Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.7, No.8, 2016
www.iiste.org

Profit Efficiency of Groundnut Production: Evidence from Eastern Province of Zambia

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Abstract
The study analysed profit efficiency and its determinants in smallholder groundnut production in the context of profit maximization as an incentive for optimum production in Eastern Province of Zambia. The stochastic frontier approach with the application of the flexible translog profit function and inefficiency model was used in estimating the profit efficiency. Secondary data for the 2012 Rural Agricultural Livelihoods Survey from Central Statistical Office of Zambia, which used a multi-stage sampling method, was utilized. Cross sectional data for 1,232 farm households was used in this analysis. Results showed existence of high level of inefficiency in groundnut farming because the gamma ratio (γ = 0.6445) was comparatively large. Seed price and value of fixed capital are key variables highly significant in the profit function. The result further revealed that the profit efficiencies of the farmers varied widely between 9.5% and 92.38%. The groundnut farmers were able to realize 72.5% of their frontier profit on the average suggesting that an estimated 27.5% of the profit is lost due to a combination of technical and allocative inefficiencies. Education level, credit access, land tenure, distance to market, storage facility and weeding were significant factors found to influence profit efficiency. Technologies that enhance fixed capital, improving availability and access to improved seed varieties and credit, and land reform measures aimed at promoting titled land ownership are required to achieve significant positive effects on profit efficiency. Also, policy measures that will improve weed control mechanisms, reduce transportation cost and encourage education advancement and ownership of proper storage facilities among smallholder farmers are advocated.
Keywords: Groundnut, Profit Efficiency, Stochastic Frontier, Zambia

1. Introduction

Groundnuts form a very important part of Zambia's food security. It is a multipurpose crop and every part of the plant has its own utility. Given the significant local and regional demand, groundnuts sales have been one of the major sources of steady income for the rural households (Zulu *et al.*, 2014; Mofya-Mukuka and Shipekesa, 2013). Groundnuts also serve as an important raw material in the manufacturing of peanut butter, cooking oil, sweets, and animal feed. Groundnut oil is also used in the preparation of soaps, cosmetics and lubricants. Seedcake, after extraction of oil is fed to livestock because of its residual protein value and is also used as manure. Leaves and stem are used as fodder (CSO, 2013).

In Sub-Saharan Africa (SSA), groundnuts provide 60% of dietary protein requirement in the cereal diets in regions where animal protein is either scarce or beyond the reach of most of the poor households. Its seed has 26% protein content, a critical nutrient for reducing impaired growth in children (N2Africa, 2006). In Zambia groundnuts are often considered a women's crop due to their importance for home consumption. They are eaten in their raw form or processed as powder and used in combination with other foods especially vegetables as relish. The farmers in Eastern Province have few animals and so they get most of their protein from non-meat sources (CSO, 2013).

Being a leguminous plant, groundnuts provide nitrogen fixation in the soil, which enhances soil fertility in a more environmental friendly manner, with the potential benefit of improving crop yield, while reducing the need for chemical fertilizers and their associated water and soil pollution (Zulu *et al.*, 2014). These multiple uses of groundnuts make it an excellent cash crop for domestic markets as well as for foreign trade in several developing and developed countries. It is grown on a large scale in almost all the tropical and subtropical countries of the world with average annual production of about 40 million tonnes, accounting for 8% of the world's total oilseed production. It is 4th most important oil seed crop of the world (USDA, 2015).

More than 660,000 (50%) households grow groundnuts in Zambia and it is the second most widely grown crop after maize (MAL, 2013; Sitko et al., 2011). It is grown on small plots ranging in size from 0.25 to 1 hectare. This crop is grown throughout the country, but the Eastern, Northern and Central provinces account for approximately 70% share of national production. In terms of regional distribution, Eastern Province comprises the largest share of area planted to the groundnut crop at 33% (MAL, 2013).

Smallholder farmers, however, continue to realize low and declining groundnut crop yields and cultivated land. The quantity of groundnut produced by smallholder farmers significantly declined in the last three years from 164,602 tonnes of shelled groundnuts in 2009/10 to 106,792 tonnes in 2012/13 agricultural season. Similarly, the total area planted reduced from 268,803 hectares in 2009/10 to 207,249 hectares in

2012/13 agricultural season. In 2012/13, less than 110,000 tonnes of groundnuts were harvested nationwide (MAL, 2013; CSO, 2014). Zambia was the 39th largest groundnut producer in the world in 2011, but now its ranking has dropped to 51st in the world (FAOSTAT, 2015).

The low yields of groundnuts are contributing in creating a disparity between the rate of production and the demand, leading to a supply demand gap (Sitko et al., 2011). The average national yield of 0.52 tonnes per hectare is far much too low compared to world average yield of 1.63 tonnes per hectare and even less than Malawi and South Africa, which averages 1.05 and 2.12 tonnes per hectare respectively. In the North Western Province of Zambia there are few smallholder farmers planting groundnuts but their average output per hectare is 0.81 tonnes or 36% higher than in Eastern Province (MAL, 2013; USDA, 2015). This low productivity in eastern province prohibits farmers from earning significant returns from their groundnut enterprises and hence reduces farm incomes.

Groundnuts are among the major cash and high value crops targeted for increased production and productivity and has been presented as a key investment and economic diversification opportunity by government (MAL, 2004). Policy initiatives have been taken aimed at improving both yield and sales of groundnuts in Zambia, including the Smallholder Agribusiness Promotion Programme (SAPP) and the Farmer Input Support Programme (FISP) in Eastern Province. This provided a lot of potential for attaining the critical mass required for input supply such as certified seed and fertilizer, particularly among resource poor farmers, and was expected to lead to increased groundnut production in line with market specifications. But because farmers plant less than 30% of available plots to groundnuts (CSO, 2013), the commodity does little to alleviate poverty and its contribution to scaling up rural incomes falls far short of its potential.

One of the major problems of groundnut production is low yield at 32% Zambia's proportion of both the world and key southern African countries averages. This is attributed to poor production techniques used by smallholder farmers, and inadequate supplies of inputs such as improved seed varieties, fertilizer, chemicals and machinery. There is inadequate supply of groundnut to meet the demand, and market participation is low with only 45% of the producers selling groundnuts (Sitko *et al*., 2011; CSO, 2013). Currently, the failure to meet international quality standard due to high levels of aflatoxins in groundnuts remains the major constraint to accessing the export market. This is compounded by the price instability making it difficult for producers to plan their production and to forecast their profits and eventually their income levels (Ross and de Klerk, 2012; Mofya-Mukuka and Shipekesa, 2013).

The major policy challenge is to reverse the current downward spiral by improving the capacity of groundnut farmers to increase production and productivity to meet the growing local and export demands. The low output realized by farmers is an indication that resources needed in groundnut production are not at optimal levels. This problem is technical but a production function approach may not be appropriate to use because it is criticized as suffering from simultaneous equation bias because input levels are endogenously determined. The profit function approach avoids these problems because when input and output prices are exogenous to farm household decision making, it can be used to explain input use and output supplied.

Little attention has been devoted in ascertaining the profit efficiency of the groundnut farmers in Zambia and there is paucity of empirical literature. Past studies limitations on food crops is that they assumed technical efficiency in terms of input use and production technology and for groundnut production they looked at market participation decision and choice of the marketing channel only (Denison, 2011; Ross and de Klerk, 2012; Mofya-Mukuka and Shipekesa, 2013; Zulu et al., 2014). These existing studies on groundnuts, in addition to the ones on efficiency by Musaba and Bwacha (2014) and Kabwe (2012), did not focus on profit efficiency in groundnuts. There is limited application of profit frontier function in the study of efficiency in Zambia. This indicates that the existing knowledge on efficiency in crop production especially groundnut production is highly limited in Zambia. Measuring profit efficiency level of farmers helps determining the extent to which it is possible to raise profitability by improving the neglected source of efficiency with the existing prices, resource base and available technology. To the researcher's knowledge, no study has been done to evaluate profit efficiency of smallholder groundnut farmers in Eastern province of Zambia. This study contributes to existing literature on the link between groundnut profit efficiency and the major determinants in the Zambian context. The specific objectives are:

i. To identify the major determinants of profit efficiency in groundnut production among the smallholder farmers.
ii. To determine the profit efficiency levels of the smallholder groundnut farmers.

The justification for the study is based on: (i) the need to accelerate growth in smallholder agriculture to reduce poverty, through improved marketing and increased productivity; (ii) the need to contribute to the Vision 2030 GRZ policy framework, which supports the development of an efficient, sustainable and competitive agricultural sector in order to ensure food security and income generation at household and national levels, and to maximize the sector's contribution to GDP as well as to expand and diversify exports; (iii) the opportunity to focus on smallholder productivity and diversification (away from maize); and (iv) the opportunity to guide policy and investments related to these issues.

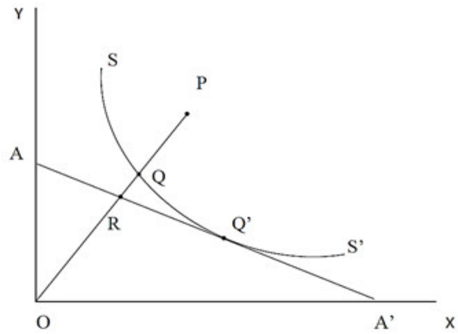
2. Literature Review

2.1. The Concept of Efficiency

First, Efficiency is the ability to produce a given level of output at the lowest cost (Farrell, 1957). The concept of efficiency has three components: technical, allocative and profit (economic). Technical efficiency is the ability of a firm to achieve a higher level of output given similar levels of inputs. Allocative efficiency deals with the extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to production value is equal to the factor costs. The production of a given output is, therefore, profit efficient when the producer combines resources in the least combination to generate maximum output as well as ensuring least cost to obtain maximum profits. Technical and allocative efficiencies are components of profit efficiency. The concept of efficiency carried out by Farrell (1957) could be clarified in terms of Figure 2-1.

Figure 2-2: Technical, Allocative and Profit Efficiency Measures

Source: Farrell (1957)



Suppose a firm using two factors of production to produce a single product under conditions of constant returns to scale. The isoquant SS' characterizes the technological set that obtains the minimum combination of inputs needed to produce a unit of output. Every combination of inputs along the unit isoquant is considered as technically efficient and thus Q and Q' are two technically efficient points and P is inefficient point. Consider a firm at point P, using quantities of input to produce a unit of output, the technical inefficiency of this firm could be explained by distance QP, the input package the firm at point P could save without decreasing the amount of output. The ratio QP/OQ indicates the percentage by which all inputs need to be reduced to achieve technical efficiency production. Hence, the technical efficiency (TE) of the producer under analysis (1- QP/OP) would be presented by the ratio OQ/OP. For a technically efficient farmer/firm, TE = 1 but for all inefficient farmers, a degree of TE < 1 is achieved.

If information on market prices is known, it is possible to calculate the profit efficiency of the firm under deliberation. In this diagram, the line AA' represents iso-cost line, hence, R and Q' have the same total cost. However, the output at point R production is outside the technology set, this it is not reachable given the output we want to produce. Q', intersection between AA' iso-cost and SS' iso-quant (production frontier), is the combination of inputs that gives lowest total cost, and is simultaneously part of the technology set. Thus, point Q' is supposed to be technical efficient as well as allocative efficient (AE). And the profit efficiency (PE) can be evaluated by the ratio:

PE = OR/OP

Then allocative efficiency and technical efficiency can also be designed by using the iso-cost line:

AE = OR/OQ

TE = OQ/OP

From these equations, the relationship between technical, allocative, and profit efficiency can be interpreted by:

TE*AE = (OR/OQ)*(OQ/OP) = OR/OP = PE

Thus, the profit efficiency (overall efficiency) of a farm is equal to the product of the technical efficiency and allocative efficiency.

2.2. Measurement of Profit Efficiency

There are two approaches; stochastic frontier analysis (SFA) (parametric approach) and data envelop analysis (DEA), also named as non-parametric approach mostly used to measure productive efficiency (Ogundari, 2006; Bidzakin et al., 2014). Both methods estimate the efficiency frontier and calculate the firm's technical, allocative and profit efficiency relative to it. The frontier shows the best performance observed among the firms and it is considered as the efficient frontier. The SFA approach requires that a functional form be specified for the frontier production function while DEA approach uses Linear Programming to construct a piece-wise frontier that envelops the observations of all firms. An advantage of the DEA method is that multiple inputs and outputs can be considered simultaneously, and inputs and outputs can be quantified using different units of measurement. However, a strong point of SFA in comparison to DEA is that it takes into account measurement errors and other noise in the data (Bidzakin et al., 2014). This point is very important for studies of farm level data in developing economy as data generally include measurement errors (Ogundari, 2006).

The SFA, (or econometric frontier approach), specifies the relationship between output and input levels and decomposes the error term into two components: (a) a random error, and (b) an inefficiency component. The random error is assumed to follow a symmetric distribution with zero mean and a constant variance while the inefficiency term is assumed to follow an asymmetric distribution and may be expressed as a half-normal, truncated normal, exponential or two-parameter gamma distribution (Ogundari, 2006).

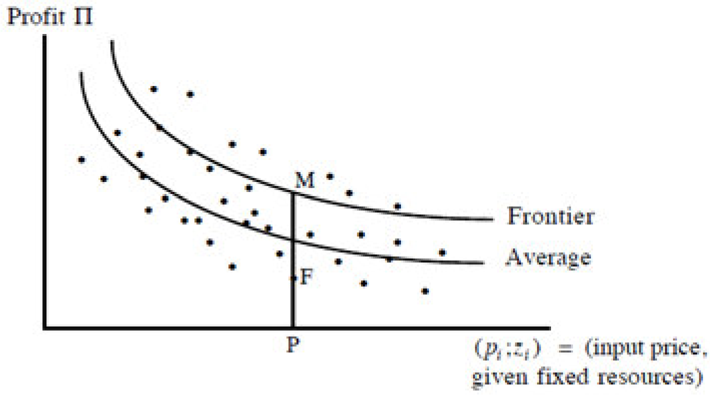
3. Study Methodology

3.1. Theoretical Foundation

This study is based on the analysis of economic efficiency of farms derived from production frontier proposed by Farrel (1957). Within a profit-function context, profit efficiency is defined as the ability of a farm to achieve the highest possible profit, given the prices and levels of fixed factors of that farm (Ali and Flinn, 1989). From Farrel analysis, a farm is economically efficient in resource use when it operates on the economic efficiency frontier, otherwise it is economically inefficient. Thus, the envelope curve in Figure 3-2 traces the profit frontier for a sample of farms; interaction between farm-specific prices (P_i) and levels of fixed factors (Z_i) allows the profit frontier to be farm specific. Profit inefficiency in this context is defined as profit loss from not operating on the profit frontier, again recognizing farm-specific prices and resource base. For example, assume a farm is operating at point F: comparative profit efficiency is defined as FP/MP, and profit inefficiency as (1 - FP/MP).

Figure 3-3: Frontier (MLE) and Average (OLS) Stochastic Profit Functions

Source: Ali and Flinn (1989)



A production function approach to measure efficiency may not be appropriate when farmers face different prices and have different factor endowments (Yotopoulos *et al*., 1973). This led to the use of stochastic profit function models to estimate farm specific efficiency directly (Rahman, 2003; Ogundari, 2006). The profit function approach combines the concepts of technical and allocative efficiency in the profit relationship and any error in the production decision is assumed to be translated into lower profits for the producer (Ali *et al*., 1994). A profit function is much superior to production function because first it permits straight forward derivation of own-price and cross-price elasticities and output supply and input demand functions. Second, the indirect elasticity estimated via profit functions have a distinct advantage of statistical consistency. Third, the profit function avoids problems of simultaneity bias because input prices are exogenously determined. Problems of endogeneity can be avoided by estimating the profit or cost function instead of the production function (Ogunniyi, 2011).

The Cobb-Douglas profit functional form is popular and is frequently used to estimate farm efficiency despite its known weaknesses (Sunday *et al*., 2012; Sadiq and Singh, 2015). The translog model has also been used widely (Hyuha *et al*., 2007; Ogunniyi, 2011; Assa *et al*., 2012) despite its susceptibility to multicollinearity and potential problems of insufficient degrees of freedom due to the presence of interaction terms. The flexible translog profit function estimation will be used in this study. The choice of translog stochastic profit function is based on the suitability of the model in estimating sole enterprise profit function as well as its excellent ability to analyze interactions among production inputs. The assumptions of homogeneity and separability impose more restrictions on the technology which would bias the estimates if the functional form is not Cobb-Douglas function. Also with more than two factors of production, the assumption of constant elasticity of substitution (which operates only with two independent variables) requires highly restrictive conditions on the elasticity values, which would make the assumptions untenable. Due to these shortcomings the Cobb-Douglas functional forms are incapable of explaining exact relationships among variables.

Battese and Coelli (1995) extended the stochastic production frontier model by suggesting that inefficiency effects can be expressed as a linear function of explanatory variables, reflecting farm-specific characteristics. This allows estimation of the farm-specific efficiency scores and the factors explaining efficiency differentials among farmers in a single stage estimation procedure. Following Rahman (2003), this study utilizes this Battese and Coelli (1995) model by postulating a profit function, which is assumed to behave in a manner consistent with the stochastic frontier concept. Assuming a farm that maximizes profits, then farm profit (π) from groundnut, measured in Zambian Kwacha (ZMK), equals the difference between the total revenue and total variable cost given by:

$$\pi = \sum (TR - TVC) = \sum (p_y Q - w_i X_i) \quad (1)$$

where *TR* is the total revenue from groundnut activity; *TVC* are total variable costs (seed, fertilizer, labour,) of securing revenue per rural farm household *i*; *Q* is groundnut output; X_i represents the quantity of input used; p_y and w_i are the output and input prices, respectively. To normalize the profit function, π is divided throughout by p_y (the market price of groundnut output) to obtain:

$$\frac{\pi}{p_y} = \frac{\sum (p_y Q - w_i X_i)}{p_y} = Q - \frac{w_i X_i}{p_y} = f(X_i, Z) - \sum P_i X_i \quad (2)$$

where *Z* represents fixed inputs; $P_i = w_i/p_y$ represents the normalized price of input X_i; and $f(X_i, Z)$ represents the production function. Following Sadiq and Singh (2015), the profit function model for the profit efficiency analysis can be specified as follows:

$$\Pi_i = \frac{\pi}{p_y} = f(X_i, Z)\exp(\varepsilon_i) = f(X_i, Z)\exp(V_i - U_i) \quad (3)$$

here; Π_i is the normalized profit of i^{th} farmer; X_i is the vector of variable inputs; Z represents the vector of fixed inputs; p_y is the output price and ε_i is the composite error term. This stochastic error term consist of two independent elements "*V*" and "*U*". The element V_i account for random variations in profit attributed to factors outside the farmer's control. It is assumed to be independent and identically distributed random error, having normal $N(0,\sigma^2)$ distribution, independent of the U_i. The U_i is the profit inefficiency effect, which is assumed to be non-negative truncation of the half-normal distribution $N(\mu,\sigma^2)$. N represents number of farms involved in the cross-sectional survey. The inefficiency effects (U_i) can be specified as;

$$U_i = \delta_0 + \sum_{d=0}^{1} \delta_d M_{di} + \omega_i \quad (4)$$

where M_{di} is the d^{th} explanatory variable associated with inefficiencies on farm *i*, ω_i is the two sided random error and δ_0 and δ_d are unknown parameters (Adamu and Bakari, 2015).

The profit efficiency (*PE*) of an individual farmer is derived in terms of the ratio of predicted actual profit to the corresponding frontier profit given the price of variable inputs and the level of fixed factors of production of farmers. Mathematically, it is expressed as:

$$PE_i = \frac{\text{Actual farm profit}}{\text{Frontier farm profit}} = \frac{f(X_i, Z)\exp(V_i - U_i)}{f(X_i, Z)\exp(V_i)} = \frac{\exp(V_i - U_i)}{\exp(V_i)} = \exp(-U_i) \quad (5)$$

A one sided component $U_i \geq 0$ reflects profit efficiency relative to the frontier. Thus, if $U_i = 0$, it implies that farm profit lies on the efficiency frontier (i.e. 100% profit efficiency) and is obtaining potential maximum profit given the price it faces and the level of fixed factors. If $U_i > 0$, the farm profit lies below the efficiency frontier. The farm is inefficient and loses profit as a result of inefficiency (Oladeebo and Oluwaranti, 2012; Sadiq and Singh, 2015). The farm specific profit efficiency is again the mean of the conditional distribution of U_i given by *PE* and is defined as:

$$PE = \exp(-U_i) = E[\exp(-U_i) \mid \varepsilon_i] = E\left[\exp(-\delta_0 - \sum_{d=0}^{1} \delta_d M_{di}) \mid \varepsilon_i\right] \quad (6)$$

PE takes the value between 0 and 1, and it is inversely related to the level of profit inefficiency. *E* is the expectation operator (Oladeebo and Oluwaranti, 2012). According to Coelli (1996), the method of maximum likelihood is used to estimate the unknown parameters, with the stochastic frontier and the inefficiency effects functions estimated simultaneously. The likelihood function is expressed in terms of the variance parameter;

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \qquad \gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2} = \frac{\sigma_u^2}{\sigma^2} \quad \text{and} \quad (7)$$

where, σ^2 is the total variance for the combined error term ε_i; σ_v^2 is the constant variance for the symmetric error term V_i; σ_u^2 is variance for the non-negative error term U_i, and; γ is ratio of farm - specific efficiency effects to the total output variance. The overall variance of the model (σ^2) measures the total variation of profit from the frontier which can be attributed to profit inefficiency. Gamma (γ) represents the share of inefficiency in the overall residual variance with values between 0 and 1. If $\gamma = 1$, profit inefficiency is the dominant source of error and there is no effect of random errors in the data. On the other hand, if $\gamma = 0$, it shows that the dominant source of error could be attributed to random factors alone and thus, no inefficiency effect (Adamu and Bakari, 2015).

3.2. Sources of Data

The study utilized recent data for the 2012 Rural Agricultural Livelihoods Survey (RALS12) from Central Statistical Office (CSO) of Zambia. RALS12 was conducted by Indaba Agricultural Policy Research Institute (IAPRI) in partnership with the Ministry of Agriculture and Livestock (MAL) and CSO. The purpose of the RALS12 was to provide policy relevant information that is not practical to collect annually from the GRZ agricultural surveys. Detailed information on crop production, sales and input use for field crops as well as demographic variables for farm household operations for the 2010/11 agricultural season and the marketing season from 1st May 2011 to 30th April 2012 was collected.

The RALS12 covered rural and urban areas in all the 10 provinces of the country. The sample provided district representation of Eastern Province and provincial representation of the remaining 9 provinces. Eastern Province was overly sampled with 2,000 households providing a representative sample at district level. Zambia is administratively demarcated into 10 provinces, 74 districts, 150 constituencies and 1,430 wards, with the ward being the lowest administrative unit in the country. The CSO has further divided wards into Census Supervisory Areas (CSA) which have further been subdivided into Standard Enumeration Areas (SEA). The SEA is the smallest area with well-defined boundaries and is covered by an enumerator during enumeration. Each SEA contains approximately between 100-150 households.

The sample was designed to be representative of the rural farm households cultivating less than 20 hectares of land for farming purposes and/or raising of livestock. A sample of 442 Standard Enumeration Areas (SEAs) was drawn using probability proportional to size sampling scheme. The measure of size of the SEAs is the number of households located within each SEA on the area sampling frame as per the 2010 Census of Population. RALS12, which was carried out in 2012, covered 8,839 households in Zambia. Cross sectional data for 1,232 farm households in eastern province was used in this analysis.

3.3. The Study Area

The study was conducted in Eastern Province since it is a top producer of groundnuts. The province's population is 1,592,661 or 12% of the total population of Zambia. More so than any other province in the country Eastern Province is predominantly rural, with 87% (1,392,338) of the population living in rural households (CSO, 2012a). It has eight districts and a total of 165,872 groundnut producer farmers (27% at national level). They produce over 30,000 tonnes of groundnuts per year and this equates to approximately 30% of space Zambia's total output. The top four groundnut growing districts of Chipata, Petauke, Lundazi and Katete districts accounts for approximately 75% provincial output (CSO, 2013, MAL, 2013). The province's economy depends on agriculture and has the greatest potential for smallholder-led agricultural growth. Smallholder farmers in the province produce groundnuts, sunflower, soybean and commercial crops like cotton and tobacco. The province also has a sizeable herd of livestock, namely cattle, goats and pigs (MAL, 2013).

3.4. Empirical Model and Hypotheses

This study estimates a flexible translog profit function (equation 8) and inefficiency function (equation 9). This function has both linear and quadratic terms with the ability of using more than two factor inputs and can be approximated by second order Taylor series (Christensen et al., 1973). The model is adopted from Rahman (2003) with some modifications. Thus, the normalized translog stochastic profit frontier for the farm is defined as:

$$\ln \pi = \alpha_0 + \sum_{i=1}^{3} \alpha_i \ln p_i + \frac{1}{2}\sum_{i=1}^{3}\sum_{k=1}^{3} \tau_{ik} \ln p_i \ln p_k + \sum_{i=1}^{3}\sum_{l=1}^{2} \phi_{il} \ln p_i \ln Z_l + \sum_{l=1}^{2} \beta_l \ln Z_l \quad (8)$$

$$+ \frac{1}{2}\sum_{l=1}^{2}\sum_{q=1}^{2} \varphi_{lq} \ln Z_l \ln Z_q + V_i - U_i$$

where;

$$U_i = \delta_0 + \sum_{d=1}^{8} \delta_d M_{di} + \omega_i \quad (9)$$

π = restricted profit normalized by price of output (p_y); P_i = price of the ith input normalized by the output price (p_y); i = 1, 2 and 3 for seed, fertilizer and labour prices respectively; Z_l = quantity of fixed input, l; l = 1 for land sizes and 2 for capital; V_i = two sided random error; U_i = one sided half-normal error; ln = natural logarithm; M_d

= variables representing institutional and socio-economic characteristics of the farm to explain inefficiency, d; d = 1, 2, 3, 4, 5, 6, 7 and 8 for education, household size, credit, land tenure, extension, distance, storage facility and weeding respectively; ω_i = two sided random error; α_0, α_i, τ_{jk}, β_l, ϕ_{lq}, φ_{il}, δ_0 and δ_d are the unknown parameters. Symmetry is imposed by constraining **(8)** according to $\tau_{ik} = \tau_{ki}$ for all i, k, and the function is homogenous of degree one in prices of all variable inputs and output.
The following hypotheses require testing with the generalized Likelihood Ratio (LR) test;

$$LR_\lambda = -2\{\ln[L(H_0)/(L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[(L(H_1)]\} \tag{10}$$

where $L(H_0)$ and $L(H_1)$ are the maximum values of the log likelihood functions under the null and alternative hypothesis, respectively. The statistic test LR_λ has approximately a chi-square (χ^2) distribution with a number of degrees of freedom equal to the number of parameters (restrictions), assumed to be zero in the null hypothesis. When LR_λ is lower than the correspondent critical value (for a given significance level) we fail to reject the null hypothesis.
The following null hypotheses are tested:

i. H_0: $\tau ik = \phi il = \varphi lq = 0$. The coefficients of the cross terms in the translog model are equivalent to zero. If the squared values and the interaction terms sum up to zero, then the translog specification is not necessary, the Cobb-Douglas form is appropriate.
ii. H_0: $\gamma = 0$. There are no profit inefficiency effects present in the model. With regard to hypothesis ii, the profit inefficiency model can only be estimated if the inefficiency effects are present.
iii. H_0: $\gamma = \delta 0 = \delta 1 = \ldots \delta 8 = 0$. The null hypothesis specifies that the profit inefficiency effects are not present in the model at every level, the joint effect of these variables on profit inefficiency is statistically insignificant.

3.5. Definition of Study Variables

The choice of explanatory variables in this study is based on theory, empirical literature, data availability, and the researchers' knowledge of the contextual setting. The potential explanatory variables which are hypothesized to influence smallholder groundnut farmers' profit efficiency in the study area are summarized and presented in Table 3-1.

Table 3-7: Variable descriptions, units of measurement and hypothesized relationships

Variable	Description	Sign	References
Inefficient Factors			
Education	Completed highest level of formal education of household head (years).	+	Sadiq and Singh, 2015.
Household size	Number of people in household (proxy for labour).	+	Oladeebo and Oluwaranti, 2012.
Credit	Access to loans/credit by household to support agricultural production (yes=1, no=0).	+	Adamu and Bakari, 2015; Hyuha *et al*., 2007.
Land Tenure	Land title as a proxy for tenure security (state or customary land) (titled=1, no title=0)	+	Place *et al*., 1994; Donkor and Owusu, 2014
Extension	Access to advice on problems associated with aflatoxins in groundnuts (yes=1, no=0).	+	Tanko and Obalola, 2013.
Distance	Distance to nearest established market place (km)	-	Abdullai and Huffman, 2000.
Storage facility	Availability of a groundnut storage facility (available=1, not available=0)	+	Mohammed *et al*., 2013.
Weeding	Number of weeks after planting when the household finished the 1st weeding (weeks)	-	Assa *et al*., 2012.
General Model			
Seed price	Normalized price of seed per kg (ZMK).	-	Ani *et al*., 2013;
Fertilizer price	Normalized price of fertilizer per kg (ZMK).	-	Ani *et al*., 2013; Taru et al., 2008.
Labour wage	Normalized wage of hired and family labour per man-day (ZMK).	-	Ajijola *et al*., 2014; Ani *et al*., 2013
Size of land	All land operated for agricultural purposes owned by farmer (ha).	+	Tanko and Obalola, 2013.
Capital	Value of fixed capital (ZMK).	+	Hyuha *et al*., 2007.

4. Results and Discussions

4.1. Descriptive Statistics of Variables

Table 4-1 shows the summary statistics of the variables. The results reveal that out of 1,232 smallholder farm households selected for analysis female headed households comprise 19.97%. This suggests that groundnut production in Eastern Province is a male household dominated occupation as about 80.03% of the farmers were males. The average age of farmers is 46 years. Average household size is 6 persons with farmer's years spent at school averaging 5 years. The smallholder farmers in the province own average land holdings of 0.92 hectares size operated for agricultural purposes.

The average groundnut yield of 500.94kg per hectare was recorded over the sampled area. Also an average output price of ZMK3.61 per kg of groundnut was recorded. Further the farmers obtained an average profit margin of ZMK 287.46 from groundnuts sales. Only 43.99% of the farmers had access to advice on problems associated with aflatoxins in groundnuts and 7.79% had titled state or customary land. The proportion of farmers that had access to credit to support agricultural production was approximately 50%, mainly attributed to out-grower scheme loans. The respondents report on average 21 kilometres of distance to the nearest established market place. Nearly 48.94% of the sampled farmers had groundnut granary storage facilities used to store the groundnuts after drying. When asked about membership to a cooperative the majority (56.82%) indicated that they had such membership.

Table 4-8: Summary statistics of variables for the sampled households

Variables	**Mean**	**Std. deviation**
Profit (ZMK)	287.46	45.56
Groundnut yield (kg/ha)	500.94	421.78
Groundnut price (ZMK/kg)	3.61	0.83
Seed price (ZMK/kg)	3.50	1.42
Fertilizer price (ZMK/kg)	3.83	0.41
Size of Land (ha)	0.92	0.70
Number of man-days of labour/day	2.83	1.38
Wage rate (ZMK/day)	14.13	6.91
Value of fixed capital (ZMK)	7,061.05	2,470.00
Age of household head (years)	46.08	14.84
Education level (years)	5.09	3.99
Household Size (number)	5.81	2.59
Distance to market (Km)	21.06	8.99
Weeding (weeks hh finished 1st weeding)	3.16	1.15
Storage facility (% available=1)	48.94%	
Gender (% female=0)	19.97%	
Land tenure (% yes=1)	7.79%	
Extension access (% yes=1)	43.99%	
Credit access (% yes=1)	50.49%	
Cooperative Membership (% yes=1)	56.82%	
Sample size	**1,232**	

Note; 1 USD = 5.239 ZMK (approximately) as of April, 2012 currency exchange rate.
Source: Computed from RALS12 data.

4.2. Likelihood Ratio Tests

In Table 4-2 are presented the statistical tests applied in order to verify the consistency of specific hypotheses related to the profit frontier function adopted in the empirical model. The system of log likelihood ratio test used to ascertain the appropriate form that fits the data was rejected in favour of translog frontier function since the generalized likelihood-test statistic 45.36 is significantly different from zero at 5% level. The translog does not reduce to Cobb-Douglas profit function in this case, meaning results from the translog model are more accurate and adequate representation of the data, given the assumptions of the frontier model.

In addition, the null hypothesis that the inefficiency effects are not present in the model is also rejected at the 5% level of significance (LR_{λ} statistic 8.36, $p = 0.002 < 0.05$) in favor of the presence of inefficiency effects. Thus, a significant part of the variability in profits among farms is explained by the existing differences in the level of technical and allocative inefficiencies. The result of the second hypothesis revealed that the frontier profit function was more appropriate to fit the data than the average response profit function.

Table 4-9: Likelihood ratio tests of stochastic profit frontier parameters

Null hypotheses	**χ2 Test Statistic**	**df**	**Prob > χ2 statistic**	**Decision; Implication**
H_0: $\tau_{ik} = \phi_{il} = \varphi_{lq} = 0$	45.36	15	0.0001	Reject Ho; Translog is appropriate
H_0: $\gamma = 0$	8.36	1	0.002	Reject Ho; Inefficiency effects are present in the model
H_0; $\gamma = \delta_0 = \delta_1 = \ldots \delta_8 = 0$	6.96	8	0.0000	Reject Ho; Explanatory variables determine the *Ui*.

Source: Computed from RALS12 data.

The last test says that the variables in the inefficiency effects model do not explain the inefficiency term U_i. The null hypothesis is rejected at 5% level confirming that the joint effect of socio-economic and institutional indicators on profit inefficiency is statistically significant, so the decision to exclude them was discarded.

4.3. Translog Profit Function Estimates

The maximum likelihood estimates (MLE) of the parameters of the stochastic profit frontier model are presented in Table 4-3. The model reported a Wald chi-square statistic of 140.69 which was significant at 1% denoting that all covariates in the model are jointly significant. The variables included were tested for multicollinearity using Variance Inflation Factor (VIF). The mean VIF of 1.41 was found and this showed that there was virtually no multicollinearity in the model since the value of VIF found is less than 10. In addition, Breusch Pagan (BP) test (H_0: constant variance) revealed that there was no serious problem of heteroskedasticity in the model as justified by a value of 1.90 ($p = 0.168 > 0.05$). A sigma square (σ^2) coefficient of 0.7105 is statistically significant at 1% probability level denoting that the equation has a good fit and confirms the correctness of the specified distribution assumption of the composite error term for the model. The implication is that the inefficiency equation (U_i) can explain the differences between each farm's profit and the profit on the frontier function.

The estimated gamma or variance ratio parameter (γ) is statistically greater than zero at the 1% level and comparatively large (0.6445) given the (0,1) interval within which γ lies. This value of γ shows that 64.45% of disturbance in the system is due to profit inefficiency, with one-sided error and 35.55% is due to stochastic disturbance with two-sided error. This result implies that variation in actual profit from maximum profit between farms mainly arose from differences in farmer practices rather than effects of exogenous factors outside the control of the farmer, confirming the fact that a high level of inefficiencies exists in groundnut farming and are indeed stochastic (Adamu and Bakari, 2015).

In the stochastic profit frontier model presented in Table 4-3, the dependent variable is normalized groundnut profit from an output of the 2010/2011 agricultural season measured in ZMK. All the estimated coefficient parameters of the normalized profit function, based on the assumption of competitive markets, carry the theoretically expected signs in the MLE model except the price of seed. The estimated function reveals that the price of seed and value of fixed capital significantly affected the farm level profit and have important implication on the profit efficiency of groundnut farmers in the study area.

Journal of Economics and Sustainable Development www.iiste.org
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.7, No.8, 2016

Table 4-10: Maximum likelihood estimates of the stochastic translog profit frontier model

Variables	Parameters	Coefficients	Std. error	p-values
General model				
Constant	α0	8.3753***	1.7199	0.000
lnP1 (Seed)	α1	1.0097**	0.4628	0.029
lnP2 (Fertilizer)	α2	-1.3225	0.8707	0.129
lnP3 (Labour)	α3	-0.5549	0.4724	0.240
½lnP1 x lnP1	τ11	0.0674	0.0522	0.196
½lnP2 x lnP2	τ22	-0.3051	0.3413	0.371
½lnP3 x lnP3	τ33	-0.0085	0.1259	0.946
lnP1xlnP2	τ12	0.3919**	0.1845	0.034
lnP1xlnP3	τ13	-0.1230	0.1085	0.257
lnP2xlnP3	τ23	0.1694	0.1646	0.303
lnP1xlnZ1	ϕ11	0.1654*	0.0915	0.070
lnP1xlnZ2	ϕ12	-0.0517*	0.0270	0.056
lnP2xlnZ1	ϕ21	0.1614	0.1574	0.305
lnP2xlnZ2	ϕ22	0.1340**	0.0498	0.007
lnP3xlnZ1	ϕ31	0.0861	0.0754	0.254
lnP3xlnZ2	ϕ32	0.0209	0.0260	0.422
lnZ1 (Land size)	β1	0.4338	0.4096	0.290
lnZ2 (Capital)	β2	0.3537*	0.1916	0.065
½lnZ1 x lnZ1	φ11	-0.0576	0.0807	0.476
½lnZ2 x lnZ2	φ22	0.0151	0.0127	0.232
lnZ1xlnZ2	φ12	0.0005	0.0221	0.982
Diagnostic statistics				
Sigma-square	σ2 = σ2v+σ2u	0.7105***	0.0596	
Gamma	γ = σ2u/σ2v + σ2u	0.6445***		
Log likelihood function	(llf)	-1316.5914		
Wald chi2 (20)		140.69***		0.000
Mean VIF		1.41		
Breusch Pagan		1.90		0.168
Sample size		1,232		

*Note: *, **and *** signify levels of significance at 10% (p<0.10), 5% (p<0.05), and 1% (p<0.01) respectively.*
Source: Computed from RALS12 data.

The sign on the coefficient of seed price was positive contrary to the expected negative sign and was significant at 5% level. Price of improved seed varieties shows a positive effect on profit and the effect is very large since it contributes 10% when cost of seed increases by 10%. The reason is that a higher price of seed means that farmers use more quantity of improved seed varieties as opposed to recycled seed. This revealed that the marginal value productivity of improved seed was greater than its price, therefore, it is rational to obtain a higher profit. This result shares the opposite version of the law of profits in production but it corroborates with the findings by Mohammed *et al*. (2013). Adamu and Bakari (2015) also found that using high quality seed, which was relatively expensive than local variety, increased farm profit of rain-fed rice farmers in Nigeria. In line with this, Kumbhakar (2001) cautioned the use of models that do not incorporate inefficiency in modelling agricultural production.

The coefficient of fixed capital (0.3537) has positive significant relationship with farm profit at 10% level. This indicates that capital is an important factor in explaining changes in profit. The implication is that a 10% increase in the value of fixed capital assets owned by a farmer will bring about a marginal increase in farm profit of 3.5%. Thus, expansion in farm capital, in the form of necessary tools, implements and equipment contributes positively for groundnut supply and significantly increases farm profit. This is in line with the finding of Hyuha *et al*. (2007) who in their study of profit efficiency among rice producers in Uganda established a positive relationship between capital and gross profit of their respondents.

The results further reveals that the coefficient of fertilizer price, labour wage and land size had the expected signs but were not significant. The reason for the fertilizer cost being insignificant factor might be due to its lesser contribution to profit as most farmers do not use fertilizer in production of groundnuts. FISP also provides the fertilizers to most farmers at subsidized prices. Mofya-Mukuka and Shipekesa (2013) reported that none of the farmers applied fertilizer or manure to groundnuts fields. The lack of significance of labour wage suggests that availability of unpaid family labour for most smallholder farmers makes labour wage not a major constraint in groundnut production. Moreover it was observed that additional cost to use more labour reduced profit. The slope coefficient of size of land (0.4338) shows that the variable has a positive but insignificant relationship with the farm profit.

The profit elasticities with respect to changes in variable input prices and fixed factors, computed at mean values, are shown in Table 4-4.

Table 4-11: Estimated profit elasticities

Prices and fixed inputs	Profit elasticity
With respect to:	
P_1 (Seed)	-0.44
P_2 (Fertilizer)	-0.03
P_3 (Labour)	-0.08
Z_1 (Land size)	0.02
Z_2 (Capital)	1.25

Source: Computed from RALS12 data.

Estimates of the profit elasticities (Table 4-4) showed that the elasticity of groundnut profit is highest with respect to capital (1.25), followed by seed (0.44), labour (0.08), fertilizer (0.03) and land (0.02). An increase of seed price by 10% would decrease profitability by 4.4%. Similarly, a 10% rise in labour wage and fertilizer price will reduce profitability by 0.8% and 0.3% respectively. The incremental contribution of capital to profit is very high at 1.25 indicating that a 10% increase in value of fixed capital will increase profits by 12.5%. Profit response to size of land operated for agriculture purposes is very low. The elasticity estimate reveals that a 10% increase in size of land will raise profits by almost 0.2%.

The price of seed dominates the profit share followed by labour wages and then price of fertilizers among the production costs that reduce profits. The highly inelastic response to land may reflect the presence of other technological and infrastructural constraints that limit groundnut profitability. The elasticity of profit in terms of the price of fertilizer was found to be among the lowest. This may be attributed to the low use of fertilizer inputs by farmers in groundnut production. These results also show that capital is the most limiting factor in groundnut profitability, suggesting that technologies that enhance the value of fixed capital are likely to achieve significant positive effects on groundnut profits.

4.4. Profit Inefficiency Determinants

The estimated coefficients of socio-economic and institutional factors accounting for inefficiency in groundnut production are listed in Table 4-5. The purpose was to determine factors that explain profit efficiency. These variables included in the model were in line with theory and had consistent expected signs. The negative signs indicate that the variables have a negative effect on inefficiency or a positive impact on efficiency, while the positive signs imply that the variables negatively affect profit efficiency (because the value of U_i would be higher when the farm is further away below the profit frontier). The maximum likelihood estimates results showed that coefficients on six of the eight variables were statistically significant to affect the level of profit efficiency of farmers. Sources of variation in the profit inefficiencies of farmers include education, credit, land tenure, distance, storage facility and weeding.

Table 4-12: Determinants of profit inefficiency for groundnut farmers

Variables	Parameters	Coefficients	Std. error	p-values
Inefficiency effects				
Constant	$\delta0$	-1.1268**	0.5474	0.040
Education	$\delta1$	-0.0494*	0.0289	0.088
Household Size	$\delta2$	-0.0989	0.0667	0.138
Credit	$\delta3$	-0.5011*	0.2634	0.057
Land tenure	$\delta4$	-1.0289*	0.6033	0.088
Extension	$\delta5$	-0.0815	0.2033	0.689
Distance	$\delta6$	0.0115**	0.0058	0.048
Storage facility	$\delta7$	-0.5137*	0.2946	0.081
Weeding	$\delta8$	0.2146**	0.0960	0.025

*Note: * and ** signify levels of significance at 10% ($p<0.10$) and 5% ($p<0.05$) respectively.*

Source: Computed from RALS12 data.

The results in Table 4-5 shows that the coefficient on education was negative and statistically significant (p<0.10). This implies that to an extent more education brings about decrease in inefficiency (increase in profit efficiency) in groundnut production. This is due to the ability of more educated farmers to adopt the best farm practices to produce the frontier output using the least cost combination of the productive inputs available than farmers with less education. A marginal increase in the highest level of formal education of the household head results in a 4.94% increase in profit efficiency. These results are consistent with Ali and Flinn (1989) and Sadiq and Singh (2015). Giving education to groundnut farmers in particular would therefore be very beneficial in terms of significantly reducing profit inefficiency.

The result of this study also shows that access to credit decreased profit inefficiency (p<0.10). The negative effect (-0.5011) suggests that credit is a major contributor of profit efficiency among groundnut producers in the study area. Credit availability shifts the cash constraint outwards and enables farmers to make timely purchases of those inputs that they cannot provide from their own sources, which eventually translate into increased profit efficiency. Farmers who face a credit constraint on purchased inputs experience higher profit inefficiency. This is consistent with the findings of Hyuha et al. (2007) in a study of profit efficiency for rice producers in Uganda. Adamu and Bakari (2015) and Assa et al. (2012) also reported a negative influence for credit among rice farmers in Nigeria and Irish potato farms in Malawi respectively.

With respect to Land Tenure, titled land was significant and positively related to profit efficiency at 10% level. This implies that titled land increase farmers' access to formal credit which leads to a higher likelihood of land improvements, more intensive use of variable inputs, and higher output per unit of land (Place *et al*., 1994). Smallholder farms may be less efficient if collateral requirements affect their ability to raise working capital. Similar result was found in the work of Donkor and Owusu (2014). In their study on effects of land tenure systems on resource-use productivity and efficiency in Ghana's rice industry, owned land and fixed rent reduced the inefficiency of rice production.

Further findings indicate that distance to the market showed a negative effect on profit efficiency as earlier expected and it was significant at 5% level. It was found that an increase in the distance to the market by one kilometer lead to a decrease in the farm's profit efficiency by 1.15%. The positive effect of distance to nearest established market place on profit inefficiency is as expected related to higher transactions and transport costs. This might be due to the fact that as farmers are located far from market, there would be limited access to input and output markets and market information. Moreover, higher distance to market leads to higher transaction cost that reduces the benefits that accrue to the farmer. More importantly, longer distance from market discourages farmers from participating in market-oriented production. This result is consistent to the findings of Abdullai and Huffman (2000) on the economic efficiency of rice farmers in Northern Ghana.

Coefficient of storage facility was negative and statistically significant at 10% level. This means that availability of a groundnut storage facility reduces profit inefficiency among the groundnut farmers. This is consistent with expectation, that farmers with storage facility could hold back their harvest until when favorable producer price is offered. Mohammed *et al*., (2013) also found a negative relationship between farmers having a storage facility and profit inefficiency of castor seed producers in Nigeria, even though their study only sought to know whether farmers had storage facilities without being specific on whether such facilities were used for castor storage.

The number of weeks after planting when the household finished the 1st weeding was also among the significant variables in determining profit efficiency. This variable registered a significant result (p<0.05) and positively affected profit inefficiency in groundnut production. The result indicate that groundnut farmers become inefficient as the duration of weeding increased. Hence, there is a possibility to increase the profit efficiency level through advising farmers to protect their groundnut field from any kind of weed on time without searching for any other external inputs. This result is in line with the arguments of Assa *et al*., (2012) in their study of Irish potato farms in Dedza district of Malawi.

4.5. Profit Efficiency Levels

The distribution of profit efficiency of groundnut production is presented in Table 4-6. The farmers exhibit a wide range of profit efficiency ranging from 9.5% to 92.38% for the worst and best farmer respectively. Results revealed that few farmers (about 0.32%) are close to the profit efficiency frontier while about 0.08% are very far from the efficiency frontier. It is observed that even the best efficient groundnut farmer was not optimal in resource allocation and need improvement to attain frontier profit. This improvement can be achieved if inefficiency determinants are minimized. Similar results have been reported by Sadiq and Singh (2015) who obtained a minimum of 12% and a maximum of 95% for maize farmers in Niger State, Nigeria. Other researchers such as Hyuha *et al*. (2007) and Ani *et al*., (2013) have documented similar findings.

The average profit efficiency score of 0.725 from the results showed that groundnut farmers achieved on average 72.5% level of efficiency. This shows that, considerable or significant amount of profit is lost (about 27.5%) from groundnut production in the eastern province of Zambia because of the existence of profit inefficiency at the given input prices and technology. This also implies that, significant quantity of groundnuts in the area is not produced due to profit inefficiency in resource use among groundnut farmers. The producers can increase their profits by 27.5% on the average to strengthen their competitiveness in the short run through the adoption of best farm practices that have technical and allocative efficiency to attain frontier. This result conformed to the findings of Rahman (2003) who reported mean profit efficiency levels of 0.77 for Bangladeshi rice farmers and also Ojo *et al*. (2009) found a mean profit efficiency level of 77.75% for small scale cowpea farmers in Nigeria.

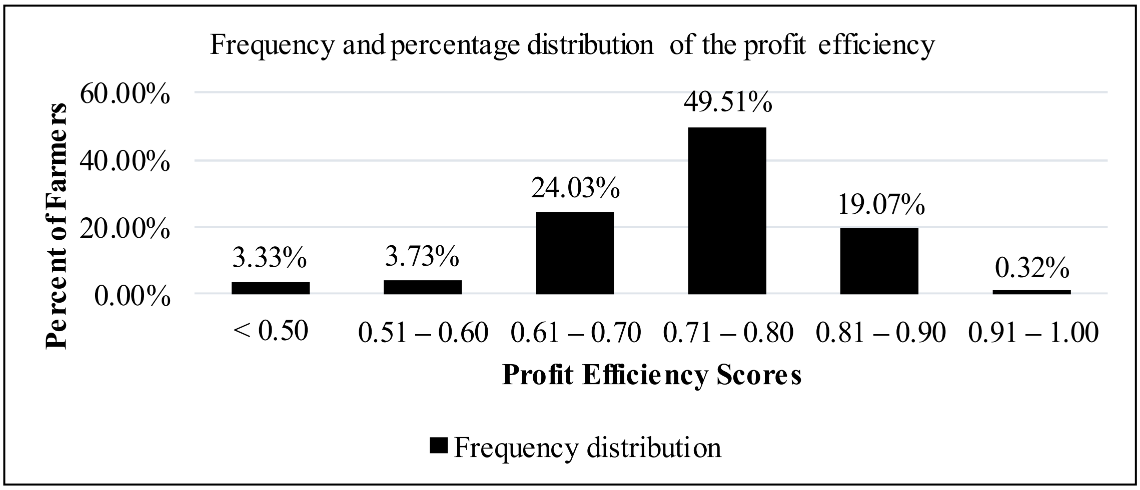
Table 4-13: Distribution of profit efficiency scores among farmers in the study area

Efficiency class	**Frequency**	**Percentage**
0.00 - 0.10	1	0.08%
0.11 – 0.20	4	0.32%
0.21 – 0.30	7	0.57%
0.31 – 0.40	11	0.89%
0.41 – 0.50	18	1.46%
0.51 – 0.60	46	3.73%
0.61 – 0.70	296	24.03%
0.71 – 0.80	610	49.51%
0.81 – 0.90	235	19.07%
0.91 – 1.00	4	0.32%
Total	1,232	100.00%
Minimum profit efficiency	0.0950	
Maximum profit efficiency	0.9238	
Mean profit efficiency	0.7250	
Standard deviation	0.1011	

Source: Computed from RALS12 data.

Despite the variation in efficiency, Figure 4-1 shows that about 68.9% of the farmers seemed to be skewed towards efficiency level of 0.725 and above. The least profit efficient farmer needs an efficiency gain of 89.71% [i.e. (1.00 – (0.095/0.9238))*100] in the use of specified farm resources if such farmer is to attain the profit efficiency of the best farmer in Eastern Province. Similarly an average efficient farmer will need an efficiency gain of 21.52% [i.e. (1.00 – (0.725 /0.9238))*100] to attain the level of the most profit efficient groundnut farmer. Likewise, the most profit efficient groundnut farmer needs approximately 7.62% gains in profit efficiency to be on the frontier. The efficiency results indicated that individual differences in their profit efficiency levels at their farms partly contributed to variation in their total groundnut profits.

Figure 4-4: Distribution of Profit Efficiency Scores for Groundnut Farmers



Source: Computed from RALS12 data.

5. Conclusion and Policy Implications

This research employed translog stochastic profit frontier model to evaluate profit efficiency among groundnut smallholder farmers in Eastern Province, Zambia using farm level data obtained from 1,232 farm households. The results showed that there existed a high level of inefficiency in groundnut farming because the gamma ratio (γ = 0.6445) was closer to one, meaning profit inefficiency at the given level of inputs and prices is more pronounced than the pure noise effect. The presence of inefficiency detected in the study lends support to the proposition that production models that assume absolute efficiency could lead to misleading conclusions. This was indicated by the Log likelihood test which rejected the model without inefficiency in favour of the one that incorporates inefficiency. Seed price and value of fixed capital are highly significant at 5% and 10% level respectively in the profit function. Additionally, the elasticity of groundnut profit is highest with respect to capital at 12.5% given a 10% rise in value of fixed capital.

The study's results identify efficiency drivers, including education, credit access, land tenure, distance, storage facility and weeding in the study area. These were the major determinants of profit efficiency in groundnut production among the smallholder farmers. With respect to profit efficiency levels, the variation in actual profit from maximum profit (profit frontier) between households, ranged from 9.5% to 92.38%. This mainly arose from differences in farmers' practices rather than from random variation. The study further concludes that groundnut producers in the region were able to realize 72.5% of their frontier profit on the average. The estimated average efficiency was correspondingly high, but still indicated that there existed opportunity for increased efficiency given the present state of technology. Profit realized from groundnut production can increase by 27.5% if the producers stacked to the best farm practices and use the least cost combination of the inputs.

The study findings have helped in providing information with important policy implication in promoting profit efficiency and improving farm incomes among groundnut farmers in eastern province and Zambia in general. It is expected that the policy implications given below would help in providing solution to the declining productivity and yield per hectare thereby leading to improvement in groundnut production.

i. Attempts at improving farm incomes need to look at technologies that enhance the value of fixed capital to achieve significant positive effects on groundnut profits.
ii. Seed inputs should be made available to farmers at affordable prices and at appropriate time by the stakeholders through set up of community seed banks and/or seed loans in order for farmers to secure the required quantity of seed for increased production.
iii. Training should be provided to less educated farmers to enable them adopt the best groundnut farming practices.
iv. Policy makers should introduce appropriate legislation that encourages commercial and microfinance institutions to accommodate smallholder agricultural producers to access credit at affordable interest rates and using groups as collateral.
v. Land reform measures aimed at promoting titled land ownership will have a positive role in increasing efficiency of these groundnut producers or, as a second best, allocating property rights to small farmers may in fact be efficiency enhancing.
vi. Stakeholders should develop better roads and market infrastructure in the rural areas to attract private investors, as a way to reduce the distance farmers have to cover to the market as well as transportation costs. There is also need to encourage farmers to form more well managed cooperatives or producer farmer groups and networks as avenues for accessing inputs, output markets, as well as credit facilities to invest in farming.
vii. Strategies to improve groundnut productivity should focus on farmer access to improved storage facilities. Also there is need to encouraging farmers, through extension advice, to adopt proper weed management practices.

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