportunities for education. These would significantly enhance the uptake of agricultural credit to both. Second, since the interest rate has a significant effect on agricultural credit, there is a need for the introduction of more financial institutions in the rural areas. Examples include agricultural and microfinance banks so that the farmers can have more options and procedures for securing agricultural credits should also be streamlined in order to make it simple for the farmers. Third, since cooperative membership has a significant effect on credit access, then it is important for policy makers to encourage formation of cooperatives to enable farmers pull resources together and intensify education to farmers on loan procedures. Examples include policies that encourage cooperatives formation of farmers cultivating the same crop in the area would overcome information asymmetry problem in credit financial markets.

Finally, since credit access has a significant effect on coffee production per acre, policy measures that facilitate more coffee farmers to access agricultural credit in form of cash or kind are recommended. Examples include issuing agricultural credit in form of farm inputs to increase the impact of agricultural credit access on coffee production.

5.4 Limitations of the study and further research

This study focussed on agricultural credit access in Rwanda focussing on only sectors and smallholder coffee farmers and not the whole of Rwanda, a scope that was beyond this study. Thus, further research should focus on the determinants of credit access among the coffee farmers in the whole of Rwanda. The study also used cross section data and therefore it is recommended that further research should focus on credit access over the years to see its effect over time.

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APPENDICES

Appendix I: Questionnaire

Name of the respondent: _____

a. socio - demographic characteristics

1) Gender: 1= Male / 0 = otherwise

2) How old are you? _____

3) What is your level of education?
   1= Not attended
   2= Primary
   3= Vocational training
   4= Secondary
   5= University

4) Marital status: 1= Married / 0 =otherwise

5) What is the total number of household members do you have? _____

6) Do you own land? 1= Yes / 0 = No. If yes, answer the following questions:
   a) Total land size (in acres) _____
   b) Total land allocated to coffee (in acres) _____
   c) Total number of coffee trees_____

7) What was your coffee production for the past 5 years? (in Kgs):

2015_____,2016_____,2017_____, 2018_____
2019_____

8) What was your farm income for the past 5 years? (in Rwf):

2015_____,2016_____,2017_____, 2018_____
2019_____

b. Institutional characteristics

9) Have you ever accessed agricultural credit over the 5 years (2015-2019)?
   1= Yes / 0 = otherwise, if yes, answer the following questions:

What was the amount (in Rwf)?

_____

10) From which financial institutional? _____
    what was the interest rate (in %)? _____
11) What was the grace period? 1= a month / 0 =otherwise

12) What was the repayment period? 1= a year / 0 =otherwise

13) Have you ever accessed extension service over the 5 years (2015-2019)? 1= access / 0 = otherwise
14) Are you a member of any cooperative / or farmer association? 1= member / 0 = otherwise
15) Have you ever been trained on coffee farming over the past 5 years (2015-2019)? 1= trained/ 0 = otherwise

c. Production inputs

16) Labour use in coffee

Main activities in coffee farming	**Have you ever used family labour in the following activity?**	**Have you ever used hired labour in the following activity?**
Activity 1: Seedlings preparation	1= Yes / 0 = No If yes, answer the following questions: a) Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____	1= Yes / 0 = No If yes, answer the following questions: a) Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____ d)cost for each worker / day (Rwf)?_____
Activity 2: Land preparation	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____

		d)cost for each worker / day (Rwf)?_____
Activity 3 :		
Planting coffee	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____ d)cost for each worker / day (Rwf)?_____
Activity 4:		
Weeding	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____ d)cost for each worker / day (Rwf)?_____
Activity 5:		
Pruning	1= Yes / 0 = No If yes, answer the following questions:	1= Yes / 0 = No If yes, answer the following questions:

	a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____	a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____ d)cost for each worker / day (Rwf)?_____
Activity 6: Mulching	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____ d)cost for each worker / day (Rwf)?_____
Activity 7: Fertilizer application	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____

		d)cost for each worker / day (Rwf)?_____
Activity 8:		
Pesticide application	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____ d)cost for each worker / day (Rwf)?_____
Activity 9:		
Harvesting	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____	1= Yes / 0 = No If yes, answer the following questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____ d)cost for each worker / day (Rwf)?_____
Activity 10: Transportation to processing factory	1= Yes / 0 = No If yes, answer the following	1= Yes / 0 = No If yes, answer the following

questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____	questions: a)Number of persons (above 18 years)?_____ b)How many days?_____ c)Duration of day work (hours)?_____ d)cost for each worker / day (Rwf)?_____

17) Have you ever used the organic fertilizer over the past 5 years (2015-2019)? 1= Yes / 0 = No.

If yes, answer the following questions:

a) In which year : 2015_____,2016_____,2017_____, 2018_____ 2019_____
b) How many Kgs ? 2015_____,2016_____,2017_____, 2018_____ 2019_____
c) What was the amount spent in Rwf ? 2015_____,2016_____,2017_____, 2018_____ 2019_____

18) Have you ever used the inorganic fertilizer over the past 5 years (2015-2019) ? 1= Yes / 0 = No. If yes, answer the following questions:

a) In which year : 2015_____,2016_____,2017_____, 2018_____ 2019_____
b) How many Kgs ? 2015_____,2016_____,2017_____, 2018_____ 2019_____
c) What was the amount spent in Rwf ? 2015_____,2016_____,2017_____, 2018_____ 2019_____

19) Have you ever used the pesticide over the past 5 years (2015-2019) ? 1= Yes / 0 = No. If yes, answer the following questions:

a) In which year : 2015_____,2016_____,2017_____, 2018_____ 2019_____

b) How many liters? 2015_____,2016_____,2017_____, 2018_____ 2019_____

c) What was the amount spent in Rwf?

2015_____,2016_____,2017_____, 2018_____ 2019_____

Appendix II: Determinants of Technical efficiency in coffee production among smallholder coffee farmers who accessed agricultural credit

Output from the program FRONTIER (Version 4.1c)

instruction file = terminal

data file = eg1tl-d.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a production function

The dependent variable is logged

the final maximum likelihoods estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.44449360E+01	0.18561896E+00	0.23946562E+02
beta 1	0.10109810E+00	0.36712193E-01	0.27538017E+01
beta 2	0.11699910E+00	0.64648922E-01	0.18097611E+01
beta 3	0.15479377E+00	0.38369337E-01	0.40343093E+01
beta 4	0.25147290E+00	0.32551001E-01	0.77255043E+01
beta 5	0.25036945E+00	0.47518670E-01	0.52688649E+01
delta 0	-0.28030998E+00	0.84772226E+00	-0.33066253E+00
delta 1	0.12212905E+00	0.55924135E-01	0.21838344E+01
delta 2	0.29809559E-02	0.32530981E-02	0.91634371E+00
delta 3	0.53225035E-02	0.86837630E-02	0.61292593E+00
delta 4	-0.28030998E+00	0.84772226E+00	-0.33066253E+00
delta 5	-0.15120508E-01	0.10999353E-01	-0.13746724E+01
delta 6	-0.22576340E+00	0.69430751E-01	-0.32516341E+01
delta 7	-0.33419194E-01	0.23347029E-01	-0.14314110E+01
delta 8	0.18580713E+00	0.18064627E+00	0.10285689E+01
delta 9	0.23375756E-01	0.76081741E-01	0.30724528E+00
delta10	-0.28030998E+00	0.84772226E+00	-0.33066253E+00
delta11	0.74803000E+00	0.39129430E+00	0.19116813E+01
delta12	0.52238592E+00	0.30602728E+00	0.17069913E+01

sigma-squared 0.16738696E-01 0.41226627E-02 0.40601663E+01

gamma 0.89048779E+00 0.53814812E-01 0.16547262E+02

log likelihood function = 0.11944291E+03

LR test of the one-sided error = 0.42676375E+02

with number of restrictions = *

[note that this statistic has a mixed chi-square distribution]

number of iterations = 34

(maximum number of iterations set at : 100)

number of cross-sections = 90

number of time periods = 1

total number of observations = 90

technical efficiency estimates :

firm	year	eff.-est.
1	1	0.97889441E+00
2	1	0.82513588E+00
3	1	0.88459894E+00
4	1	0.94462950E+00
5	1	0.95546129E+00
6	1	0.98651316E+00
7	1	0.81311679E+00
8	1	0.96167567E+00
9	1	0.79416979E+00
10	1	0.98167692E+00
11	1	0.98367047E+00
12	1	0.97570374E+00
13	1	0.98140208E+00
14	1	0.94189038E+00
15	1	0.97227426E+00
16	1	0.91960544E+00
17	1	0.98528803E+00

18	1	0.93714482E+00
19	1	0.95422869E+00
20	1	0.92543617E+00
21	1	0.95305074E+00
22	1	0.97447108E+00
23	1	0.93867716E+00
24	1	0.93712538E+00
25	1	0.93494908E+00
26	1	0.97499735E+00
27	1	0.95971983E+00
28	1	0.93686123E+00
29	1	0.99151466E+00
30	1	0.96288044E+00
31	1	0.94212279E+00
32	1	0.96620493E+00
33	1	0.98286846E+00
34	1	0.98319698E+00
35	1	0.97340748E+00
36	1	0.98067739E+00
37	1	0.97895411E+00
38	1	0.70983258E+00
39	1	0.96281947E+00
40	1	0.98795066E+00
41	1	0.96866109E+00
42	1	0.96510012E+00
43	1	0.94973535E+00
44	1	0.98579485E+00
45	1	0.89769963E+00
46	1	0.98038306E+00
47	1	0.87342662E+00

48	1	0.97488574E+00
49	1	0.64320386E+00
50	1	0.97412449E+00
51	1	0.97290712E+00
52	1	0.97278482E+00
53	1	0.98528255E+00
54	1	0.98617794E+00
55	1	0.97688684E+00
56	1	0.93729618E+00
57	1	0.94109815E+00
58	1	0.95419700E+00
59	1	0.82425229E+00
60	1	0.94888512E+00
61	1	0.94531053E+00
62	1	0.97265996E+00
63	1	0.95920743E+00
64	1	0.89862103E+00
65	1	0.90422459E+00
66	1	0.90647844E+00
67	1	0.95713303E+00
68	1	0.95185695E+00
69	1	0.96103553E+00
70	1	0.97573151E+00
71	1	0.97922062E+00
72	1	0.72779562E+00
73	1	0.95249854E+00
74	1	0.94431711E+00
75	1	0.97700414E+00
76	1	0.95208844E+00
77	1	0.94344770E+00

78	1	0.97825671E+00
79	1	0.89819843E+00
80	1	0.97914671E+00
81	1	0.97630166E+00
82	1	0.97128711E+00
83	1	0.96355326E+00
84	1	0.97201898E+00
85	1	0.84613855E+00
86	1	0.95945339E+00
87	1	0.66256068E+00
88	1	0.85513910E+00
89	1	0.97623256E+00
90	1	0.89670902E+00

mean efficiency = 0.93656898E+00

Appendix III: Determinants of technical efficiency in coffee production among smallholder coffee farmers who did not access agricultural credit

Output from the program FRONTIER (Version 4.1c)

Instruction file = terminal

Data file = eg1tl-d.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a production function

The dependent variable is logged

the final maximum likelihoods estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.51126546E+01	0.13251009E+01	0.38583133E+01
beta 1	0.67371135E+00	0.54511347E-01	0.12359103E+02
beta 2	0.79334557E+00	0.78047690E+00	0.10164882E+01
beta 3	0.51408131E-01	0.30611678E-01	0.16793633E+01
beta 4	-0.36348588E+00	0.67233656E+00	-0.54063084E+00
beta 5	-0.32866764E+00	0.46448192E+00	-0.70760049E+00
delta 0	0.32919657E-01	0.54473200E+00	0.60432757E-01
delta 1	-0.43040836E+00	0.21204451E+00	-0.20298020E+01
delta 2	-0.22644633E-01	0.14731041E-01	-0.15372052E+01
delta 3	0.92799045E-02	0.15627644E-01	0.59381342E+00
delta 4	0.44847608E+00	0.32450407E+00	0.13820353E+01

delta 5 0.12933790E+00 0.66617685E-01 0.19414949E+01

delta 6 -0.14716119E+01 0.66528086E+00 -0.22120159E+01

delta 7 -0.90480164E-01 0.58211965E-01 -0.15543225E+01

delta 8 0.00000000E+00 0.10000000E+01 0.00000000E+00

delta 9 0.00000000E+00 0.10000000E+01 0.00000000E+00

delta10 0.28099989E+00 0.18281678E+00 0.15370574E+01

delta11 0.70546166E+00 0.33299164E+00 0.21185567E+01

delta12 0.38376028E+00 0.18327343E+00 0.20939221E+01

sigma-squared 0.28920630E+00 0.15070126E+00 0.19190701E+01

gamma 0.98873041E+00 0.74978119E-02 0.13186919E+03

log likelihood function = 0.68977129E+02

LR test of the one-sided error = 0.67103175E+02

with number of restrictions = *

[note that this statistic has a mixed chi-square distribution]

number of iterations = 43

(maximum number of iterations set at : 100)

number of cross-sections = 132

number of time periods = 1

total number of observations = 132

technical efficiency estimates :

firm year eff.-est.

1 1 0.93556267E+00

2	1	0.81418156E+00
3	1	0.91169636E+00
4	1	0.97062505E+00
5	1	0.91553216E+00
6	1	0.97832612E+00
7	1	0.87990011E+00
8	1	0.90446314E+00
9	1	0.97099477E+00
10	1	0.96819822E+00
11	1	0.95319292E+00
12	1	0.89981305E+00
13	1	0.93420559E+00
14	1	0.92495088E+00
15	1	0.95677809E+00
16	1	0.58573765E+00
17	1	0.57773447E+00
18	1	0.79090257E+00
19	1	0.90073115E+00
20	1	0.88067132E+00
21	1	0.92258849E+00
22	1	0.77481107E+00
23	1	0.88506445E+00

24	1	0.89467590E+00
25	1	0.93389908E+00
26	1	0.65723823E+00
27	1	0.61140397E+00
28	1	0.87374761E+00
29	1	0.77235786E+00
30	1	0.89102090E+00
31	1	0.89039017E+00
32	1	0.87217013E+00
33	1	0.97461291E+00
34	1	0.96851598E+00
35	1	0.52155236E+00
36	1	0.93093920E+00
37	1	0.97335778E+00
38	1	0.97061569E+00
39	1	0.60512196E+00
40	1	0.91076335E+00
41	1	0.92272587E+00
42	1	0.90833295E+00
43	1	0.89950783E+00
44	1	0.89110108E+00
45	1	0.93027573E+00

46	1	0.90128361E+00
47	1	0.79605395E+00
48	1	0.87518198E+00
49	1	0.59917398E+00
50	1	0.96137921E+00
51	1	0.93735655E+00
52	1	0.94333021E+00
53	1	0.91822880E+00
54	1	0.90706515E+00
55	1	0.95641209E+00
56	1	0.87448729E+00
57	1	0.93424180E+00
58	1	0.91686192E+00
59	1	0.91033725E+00
60	1	0.89472219E+00
61	1	0.71155780E+00
62	1	0.64346801E+00
63	1	0.57549399E+00
64	1	0.55957099E+00
65	1	0.91253837E+00
66	1	0.90888437E+00
67	1	0.60244988E+00

68	1	0.25116221E+00
69	1	0.63424313E+00
70	1	0.90958691E+00
71	1	0.90674150E+00
72	1	0.90001884E+00
73	1	0.81088202E+00
74	1	0.91056875E+00
75	1	0.91711033E+00
76	1	0.90191171E+00
77	1	0.91422057E+00
78	1	0.70283778E+00
79	1	0.93144223E+00
80	1	0.88670622E+00
81	1	0.91535880E+00
82	1	0.96010941E+00
83	1	0.90777767E+00
84	1	0.77643575E+00
85	1	0.93222901E+00
86	1	0.97473470E+00
87	1	0.97108222E+00
88	1	0.98095187E+00
89	1	0.91803738E+00

90	1	0.70275613E+00
91	1	0.97843412E+00
92	1	0.68542717E+00
93	1	0.92622753E+00
94	1	0.89993516E+00
95	1	0.90112214E+00
96	1	0.97979220E+00
97	1	0.96533695E+00
98	1	0.92039156E+00
99	1	0.91110064E+00
100	1	0.63859466E+00
101	1	0.92467248E+00
102	1	0.96925866E+00
103	1	0.95569980E+00
104	1	0.86419268E+00
105	1	0.97707491E+00
106	1	0.89822339E+00
107	1	0.28443908E+00
108	1	0.87167080E+00
109	1	0.55527602E+00
110	1	0.96463283E+00
111	1	0.62214150E+00

112	1	0.89296323E+00
113	1	0.55248158E+00
114	1	0.92482921E+00
115	1	0.95137309E+00
116	1	0.94239638E+00
117	1	0.92058921E+00
118	1	0.52385506E+00
119	1	0.61276573E+00
120	1	0.52406713E+00
121	1	0.94092597E+00
122	1	0.56544111E+00
123	1	0.92443951E+00
124	1	0.91048943E+00
125	1	0.71073286E+00
126	1	0.90381944E+00
127	1	0.96461129E+00
128	1	0.59217909E+00
129	1	0.91854798E+00
130	1	0.94491844E+00
131	1	0.92889450E+00
132	1	0.80575667E+00

mean efficiency = 0.84505829E+00