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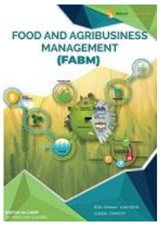

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RESEARCH ARTICLE

EMPIRICAL ANALYSES OF FINANCIAL CREDIT ON SMALLHOLDER FARMER'S PRODUCTIVITY MODELLING FARMERS CREDIT ALLOCATION FROM RURAL BANKS IN SIERRA LEONE

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ABSTRACT

Sierra Leone has experienced an increase in farmers' accessibility to financial credit facilities in recent time. Financial credit plays a significant role in enhancing productivity and efficiency within the agricultural sector of emerging nations, and Sierra Leone is not exempt from this trend. The present study investigates the allocation of financial credit among farmers and its impact on technical efficiency. A three-stage sampling methodology was employed to gather cross-sectional data from a sample of 500 agricultural producers in Sierra Leone. The objective of this study was to evaluate the influence of financial support on agricultural productivity, with the ultimate goal of enhancing economic and technical efficiency. The evaluation of the effect of allocation techniques on technical efficiency is conducted through the utilization of the random frontiers truncated-normal with the conditional average model. The present study employed the Heckman treatment effect model and stochastic frontier analysis (SFA) to examine the production efficiency of smallholder farmers. The study's empirical findings indicate that the provision of financial assistance by community banks has a notable and favorable impact on the technical efficiency of farmers. Despite the presence of many constraints, farmers' access to financial financing remains limited. This is reflected in the total technical efficiency of farmers, which was measured at 0.81 (81%). This indicates that none of the farmers were able to achieve a production threshold of 1 (100%). Nevertheless, it is worth noting that the average disparity in efficiency between individuals who borrowed and those who did not borrow was 0.09, equivalent to a 9% variation. This finding provides further evidence supporting the notion that access to financial credit has a beneficial effect on the efficiency of farmers. This, in turn, leads to a reduction in the severity of poverty and extreme poverty. Despite facing challenges such as pest and disease infestations, financial constraints, and unpredictable weather conditions, the inefficiency model demonstrated that factors such as education, membership in a farmer-based organization, experience, access to credit, and participation in a government-sponsored mass spraying program had a notable and favorable influence on efficiency scores. Hence, it is advisable to propose a policy aimed at enhancing the accessibility of financial services from community and rural banking institutions that includes every group of smallholder farmers in Sierra Leone.

KEYWORDS

Financial credit, smallholder farmers, efficiency, community Banks and Sierra Leone

1. INTRODUCTION

Agriculture serves as the major economic activity in Sierra Leone, constituting the principal means of livelihood for around 75% of the country's populace. The industrial sector has a significant role in the economy, accounting for about 80% of total exports and making a substantial contribution to the gross domestic product (GDP), which stands at approximately 29.89% according to the World Bank (2021). Notwithstanding the considerable national advantage, smallholder farmers have consistently experienced impoverishment as a result of the substantial capital demands and inherent production risks. Farmers have various challenges, including limited access to loans, insufficient availability of inputs and machinery, and unpredictable weather patterns (Afful et al., 2015). In the context of developing nations such as Sierra Leone, smallholder farmers predominantly possess ownership of farmland; yet, they often face limitations in terms of financial resources to engage in extensive commercial farming. Consequently, the availability of financial credit assumes a significant role in augmenting agricultural production (Boateng, 2015). The study conducted by suggests that the level of technical efficiency in agricultural productivity is heavily influenced by the availability of financial resources (Jan et al., 2012). The ability of smallholder farmers in Sierra Leone to obtain institutional credit is impeded by a range of obstacles, including the need for a minimum deposit, the requirement for comprehensive farm records, and the necessity of providing collateral. Furthermore, it has been observed that prominent financial institutions exhibit limited inclination towards providing loans to farmers, mostly attributed to the prevailing challenges of high illiteracy rates and a significant number of defaults (Conteh and

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Bob, 2010).

In order to address this issue, the Government of Sierra Leone, in collaboration with the Bank of Sierra Leone (BSL), established the Apex Bank (ABSL) in 2007. The primary objective of ABSL was to provide credit facilities exclusively to farmers. The successful performance of ABSL led to the subsequent establishment of community banks throughout the country. According to a report by the International Fund for Agricultural Development (IFAD) in 2018, the community banks were launched in all district headquarters in Sierra Leone in 2007. At present, Sierra Leone is home to a total of 17 Community banks, which are strategically located across different regions of the country. These banks operate under the supervision and regulation of the Apex bank. According to IFAD (2018), a requirement was imposed on these community banks to allocate 30% of its credit portfolio to the agriculture sector, 20% to cottage industries, and 50% to trade and transport. The community banks' success was overshadowed by its failure to accord high priority to the agriculture sector, resulting in comparatively less favorable treatment compared to other sectors of the economy. The limited availability of institutional credit poses significant constraints for smallholder farmers, leading them to opt for informal credit sources such as money lenders and trade creditors. However, these alternative sources often impose exorbitant interest rates and fail to provide sufficient funds for the implementation of high-technology projects in their farming activities.

Extensive research has been conducted on the influence of credit on agricultural development in South Asian nations, including India and Pakistan (Narayanan, 2016; Sidhu et al., 2008; Bashir et al., 2010; Iqbal et al., 2003). Nevertheless, the existing body of research on the relationship between rural finance and agricultural productivity in Sierra Leone is quite scarce. In their study, conducted an assessment of the efficacy of rural banks in Sierra Leone (Kadri et al., 2013). Their findings indicated that the lending policy of the Bank of Sierra Leone had a bias against the agricultural sector, resulting in less favorable treatment for this particular industry. In their study, conducted an analysis on the impact of rural banks on agricultural development and food security in Sierra Leone (Afful et al., 2015). The researchers arrived at the finding that rural banks play a significant role in reducing poverty and enhancing food security within the country. Nevertheless, the aforementioned research failed to investigate the effects of financing on the sustenance of small-scale agricultural producers in Sierra Leone. The current study employed the Stochastic Frontier Analysis (SFA) technique to estimate efficiency, while the Heckman's model was utilized to address selection bias and assess the reliability of the projected outcomes. The SFA methodology has been widely utilized in several studies to assess the technical efficiency of both agricultural and non-agricultural production systems. The agricultural applications encompass various activities such as cocoa production in Nigeria, rice production in Nepal and Vietnam, maize production in Ghana, and vegetable production in China (Amos, 2007; Binam et al., 2008; Piya et al., 2012: Hien et al., 2003; Khai and Yabe, 2011; Bidzakin et al., 2014; Zhang and Xue, 2005). The SFA methodology is frequently employed in numerous agricultural research due to its inherent advantages when compared to nonparametric data envelopment analysis (DEA). One notable benefit of employing the Stochastic Frontier Analysis (SFA) method is its capacity to elucidate the factors underlying deviations in a production function, including random effects and measurement errors. This capability is particularly valuable as it sheds light on the sources of inefficiency within the system.

The objective of this study is to examine the impact of smallholder farmers' decision-making regarding the allocation of financial credit on their technical efficiency in Sierra Leone. Smallholder farmers in Sierra Leone utilize financial credit for two primary purposes. Firstly, they employ it to address personal and communal requirements, including debt settlement, marriage expenses, funeral costs, housing expenses, healthcare expenses, and similar demands. Secondly, they utilize financial credit to fulfill agricultural necessities, such as acquiring inputs, hiring labor, and other related expenses. This study aims to model credit investments in two different scenarios with the objective of identifying the pairings that result in higher technical efficacy.

Based on the premise of financial credit allocation, the subsequent hypothesis was formulated:

The impact of credit investment on agricultural technological efficiency is contingent upon the utilization of credit within the agricultural sector. Consequently, the present study aims to adress the following question:

i: What is the effect of rural financial development on the technical efficiency of smallholder farmers in Sierra Leone?

ii: What ways might community banks contribute to the mitigation of income inequality and poverty among low-income households?

Addressing these inquiries will significantly aid policymakers in developing countries in formulating strategic frameworks for community banks to adhere to. This measure will facilitate the achievement of the main goal of establishing community banks, which is to enhance accessibility to financial resources for farmers of all backgrounds, hence encouraging and fostering agricultural productivity.

2. Literature Review

The provision of financial assistance for farming in rural areas is a prominent global topic, which has garnered significant attention from scholars who have undertaken useful investigations in this area. Zhang and Xiao conducted study that centered on rural financial institutions as the subject of study, with the aim of examining the efficacy of their assistance for small-scale farming (Zhang and Xiao, 2015). Researchers have employed a regional approach to examine the efficacy of financial aid programs for rural agriculture. By analyzing specific regions, these studies aim to gain insights into the broader national context and contribute to the existing body of research (Kolesnyak et al., 2022). A research investigation was undertaken in Chile to examine the influence of financial accessibility on technical effectiveness. The study involved a sample of farmers engaged in the cultivation of crops and animal rearing. In order to provide an accurate representation of the effects of credit provision on specialized small farmers, the translog stochastic frontier function was utilized. According to the results suggest that there is a contrasting impact of financial loan accessibility and credit volume on agricultural productivity (Kadri et al., 2013).

The study conducted by Bannerman and Fu assessed the influence of financial credit on families in Ethiopia, considering both constrained and unconstrained households (Bannerman and Fu, 2018). The objective is to discern the disparities in efficiency among these categories. Based on the research findings, it has been observed that households that have credit constraints exhibit a productivity level that is 12% lower compared to homes without such limits. The lack of efficacy shown among these groups is also heavily influenced by several factors, such as educational attainment, land fragmentation, and the quantity of loans obtained. The study conducted by Taraka, Latif, Shamsudin, Sidique, and Sidique employed the stochastic frontier approach to evaluate the impact of institutional factors on the efficiency of farm production loans in Pakistan (Taraka et al., 2012). On average, an efficiency score of 0.84 implies a level of inefficiency amounting to 16%. The technical proficiency of farmers is significantly influenced by factors such as their degree of education, access to capital, herd size, and choice of agricultural methods. The significance of agricultural financing to farmers is evident from the substantial coefficient value associated with the variable credit. A study conducted by Bashir, Mehmood, and Hassan in Nigeria aimed to gain a deeper understanding of the influence of insufficient funding on agricultural output (Bashir et al., 2010).

To do this, the farmers in Nigeria were categorized into two groups: beneficiaries and non-beneficiaries. The allocation or denial of credit in this context represents the capital, signifying that agricultural production activities encompass the utilization of credits for cultivating crops, implementing contemporary technologies, and employing suitable processing and storage methods. The socioeconomic situation of farmers, along with their understanding and attitudes towards various issues, serves as the foundation for all aspects of their activities. The analysis conducted in the aforementioned study primarily examined the impacts of loan provision on different categories and types of agricultural families. The farmer allocation behavior that occurs subsequent to loan acquisition was not taken into consideration by any of them. In reality, farmers possess the ability to manage their credit through a range of methods, each of which exerts a distinct impact on the production of their farms. Therefore, it is imperative to emphasize the methods for allocating credit to farmers. This study represents the inaugural investigation in Sub-Saharan Africa that explores the methods of farmer loan allocation and their subsequent impacts on farm technical efficiency.

2.1 Theoretical and Empirical Framework

The theoretical framework is grounded in neoclassical philosophy, which posits that the primary objective of any business entity is to optimize its profitability (Song and Hong, 2021). To optimize profits, a company allocates resources in accordance with prevailing market conditions. Therefore, the rationality of a farmer can be observed when the production system operates efficiently on the production frontier, aiming to generate a desired output using a set of n inputs denoted as x = x1 x2, which are acquired at prices w = w1 w2. In the context of fixed inputs, the production system endeavors to optimize the combination of inputs in order to get outputs that are in closer proximity to the production frontier. Technical efficiency (TE) refers to the identification of the optimal mix of inputs that enables a production process to operate as closely as possible to the production frontier. According to Geta, Bogale, Kassa, and Elias, any additional deviations observed beyond the production frontier can be attributed to the technical inefficiency (TI) of the production system (Geta et al., 2013). Input-oriented production systems aim to optimize the utilization of input combinations in order to attain a predetermined level of output. The bulk of agricultural production systems aim to reach the optimal level of outputs by focusing on output-oriented strategies that utilize fixed quantities of inputs. Farmers make decisions regarding the quantities of inputs to be utilized before to engaging in the production process. Once these quantities are determined, they remain fixed, and farmers strive to maximize their yields throughout the agricultural process.

There are two methods employed for evaluating TE: i. the parametric approach and ii. the nonparametric approach (Piya et al., 2012). The parametric method utilized two distinct methodologies. The initial step involves the estimation of TE scores, followed by the determination of TE score components by the utilization of a Tobit regression model incorporating farmers' sociodemographic factors. From an econometric perspective, this model challenges the assumption of independent and identically distributed distributions. The second methodology (2) simultaneously evaluates the treatment effect (TE) and its determinants. The aforementioned task is achieved through the utilization of the "stochastic frontier truncated-normal: conditional mean with explanatory variable" model. The aforementioned study conducted by Shavgulidze, and Zvyagintsev, employed this particular methodology to assess the total factor productivity of several economic sectors (Shavgulidze, and Zvyagintsev, 2017). In their study, employed a comparable model to assess the impact of extension service accessibility on agricultural total factor productivity (Dinar et al., 2018). This methodology allows for the simultaneous consideration of the variable of interest's impact as both a production input and a determinant of technical efficiency within a production system. The variables of concern in this study are the amount of loan extended and the credit allocation tactics employed by farmers. There exist two categories of TE determinants, namely: (1) human capital factors encompassing age, gender, education level, and agricultural experience; and (2) institutional features including access to loans, availability of extension services, and other related factors. The utilization of the one-step stochastic model is employed to analyze the impact of credit allocation strategies on agricultural total factor productivity. Furthermore, this study used a Tobit model that incorporates human capital components in order to identify the factors that influence TE scores.

3. Materials and Methods

Sierra Leone is located on West Africa's Atlantic coast. The total land area is 72,300 km2 (27,915 mi2), with a coastline length of 402 km (249.8 mi). This area accounts for approximately 91% of Maine's land area with a population of 7,092,113 as of the 2021 mid-term population and housing census. The agricultural sector is dominated by smallholder subsistence farmers utilizing local traditional tools with outdated methods and limited farm inputs. The country is faced with declining rural population and absence of formal institutional credit to smallholder farmers and also pressured by the government to increase production efficiency to meet global demand and food self-sufficiency. Smallholder farmers' access to financial credit is mostly constrained by lack of collateral security, the region has a total of 17 rural community banks supervised by the Apex bank Sierra limited.

3.1 Study Area

Figure 1: Map of Sierra Leone showing survey Area

3.2 Sample and Sampling Techniques

The selection of smallholder farmers from the region was conducted in a manner that aimed to create a representative sample for the purposes of this study. This was achieved through the implementation of a three-stage sampling approach. The districts selected for this investigation were Kailahun, Portloko, Tonkolili, Koinadugu, and Bo. In the initial phase, a district-level sampling approach was employed, wherein five agricultural growing districts were randomly chosen among a total of 13 districts within the region. For the second stage of sampling, a total of five villages that were experiencing growth were selected randomly from each district (as depicted in figure 1). During the third stage, a total of twenty farmers were chosen from each village, with the assistance of extension officers operating in different districts. In addition, a total of five community banks, specifically Pendembu, Marampa, Yoni, Kabala, and Sumbuya, were chosen in accordance with the preferences expressed by farmers. Each bank was selected from a distinct representative district, with the purpose of verifying the assertions made by farmers regarding their ability to obtain credit. A study was conducted using a sample size of 500 smallholder farmers. The researchers performed face-to-face interviews with a specific group of farmers and rural bank heads. These interviews utilized semi-structured questions that covered various important topics, including demographic factors, farm characteristics, farm income and expenditure, and credit disbursement. The chosen sample is considered to be a representative of the Western region, which is widely recognized to possess substantial potential for cocoa intensification. Additionally, it is thought to present prospects for enhancing farmers' income. While the chosen districts exhibited the highest proportion of total output during the 2021-2022 season, as well as the largest cultivated area, it is noteworthy that the region as a whole contributes almost 60% of the nation's overall output. The questionnaires included in this study underwent a pretesting process with a sample of thirty farmers. This pretesting aimed to address issues related to interpretation challenges and potential order bias. Data was collected during the cocoa harvesting season of 2021/2022, whereby it was seen that out of a sample size of 500 smallholder farmers, 120 households actively engaged in the financial credit program, while the remaining 380 households did not partake in the program.

3.3 Data Analysis

The data analysis in this study involved the utilization of two statistical software packages, namely STATA 15.0 and FRONTIER 4.1. These software tools were employed to investigate and analyze the data pertaining to agricultural productivity, credit utilization, and technical efficiency scores. The calculation of productivity in kilograms per hectare (kg/ha) involved dividing the total quantity (in kilograms) by the area of the farm (in hectares). A commonly employed stochastic production frontier model and a one-step stochastic frontier analysis (SFA) were utilized to represent the productivity and technological efficiency of farmers. The study employed Heckman's treatment effect model to evaluate the factors that contribute to farmers' participation in the credit program, as well as to examine the resilience of the credit program's impact on farmers' levels of efficiency. Subsequently, an assessment was conducted to examine the impact of credit accessibility on the technical efficiency of those who have taken credit and those who have not. The findings were then utilized to infer potential socioeconomic disparities between these two cohorts.

3.4 Stochastic Frontier Analysis (SFA)

The econometric technique known as Stochastic Frontier Analysis (SFA) was introduced by Coelli in 1998. A group researchers found that both approaches yield findings that are strongly linked (Toma et al., 2017). To provide more clarification, it is important to note that the results obtained from the DEA technique exhibit a high degree of sensitivity. This sensitivity arises from the omission of an analysis pertaining to the impact of random factors on technical efficiency. Consequently, the utilization of Stochastic Frontier Analysis (SFA) was employed to evaluate the technological efficiency of agricultural output, given its suitability for agricultural research where data often exhibits susceptibility to natural influences. The SFA approach was introduced by and it can be described in the following manner (Aigner et al., 1977; Meeusen and Van Den Broeck, 1977).

$$Y i = f(X i , \beta) \exp (v i - u i) \quad (1)$$

The equation can be expressed as Y subscript i equals the function f of X subscript i and β, multiplied by the exponential function of the difference between v subscript i and u subscript i. The user's text lacks any academic content or context. Let Y_i denote the output of the i-th sampled farmer, and let X_i and β represent the vector of inputs and parameters to be estimated, respectively. The random error and inefficiency error terms are denoted as $v \sim N(0, \delta v^2)$ and $\sim N[f(\mu, \alpha), \delta u^2]$ correspondingly.

The error term u, which represents inefficiency, exhibits a constant variance of δu^2 and a location parameter μ. The distribution often exhibits a positive truncated normal distribution, with the location parameter μ being contingent upon additional explanatory variables. In general, the relationship between the variable μ and the variable z can be expressed as μ = αz, where α is a vector of parameters to be evaluated, with dimensions 1 x p. The estimation of technical efficiency and its determinants can be conducted simultaneously through the utilization of the production frontier in Equation 1 inside the standardized approach. The equation representing the inefficiency effects, as proposed by Battese and Coelli, is defined as follows (Battese and Coelli, 1995):

$$u i = f(u i , \alpha) \quad (2)$$

The following expression represents the output-oriented technical efficiency (TE ί) of the ί -th farmer.

$$T E i = Y i / Y * i = f (X i , \beta) \exp (v i - u i) / f (X i , \beta) \exp (v i) = \exp (-u I \quad (3)$$

The expression for the total effect of variable i, denoted as TEi, can be represented as the ratio of the observed outcome Yi to the counterfactual outcome Y*i. This ratio is a function of the covariates Xi and the parameter β. Additionally, it involves the exponential of the difference between the individual-specific random term vi and the population-level random term ui. Simplifying this expression further, we find that TEi is equal to the exponential of the negative value of ui.The user's text does not provide any information to be rewritten in an academic manner.Where Y_i represents the observed production in the presence of inefficiency, and Y_i* represents the output at the frontier without inefficiency. The estimated TE ί value is within the range of 0 and 1. In order to assess the production patterns of producers in the region, we utilized the Cobb-Douglas (CD) production function, which is predicated on the primary approximation of any unidentified function. Due to the relatively limited sample size, the CD function was favored over the translog production function. This preference stems from the fact that the translog function has the capacity to accommodate a greater number of parameters, which typically necessitates a higher degree of freedom in order to yield a precise estimation. Moreover, the anticipated outcomes of this model align with both theoretical frameworks and empirical evidence from the context of Sierra Leone's production practices. The CD function employed for assessing the efficiency and inefficiency of farmer produce is outlined as follows:

$$InY i = 0 i =1 InX i + (v i - u i) \quad (4)$$

$$u i = \alpha 0 + \alpha 1 \text{ CDusei } z i \quad (5)$$

In equation (4), the value of variable i in the InY dataset is incremented by the difference between the values of variables vi and ui in the InX dataset. The value of ui is determined by the sum of α0 and α1 multiplied by the product of CDusei and zi, as shown in equation (5).

In the given context, Y ί represents the yield in kilograms per hectare (kgha^−1), while X ί denotes a vector consisting of five conventional inputs, namely fertilizer, labor, capital, extension access, and farm size. The factors utilized in this investigation are displayed in Table 1. All question marks and alpha symbols are parameters that need to be computed. In addition, m ί denotes the variables that determine TE apart from credit utilization (CDuse ί). Meanwhile, u ί is a non-negative stochastic variable that captures production inefficiency and adheres to a truncated normal distribution. z ί represents a random error in the inefficiency model, and v ί is a random error that follows a normal distribution. Battese and Coelli propose the utilization of the gamma (γ) parameter subsequent to the estimate of stochastic frontier analysis (SFA) in order to identify the presence of inefficiency (Battese and Coelli, 1995). The equation for the overall variance is represented as δ2 = δv 2 + δu 2, where δ2 denotes the total variance, δv 2 represents the volatility due to v, and δu 2 represents the variance due to u. Additionally, the ratio γ is defined as δu 2 divided by δ2. When γ equals zero, the absence of inefficiency implies that the ordinary least squares (OLS) approach is advantageous. When γ equals one, the deviation is solely attributable to inefficiency. Furthermore, if γ falls within the range of zero to one, the deviations are caused by both inefficiency and random factors.

3.5 The Stochastic Frontier Model.

The Stochastic Frontier Model (SFM) is a statistical framework used to analyze the efficiency and productivity of firms. The utilization of credit, either independently or in conjunction with other production inputs, is believed to enhance the whole efficiency of the production system. Credit is seen as one of the production inputs within this particular system. When combined with other inputs such as manpower, pesticides, and financial resources, credit plays a crucial role in determining a farm's total efficiency (TE). The examination of the relationship between the variables of credit and inputs demonstrates the amalgamation of these factors. Each variable resulting from this interaction represents the credit allocation scheme. For instance, the variable "credit labor" demonstrated an increase in the allocation of credit towards the quantity of labour needed. The stochastic model depicted below captures the effects of these interactions. The equation can be expressed as

$$i = f\ (xi) \exp\ (Vi - ui\ (zi)) \quad (6)$$

In this context, yi represents the production level of a specific farm denoted as i. The vector xi represents the inputs used in the production process. The term (·) is the production frontier, which represents the maximum attainable production level given the inputs. The composite error term wi is calculated as the difference between the value Vi and the unobservable term ui. The error term Vi is associated with the presence of omitted variables and uncontrollable factors that affect the farmer, such as climate variability and soil fertility. The variable "ui" represents a nonnegative component that quantifies inefficiency. In the context of output-oriented technical efficiency, the corresponding technical efficiency measure, denoted as ETi, can be expressed as $ETi = \exp(-ui)$, where ETi belongs to the interval [0, 1]. In a study conducted by Guliyev, Liu, Endelani Mwalupaso, and Niemi the authors examined a particular topic (Mwalupaso, and Niemi, 2019). The output-oriented method is well-suited for agricultural production, as it involves pre-determining the quality and amount of inputs prior to initiating the production process. In the context of the production function, there exists no association between the stochastic error term and the preset inputs. The estimation of Equation (1) does not exhibit simultaneity bias. The underlying assumptions about the error terms are as follows: the random variable ui follows a half-normal distribution, the random variable Vi follows a normal distribution, and the covariance between Vi and ui is equal to zero. The logarithmic transformation of equation (1) can be expressed as ln $(yi) = \beta 0 + \sum \beta k$ ln (xki).

Let us consider the expression k (2) + 0.5$\sum \sum \beta kp$ ln (xik) ln (xip) + V$i - ui$ (7)

The variables k and p are being considered in this context. Based on the given assumptions, the following conditions are considered: (1) the symmetry of the variables βkp and βpk; (2) the variable Vi follows a normal distribution with constant variance σV2, independently and identically distributed (i.i.d.); (3) any deviations from the frontier ui are assumed to be independently and identically distributed (i.i.d.) and follow a normal distribution, with no correlation to the variable Vi [19, 20].

The variance of ui is calculated.

In the given equation, θjzj + εi, j (8)

the variables θ_jz and ε_i represent the components of a mathematical expression.The θj variables represent the estimators that quantify the impact of the zj variables on the treatment effect (TE). Meanwhile, the εi term denotes the error component, which follows an independent and identically distributed (i.i.d.) normal distribution.

3.6 Specification of Variables

In equation (2), yi represents the income generated by a farm. The vector xi consisted of four factors, including area (measured in hectares), labor quantity (measured in man-days), capital, intermediary inputs, and other variables. According to the vector zj comprises the credit amount, the square of credit, and the interaction factors (Guliyev et al., 2019). The anticipated effect of the elasticities of the inputs vector xi on the production level is expected to be advantageous. The effects of credit and interaction factors on the treatment effect (TE) are not assumed.

The Tobit Model is a statistical model used in econometrics to analyze censored data. In a study conducted by the researchers employed a regression analysis to examine the impact of human capital parameters, such as age, gender, and education level, on technical efficiency (TE) scores (Iqbal et al., 2003). The purpose of this analysis was to determine the marginal effects of these factors on TE. The equation can be expressed as:

$$Yi* = Xi\beta + \varepsilon i \quad (9)$$

In this context, the dependent variable is denoted as Yi, while Xi represents the vector of independent variables used for estimation. The error term, denoted as i, follows a normal distribution with a mean of zero and a constant variance. Considering the fact that the technical efficiency (TE) ratings for farm i fall within the range of 0 and 1, this leads toIf the value of Y* is greater than 0 and less than 1, then Yi is equal to Y*. The user's text does not contain any information or context to rewrite in an academic manner.The value of Yi is equal to zero when Y* is less than or equal to zero. Hence, the empirical model is. The equation can be expressed as Yi = βnXi + εi, where Xi represents the independent variable and Yi represents the dependent variable. βn is the coefficient associated with Xi, and εi represents the The Maximum Likelihood model is employed as a means of mitigating the mistakes observed in the Ordinary Least Squares (OLS) model (Jaime and Salazar, 2011).

4. Results and Discussion

In descriptive statistics, the dependent variables are technical efficiency and total yield. The study then categorized the explanatory variables into three distinct groups: socioeconomic factors, farming features, and institutional components. Based on the analysis of descriptive data, it can be inferred that a significant majority of the participants were male, suggesting that men have a dominant role in agricultural output within the research area. This outcome was predictable, given that males in Sierra Leone, particularly in rural agricultural communities, tend to possess greater access to resources compared to females. This discovery aligns with the findings of (Piya et al., 2012). Furthermore, it was underscored that women in African societies experience marginalization in relation to their male counterparts in terms of their access to resources, information, and financial opportunities. The average age of farmers was found to be 37.5 years, a figure deemed suitable for engaging in agricultural production due to the physically demanding and labor-intensive nature of the work. This observation aligns with the findings of who concluded that older farmers tend to exhibit lower levels of efficiency compared to their younger counterparts (Mumuni and Oladele, 2016).

The vast majority of agricultural workers reside within a radius of 10 kilometers from the designated financial institutions, with an average household size of 4.01 individuals. The present study provides additional support to the research conducted by while presenting contrasting evidence to the assertions made by regarding the literacy levels of farmers in Sierra Leone (Kongor et al., 2018; Baah, 2006). In addition to agricultural pursuits, it was found that 90% of the participants generated supplementary income by engaging in hobbies such as animal husbandry and fishing. The mean duration of agricultural experience was found to be 10.81 years, a statistically significant finding. This is noteworthy as farmers are able to leverage their past experiences and expertise to enhance current patterns of output. Danso Abbeam reported that the mean age of farms was 11.05 years, with a predominant presence of small-scale farmers who owned farms measuring less than 3 hectares (Danso Abbeam, 2014). Notwithstanding the government's endeavors to provide financial aid to farmers, it was found that a significant majority (76%) of farmers in the designated research area lacked access to formal institutional loans from community banks.

This study corroborates the research conducted by which revealed a shift in the priorities of rural banks from agriculture to commerce and business (Kadri et al., 2013). In addition, a significant proportion of farmers, specifically 79%, were able to avail themselves of extension services. Conversely, the remaining farmers were compelled to depend on their social networks, specifically friends, in order to address any farming-related issues they encountered. The persistence of this problem can be attributed to the fact that a significant number of cocoa farms are situated in rural areas characterized by inadequate road infrastructure. In addition, it is worth noting that extension agents face a significant challenge in terms of insufficient transportation resources to effectively reach and visit these economically disadvantaged areas.

Ultimately, a majority of farmers, specifically 56%, have chosen to align themselves with the Farmers' Business Organization (FBO), thereby enabling them to avail themselves of the benefits offered by the government-sponsored award program. The aforementioned variables play a crucial role in accurately assessing the influence of financial credit engagement in the agricultural sector, as they encompass social and managerial elements that are essential for conducting assessments on productivity and technical efficiency.

Table 1: Presents the descriptive data of the farm homes that were sampled for this study.

Description of variables	Mean	Std. Dev.		Max.	Mn.
Dependent variables					
yield (kgha −1)	305.23	35.32		410.3	102.21
Explanatory variables *Socio-economic characteristics* Gender (1 = male, 0 = female	0.90	0.23		1.00	0.00
Technical effciency	0.81	0.31		0.99	0.59
Age (years)	37.5	2.13		59.00	21.00
Education (1 = yes, 0 = no)	0.37	0.12		1.00	0.00
Household size (count)	4.01	0.12		8.00	3.00
Off-farm income (1 = yes, 0 = no)	0.90	0.23		1.00	0.00
Experience (years)	10.81	1.21		15.00	5.00
Distance to bank (km)	13.50	3.70		28.23	2.54
Farming characteristics					
Age of farm (years)	11.05	1.32		20.07	5.05
Farm size (ha)	2.43	0.18		6.45	1.79
Disaster (1 = yes, 0 = no)	0.04	0.01		1.00	0.00
Fertilizer use (1 = yes, 0 = no	0.89	0.43		1.00	0.00
Labor input (hr/ha)	15.4	2.94		23.40	8.23
Institutional factors					
Farmer-based organization, FBO (1 = yes, 0 = no)	0.56	0.14		1.00	0.00
Financial Credit access (1yes,0 = no)	0.24	0.13		1.00	0.00
Access to extension service (1 = yes, 0 = no)	0.79	0.19		1.00	0.00
Credit amount received (US$)	520.00	53.43		850.0	175.00
Participate in grant program (1 = yes,0 = no)	0.71	0.11		1.00	0.00

Source: authors' calculations from field survey, 2022

4.2 The Utilization of Credit by Individuals Who Have Been Granted Credit

Several significant results have been shown about the 120 individuals who received credits, accounting for 24% of the total, from the community banks that were chosen for this study. Before this discussion, a significant proportion of farmers depended on their own personal resources to finance their agricultural endeavors. This statement suggests that the formal credit sector has not adequately fulfilled the credit needs of farmers, hence weakening the assertion that the formal credit sector is the primary source of credit for the agricultural sector (Kadri et al., 2013; Afful et al., 2015). Our research supports the argument made by Steel and Andah that the primary obstacle preventing the majority of farmers from accessing credit from unit banks in Sierra Leone is the lack of collateral security (Steel and Andah, 2008).

4.3 The Productivity Frontier Analysis

The empirical results of the stochastic frontier analysis (SFA) obtained using maximum likelihood estimation (MLE) using the Frontier 4.1 program are presented in Table 3. The model's wide applicability is ensured through the utilization of previously established model specification tests. The rejection of the null hypothesis, which assumes no inefficiency in agricultural production, is based on the log-likelihood ratio test (LR test). This test measures the extent to which the inefficiency component of the disturbance term (ui) deviates significantly from zero. Moreover, a lambda value that is considerably greater than zero serves as an indication of the substantial impact of production inefficiency in the region (Bravo-Ureta et al., 2012). A scale elasticity that deviates significantly from 1 serves as an indicator of a continual return to scale in the manufacturing of cocoa. A sigma-squared (σ^2) value of 0.545 suggests a satisfactory level of fit, indicating that the composite error term's distributional assumption is appropriate, rather than relying just on the average response specification. The appropriateness of doing a stochastic frontier analysis can be determined by evaluating the value of the Gamma parameter (γ) (Bezat, 2011; Kea et al., 2016; Taraka et al., 2012). The estimated gamma (γ) value of 0.75 suggests that approximately 75% of the fluctuation in output can be attributed to inefficiencies in resource utilization and other agricultural practices.

Furthermore, it is observed that 29% of the differences between the actual output and the frontier output are caused by random causes. This implies that the presence of technological inefficiency has a significant role in elucidating the variations in output levels observed among cocoa growers in the region. This discovery exhibits resemblance to the findings of (Gockowski et al., 2011; Danso-Abbeam et al., 2012). In addition to the size of the farm, all of the classical inputs exhibited a favorable and statistically significant impact on output. The phenomenon described can be ascribed to the excessive cultivation practices employed in agricultural activities, as well as the prevalence of smaller farm sizes within the region (Wessel and Quist-Wessel, 2015). In addition, the cultivation of cocoa necessitates a substantial amount of land to accommodate the implementation of novel production techniques and the eradication of diseases, while also facilitating the proper uptake of essential nutrients (Baah, 2006; Danso-Abbeam et al., 2014). In addition to several other input factors, capital emerges as the primary determinant in production, as indicated by the calculated coefficient. A group researchers have documented comparable results, highlighting the indispensability of capital as a crucial determinant in all agricultural productivity (Solís et al., 2009; Shavgulidze and Zvyagintsev, 2017).

Table 2: Constrain Related to Financial Credit Accessibility at The Banks in The Research Area

Factors that contribute to the inability to obtain financial credit from banks.	%	No of farmers
Average Required	12.6	48
Collateral Required	40.8	155
Updated farm records from the farmers	23.7	90
Fixed income guarantees by the bank	22.9	87
Average Required	12.6	48

Source: authors' calculations from field survey, 2022

Table 3: Maximum likelihood for the Stochastic Frontier Analysis

Variable	Coefficient	t-stat.	Std. Error.
Constant	4.897	3.550 ***	1.379
Capital	0.632	2.014 **	0.313
Labor input	0.431	1.215 *	0.354
Fertilizer use	0.311	2.221 **	0.140
Gender	0.015	0.271	0.055
Education	-0.211	-2.134 **	0.098
Farm size Inefficiency Effects Model	-0.510	-2.175 **	0.234
Constant	4.173	4.107 ***	1.016
Age	0.038	0.211	0.180
Extension access	0.312	1.234 *	0.253
Credit access	-0.201	-1.970 *	0.102
Experience	-0.301	-2.421 **	0.124
CODAPEC	-0.613	-3.131 ***	0.195
Household size	0.073	1.211	0.060
Member of FBO	-0.451	-2.376 **	0.189
Return-to-scale	1.071		
Sigma V-squared	0.132		
Log-likelihood ratio test	68.342 **		
Sigma-squared (σ^2)	0.545		
Lambda (λ)	1.061		
Gamma (γ)	0.757		
Model Diagnostics Sigma U-squared	0.413		
Sample size (n)	500		

***;**,*are used in statistical analysis to denote levels of statistical significance at 1%, 5%, and 10% thresholds. The calculations presented in this study were conducted by the authors based on data collected during a field survey in 2022.

The total efficiency of all smallholder farmers that were sampled was found to be below one (1), indicating that none of the farms exceeded the cocoa production possibility frontier, as shown in Table 4. The mean projected total effect (TE) among the sampled farmers was found to be 0.81. This implies that the mean smallholder farmer in the surveyed region achieves an output of roughly 81% of the maximum attainable yield based on the current technological capabilities. Farmers who have the opportunity to obtain credit exhibited a mean Total Efficiency (TE) of 0.88, whereas those who did not accept credit had a TE of 0.79. On average, smallholder farmers in the research area contribute between 12% and 21% of the frontier output. In practical terms, it can be observed that the average farmer who has access to finance is able to achieve approximately 88% of the maximum potential production with the current technology. In contrast, those farmers who do not take use of credit opportunities are only able to achieve around 79% of the maximum potential production. This indicates a notable efficiency gap of 9% between these two groups.

In the immediate term, it is advisable for farmers to prioritize enhancing their output levels by 12% and 21% correspondingly. The achievement of this objective necessitates the utilization of cutting-edge agricultural technologies and the effective allocation and integration of key production factors, including financial resources, fertilizers, labor, and extension services. The minimum TE observed among individuals who took credit and those who did not take credit was 59% and 63%, respectively. This discrepancy may be attributed to the possibility that some credit takers may have utilized their credit for purposes unrelated to agriculture. In addition, it was observed that among the participants who took credit courses, 62 individuals (51.7%) achieved a maximum Total Efficiency (TE) score ranging from 0.9 to 1.0, which corresponds to a percentage range of 90-100%. On the other hand, among the participants who did not take credit courses, 139 individuals (36.58%) attained a maximum TE score ranging from 0.8 to 0.9, corresponding to a percentage range of 80-90%. Moreover, as mentioned earlier, it is not appropriate to make broad generalizations about the predominant influence of credit on the observed variations in TE levels without first addressing the issue of sample selection bias. The present discovery aligns with prior investigations. A group researchers conducted a study to estimate the average technical efficiency (TE) of smallholder farmers in Sierra Leone, finding it to be 44% (Danso-Abbeam et al., 2012). However, given the passage of time and the subsequent increase in agricultural output in Sierra Leone, the present analysis reveals higher TE values.

The parameters used in the inefficiency approach presented in Table 3 are indicative of factors that contribute to technical inefficiency, rather than efficiency in the production process. The findings suggest that a variable with a positive sign has a diminishing effect on the technical efficiency (TE) level of a farmer, while a variable with a negative sign has an increasing effect. The variables that were shown to have a significant impact on TE in production include farming experience, educational level, farmer's participation in the grant program, credit, and membership of a farmer-based organization (FBO). The statistical analysis revealed that the coefficient of credit access exhibited a substantial degree of significance at the 10% level. This finding underscores the crucial role of credit access in determining the levels of inefficiency observed in agricultural farms. The coefficient of education exhibited statistical significance at a 5% level, indicating a beneficial influence on the technical inefficiency observed in cocoa fields. This implies that farmers who have had a greater number of years of schooling are more likely to attain better levels of Total Factor Productivity (TE), potentially because of their enhanced capacity to efficiently allocate capital resources, effectively manage operations, and apply pertinent technologies in the production process.

The present discussion aligns with the findings of (Bozoglu and Ceyhan, 2007; Khairo and Battese, 2005). The aforementioned discovery also suggests that agricultural policy should be oriented towards extension education as a means of assisting farmers in enhancing their efficiency in cocoa production. The presence of a negative coefficient in the farmer's degree of experience indicates a positive relationship with technical efficiency, suggesting that as the farmer's experience increases, their technical efficiency also increases. According to have provided evidence to support the notion that farmers who have accumulated more years of expertise in the field are capable of using their past experiences to adapt their current farming techniques (Parikh et al., 1995; Abdulai et al., 2017; Okiki et al., 2004). The study revealed that the involvement of farmers in a grant program arranged by the government had a beneficial effect on total efficiency (TE) due to the periodic provision of grants to farmers without any associated costs.

In relation to the inclusion of farmers' association membership in FBO, our findings diverged from those of yet aligned with the conclusions drawn (Guliyev et al., 2019; Binam et al., 2004; Jaime and Salazar, 2011; Paz et al., 2003). These studies have consistently demonstrated that farmers who are affiliated with associations exhibit higher levels of technical efficiency compared to their non-affiliated counterparts. In contrast to previous research, the variables of gender, household size, and age were found to have no significant impact on the total factor productivity (TE) of cocoa production. There is a contention that senior farmers exhibit lower levels of technological efficiency compared to their younger counterparts (Rahman, 2010).

4.4 Assessment of the Sensitivity of the Impact of Financial Credit

The findings of Heckman's research on the factors influencing farmers' participation in the credit program, along with an assessment of the reliability of our calculations, are displayed in Table 5. The coefficient of determination, known as the Pseudo R2, has a value of 0.654, indicating that the explanatory factors have the potential to explain about 65.4% of the variability observed in farmer participation. The model has statistical significance at a significance level of 1%. Based on the results, it can be observed that several factors such as the age of the farmer, the size of the farm, the level of education, the income derived from non-farm sources, and the proximity to the bank significantly influence the farmer's inclination to engage in the loan program offered by the local community bank.

Table 4: The Distribution of Technical Efficiency Scores of Farmers

Efficiency level Overall distribution results (n = 500)			Financial credit taker (n=120)		Non- Financial credit taker (n=380)	
0.5-0.6	1	0.2	1	0.83	0	0
0.6-0.7	30	6.0	7	5.83	23	6.05
0.7-0.8	235	47.0	17	14.17	218	57.37
0.8-0.9	172	34.4	33	27.50	139	36.58
0.9-1.0	62	12.4	62	51.67	0	0
Mean	0.81		0.88		0.79	
Maximum	0.99		0.99		0.89	
Minimum	0.59		0.59		0.63	

Source: authors' calculations from field survey, 2022

At a significant level of 1%, there was a statistically significant relationship between the age of farmers and their involvement in the credit system. The rationale behind this is that a significant proportion of farmers within the research region were characterized by youthfulness and a strong inclination to allocate additional financial resources towards their agricultural operations, with the aim of enhancing productivity and ameliorating their quality of life. The observed correlation between farm size and farmers' participation decision, indicating a 5% effect, implies that farmers with larger farms exhibit a greater propensity to engage in loan utilization for agricultural purposes. The decision-making and participation choices of farmers are influenced by their level of education (Danso Abbeam et al., 2018). However, factors such as off-farm income and proximity to the rural bank have a negative effect on farmer participation. Farmers who have a secondary source of income and those who live in remote areas, where the proximity to bank facilities is limited, are less likely to engage in participation.

In contrast to the findings of previous studies the present study did not observe any significant impact of FBO membership and household size on farmers' inclination to engage in the credit program (Bernnerman and Fu, 2018; Narayanan, 2016). Regarding FBO membership, it was observed that members mostly directed their attention towards facilitating one another in the execution of agricultural tasks, namely those linked to transplanting, weeding, and harvesting. The outcome equation is employed to assess the dependability of the findings derived from the inefficiency model about the impact of bank credit on the technical efficiency scores of farmers. The IMR value of 0.673 indicates a substantial significance, suggesting a positive correlation between the error terms in both the selection equation and outcome equation. Therefore, the correlation between participation in the credit program and improved farmer wellbeing suggests that the utilization of Heckman's method is appropriate for addressing the issue of sample selection bias.

Additionally, the results indicate that the total efficiency of smallholder farmers is influenced by their participation in a financial credit program. The coefficient for credit access exhibits a positive and statistically significant relationship at a significant level of 5%. This suggests that farmers who have access to credit are 0.37 points (equivalent to a 37% increase) more technically efficient compared to those who do not accept credit. The limited impact can be attributed to the improper utilization of loans by farmers, as it was found that around 24% of credit recipients diverted the funds towards non-agricultural endeavors. The occurrence of a disaster significantly diminishes the levels of technological efficiency (TE) among farmers, as evidenced by a notable and adverse coefficient of -1%.

The statistical measure suggests that the presence of many catastrophic calamities, such as bush fires, excessive heat, pests, insects, disease outbreaks, and prolonged droughts, will result in a reduction of technical efficiency by 91.2%. The age of the farm, as determined by the age of trees present on the farm, exhibited a statistically significant impact at a significant level of 1%. This age variable was found to have a negative influence on both farm production and total efficiency. According to the findings of Wessel and Quist-Wessel the primary factor contributing to decreased production in the majority of farms is the decline in soil fertility resulting from inadequate or limited utilization of fertilizers (Wessel and Quist-Wessel, 2015). Ultimately, the coefficients associated with the variables of education, membership in the FBO, agricultural experience, and participation in the grant program exhibited a favorable and statistically significant impact on the levels of farmers' technological efficiency.

Table 5: Participant in Institutional program and (TE).

Variables	tobit (first stage)		Treatment effect (second stage)	
	Std.error	Coefficient	Std.error	Coefficient
Education	0.168	-0.341 *	0.029	0.217 **
Age	0.011	0.089 **	0.010	0.016
Gender	0.053	0.312 ***	0.012	0.018
Bank participant	0.443	0.643	0.044	0.179 ***
Off-farm income	0.001	-1.137 ***	0.384	0.482
Household size	0.016	0.065 *	0.062	0.071
Farm size	0.101	0.123		
Member of FBO			0.012	0.139 **
Distance to bank	0.271	0.157		
Grant			0.134	0.525 ***
Experience			0.015	0.327 ***
Disaster			0.043	-0.512 ***
Credit access			0.121	0.378 **
Observations		0.654		500
Age of farm	1.072	-2.26 *	0.047	-0.401 ***
Constant		500	0.238	4.145 ***
Lambda (IMR)				0.673 **
Pseudo R^2		39.48 ***		
Wald chi ^{2}				42.96 **
Sigma				0.596
Rho				0.818

***, **,* demonstrated statistical significance at the 1%, 5%, and 10% levels. The calculations presented in this study were derived from a field survey conducted by the authors in 2022.

5. Conclusion

The recognition of the significance of rural finance institutions in boosting productivity in agriculture is well recognized. The implementation of increased financial resources has resulted in improved and ensured timely utilization of agricultural inputs, increased acceptance of novel agricultural innovations, and enhanced potential for technical efficiency. The study employed the Heckman's technique and the Stochastic Frontier Analysis to analyze household farm-level data from Sierra Leone. The objective was to evaluate the association between credit utilization and technical efficiency. Empirical research has provided evidence to support the notion that the provision of financial credit can significantly enhance the productivity of smallholder farmers. The utilization of modeling techniques to analyze farmers' credit allocation decisions can provide financial institutions with valuable insights into the credit requirements of smallholder farmers, enabling them to develop and provide suitable credit solutions. The study used the one-step stochastic frontier model to examine credit allocation processes and determine their impact on enhancing farm technical efficiency.

The results of the study indicate that a significant proportion of the farmers examined, specifically 24%, were successful in obtaining financing for their agricultural endeavors, despite facing various constraints that restrict their access to bank credit. On the contrary, the estimated gamma value suggests that 75% of the variability in farm output can be attributed to inefficiencies in input utilization and other agricultural processes, while the remaining portion is attributable to random factors. Moreover, it is worth noting that none of the farmers have beyond the production possibility frontier. This may be attributed to the fact that the average farmer, based on the estimated mean total efficiency, is only able to achieve around 81% of the potential output using the current technology. The average total efficiency (TE) for individuals who took out loans was found to be 88%, whereas for those who did not take out credit, it was 79%.

This indicates a notable disparity of 9% in production efficiency between the two groups. Moreover, the inefficiency model has demonstrated that, apart from financial credit, factors such as farmers' educational attainment, membership in farmer-based organizations (FBOs), degree of competence, and participation in government-sponsored award programs have a significant impact on efficiency ratings. The influence of credit on the production of smallholder farmers exhibits variability across individual farmers, with several characteristics such as farm size, land tenure, and education level potentially playing a role in shaping this impact. Through the utilization of models that simulate farmers' credit allocation decisions, financial institutions have the ability to effectively allocate credit to those farmers who are most likely to derive significant benefits from it. This strategic allocation of credit can contribute to the advancement of sustainable agriculture and foster its overall development. This particular situation would enhance their inclination to embrace change with the aim of enhancing their agricultural resources.

In relation to policy implications, it is imperative to prioritize the allocation of resources towards medium and long-term financial support for smallholder farmers. Community banks can contribute to the attainment of this outcome through the implementation of creative strategies, such as the creation of specialized financial credit initiatives tailored specifically for farmers and the promotion of group lending practices within the farming community. In addition, it is recommended that the Ministry of Agriculture take proactive measures to encourage the establishment of farmer group formations, often known as Farmer-Based Organizations (FBOs), and facilitate the provision of extension services specifically tailored to meet the needs of smallholder farmers.

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